Conventional Counterforce Strike and Damage Limitation

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Abstract: The ability to control escalation and reduce damage in conflicts with nuclear adversaries has been an important component of American military strategy. The option of preemptive use of nuclear weapons, however, becomes increasingly unpopular in recent years – it is morally indefensible and militarily impracticable. As a result, the ability to conduct conventional preemptive strikes as a means of damage limitation against nuclear-armed adversaries looks increasingly attractive to military strategists. On a number of recent occasions, the scenario of using conventional counterforce strikes in damage limitation operations against nuclear adversaries has been used to justify the development and deployment of U.S. conventional global strike systems which raises concerns in China and some other nuclear-armed countries. However, the feasibility and wisdom of conventional counterforce strike has not been tested by rigorous research.

In the context of a hypothetical U.S.-China conflict in Asia-Pacific region, existing studies mistook the scenario of a preemptive strike against China by assuming that the U.S. will focus on and target China's intercontinental ballistic missiles (ICBM). This study points out that contrary to previous analysis, if the U.S. ever considers a first strike for the purpose of escalation control, it is more likely to target China's theater nuclear forces rather than ICBMs. Accordingly, this study conducts a comprehensive analysis on the probability that American conventional strikes might destroy China's theater nuclear forces which include DF-3A, DF-4, DF-21, DF-31 missiles, Type 094 nuclear submarines, and nuclear-capable H-6 bombers. The results indicate that most China's theater nuclear forces are survivable to conventional precision-guided strikes. China's strategy to build very robust underground facilities, in particular, is very effective in protecting nuclear forces from threats of preemptive strikes. It is very unlikely that a U.S. conventional strike can destroy a meaningful part of China's theater nuclear forces. This study also takes into account future conventional prompt global strike systems that have been envisaged and proposed. An assessment of the potential of future systems is made and the analysis shows that new systems probably would not add much to the existing U.S. conventional preemptive strike capability against China's theater nuclear forces. The research concludes that using conventional global strike capabilities against medium-sized nuclear adversaries for purpose of damage limitation is impracticable and problematic and will mostly likely lead to inadvertent escalation. The research offers a number of policy recommendations to help mitigate potential negative impact of the development of conventional global strike capabilities on strategic stability between nuclear-armed rivals.

Conventional Counterforce Strike and Theater Nuclear Weapons

There has been much debate about U.S. counterforce capability in both academia and policy circles. Previous debates have largely focused on the possibility and trade-offs for the U.S. to obtain a nuclear counterforce capability. Although some scholars contend that the U.S. has already possessed the capacity to conduct a preemptive nuclear strike and destroy all Russian or Chinese strategic nuclear forces,[1] the mainstream view held by most scholars and policy practitioners seems to remain that nuclear counterforce capability is difficult to obtain and the political and military risks associated with pursuing nuclear primacy might outweigh its potential benefits.[2] However, as the debates about counterforce capability continue in recent years, the focus of the debate is shifting. The U.S. has become increasingly interested in pursuing the idea of developing conventional weapons to deal with time-sensitive targets or targets that are hardened and deeply buried. The concept of conventional prompt global strike, for example, is indicative of such interests and efforts. Admittedly, conventional prompt global strike systems can be used to strike a broad variety of targets, ranging from terrorist leaderships to storage facilities for chemical and biological weapons. The tremendous potential of advanced conventional weapons, however, has also led scholars to contemplate the option of using conventional weapons against potential adversaries' nuclear forces. A conventional counterforce capability, as is argued, will provide the U.S. president with an alternative option if the U.S. finds itself in a crisis with another nuclear-capable country. Conventional weapons will permit the U.S. to "conduct a counterforce strike without crossing the nuclear threshold, and without killing millions".[3] The idea of acquiring a conventional counterforce capability has also been seriously studied and debated by policy makers and practitioners in the U.S.[4] The report produced by the Defense Science Board and submitted to the Department of Defense on conventional strike, for instance, explicitly includes the scenario of using conventional strike to preempt perceived nuclear missile attack from a regional power.[5] One report produced by National Research Council also suggests keeping the option of using conventional prompt global strike weapons against Russian and Chinese "critical targets" on the table. It claims that the risks associated with such conventional strike are "sufficiently low and manageable", and "they do not constitute a reason to forgo acquiring the capability".[6]

If achievable, a conventional counterforce capability is obviously more attractive than a nuclear alternative. It will provide the U.S. president the option to eliminate a perceived imminent nuclear threat without having to risk the cost of initiating a nuclear war. On the flip side of the issue, however, such a

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[1] See, for example, Keir A Lieber and Daryl G Press. "The End of Mad? The Nuclear Dimension of U.S. Primacy." *International Security* 30, no. 4 (2006): 7-44; or, Keir A Lieber and Daryl G Press. "U.S. Nuclear Primacy and the Future of the Chinese Deterrent." *China Security* no. Winter (2007): 66-89.

[2] See, for example, Peter C. W. Flory, Keith Payne, Pavel Podvig, Alexei Arbatov, Keir Lieber, and Daryl Press. "Nuclear Exchange: Does Washington Really Have (or Want) Nuclear Primacy?" *Foreign Affaires* no. September/October (2006): 149-57; or, Charles L Glaser and Steve Fetter. "Counterforce Revisited: Assessing the Nuclear Posture Review's New Missions." *International Security* 30, no. 2 (2005): 84-126.

[3] Keir A Lieber and Daryl G Press. "The Nukes We Need: Preserving the American Deterrent." *Foreign Affaires* 88, no. 6 (2009): 39-51.

[4] See, for example, Joshua Pollack. "Evaluating Conventional Prompt Global Strike." *Bulletin of the Atomic Scientists* no. January/February (2009): 13-20.

[5] Ronald Kerber and Robert Stein. "Report of the Defense Science Board Task Force on Time Critical Conventional Strike from Strategic Standoff." Washington DC: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, 2009. In this report, the scenario posits the regional power has "roughly ten mobile ICBMs moving among what appears to be a much larger number of Hardened and Deeply Buried Under Ground Facilities (HDB UGFs) and large civilian structures. An additional three HDB UGFs are used for storage of spare nuclear weapons and missile support facilities".

[6] "U.S. Conventional Prompt Global Strike: Issues for 2008 and Beyond." Washington DC: Committe on Conventional Prompt Global Strike Capability, Naval Studies Board, Division on Engineering and Physical Sciences, National Research Council of the National Academies, 2008.

conventional counterforce strategy certainly has its own problems as well, the most prominent of which is that the pursuit of conventional counterforce capability might change the existing mutually assured destruction relationship between major nuclear powers and that in turn might affect strategic stability between these countries. Before we can go deeper into the scenario of conventional counterforce strike and examine its specific impact on strategic stability, however, we need to answer a question first: is conventional counterforce capability achievable? Existing literature so far has not seriously studied the current and potential capabilities of conventional weapons as a means of conducting counterforce strikes against a regional nuclear power. The lack of study on this subject might lead to misunderstanding about important strategic issues. Russia, for example, has expressed serious concerns about a possible U.S. conventional counterforce capability;[7] and China, whose nuclear arsenal is much smaller than Russia's, would probably see it as a real and serious threat to its minimum nuclear deterrence. To what extent is such concern legitimate, and to what extent can China's nuclear modernization program be justified by the U.S. pursuant of advanced conventional prompt strike capability? To answer all these questions requires a realistic assessment about the potential counterforce capability of the U.S. conventional global strike weapon systems.

Moreover, conflicting views about conventional global strike weapons have already troubled the global movement for deep nuclear reductions. After the U.S. and Russia concluded the START Follow-On Treaty in April 2010, scholars and analysts have pointed out that further reductions beyond the START Follow-On level will not be achievable until China joins the two previous nuclear superpowers in a multilateral nuclear disarmament process.[8] China's participation in discussions about nuclear disarmament probably would not happen if its concern about U.S. conventional counterforce capability cannot be adequately addressed. Therefore, it is necessary to study the real potential of conventional global strike weapons and their impact on a regional nuclear power's– such as China's – nuclear retaliation capability.

Admittedly, this study is not the first attempt to assess the potential of conventional weapons to conduct counterforce strikes. Keir Lieber and Daryl Press's article "The Nukes We Need", for example, discusses the potential of using precision-guided bombs to eliminate Chinese intercontinental ballistic missiles (ICBMs).[9] This study, however, misunderstands the scenario under which conventional counterforce strikes may be conducted. As a result, their assessment fails to provide an adequate understanding about conventional counterforce capability.

In their study, Lieber and Press point out at the very beginning that counterforce capability is necessary for America because the U.S. needs to be able to prevent escalation and minimize damage during a conventional conflict with nuclear-armed adversaries. Such scenarios include, as the authors indicate, conflicts on the Korean Peninsula, over the Taiwan Strait, and around the Persian Gulf. The authors

[7] Eugene Miasnikov. "Long-Range Precision-Guided Conventional Weapons: Implications for Strategic Balance, Arms Control, and Non-Proliferation." International Commission on Nuclear Non-proliferation and Disarmament, 2009; Anatoli S. Diakov, Timur T. kadyshev, and Eugene V. Miasnikov. "Further Reduction of Nuclear Weapons." Moscow: Center for Arms Control, Energy and Environmental Studies at the Moscow Institute of Physics and Technology, 2010.

[8] Cristina Hansell and William C. Potter, eds. *Engaging China and Russia on Nuclear Disarmament*. Vol. 5, Occasional Paper. Monterey: Monterey Institute of International Studies, 2009.

[9] Keir A Lieber and Daryl G Press. "The Nukes We Need: Preserving the American Deterrent." *Foreign Affaires* 88, no. 6 (2009): 39-51.

particularly address the scenario of a Taiwan Strait conflict for which they believe that leaders in Beijing may choose to use or threaten to use nuclear weapons if they face imminent military defeat over the Strait. Therefore, for the U.S., the "least bad option in the face of explicit nuclear threats or after a limited nuclear strike may be a counterforce attack to prevent further nuclear use". The rationale behind their analysis might be reasonable,[10] but their model in the following sections is problematic and misses the point of their hypothetical scenario of damage limitation.

Lieber and Press's model is about a U.S. preemptive strike on twenty ICBMs in hardened silos which they claim is "the approximate size of China's current long-range, silo-based missile force". In a response article, James Actons rightly points out that Lieber and Press failed to address the fact that China's long-range nuclear force is increasingly dependent on land-mobile missiles rather than silo-based missiles.[11] Acton's argument certainly has merit, but he still does not address the key drawback in Lieber and Press's model, which is they mistakenly assume that the adversary's ICBMs are the primary target for damage limitation operations.

The strategy of damage limitation assumes that if a nuclear-armed adversary faces a catastrophic defeat in a conventional conflict it might choose to use nuclear weapons to reverse the course on the battlefield. The aim of damage limitation strategy, therefore, is to prevent this imminent threat of nuclear attack by preemptively striking and destroying those nuclear forces that the adversary is about to use; or, to prevent further nuclear use by destroying the adversary's remaining nuclear forces, if the adversary has already launched a nuclear attack. The primary target of a damage limitation operation, as a result, should be those nuclear weapons that the adversary will choose to use on the battleground to change the outcome of the war. In the Taiwan Strait scenario, if the U.S. and China fought a conventional war in the waters near Taiwan, and if China suffered such a disastrous defeat that it was believed having to resort to nuclear weapons to avoid a total loss, the mostly likely nuclear weapons that China might use are not its ICBMs, but theater nuclear weapons. Chinese ICBMs, including a handful of silo-based DF-5 missiles and newly introduced land-mobile DF-31A missiles, are generally believed to be reserved for retaliatory strikes against continental U.S. targets. In comparison, China's theater nuclear forces are primarily responsible for striking regional targets that fall short of continental U.S.[12] These theater nuclear weapons include medium range or intermediate range nuclear missiles (MRBM and IRBM, respectively), nuclear-capable bombers,[13] and possibly ballistic missile nuclear submarines.[14] These theater nuclear weapons will receive a higher priority as targets of a hypothetical U.S. preemptive strike during a regional U.S.-China conflict

[10] The authors obviously are skeptical about China's No First Use pledge. Although I do not agree with their judgment, this is not the main point of this paper and I will refrain from delving into that debate. For an in-depth analysis of China's No First Use policy, see, for example, Zhenqiang Pan. "China Insistence on No-First-Use of Nuclear Weapons " *China Security* 1, no. 1 (2005): 5-9.

[11] James Acton. "Managing Vulnerability." *Foreign Affaires* 89, no. 2 (2010): 146-48.

[12] To facilitate analysis, in this paper China's theater nuclear forces are defined as those that cannot reach continental U.S. and that are primarily used against regional targets. It is necessary to note that, Chinese official documents do not differentiate its nuclear weapons. There is no such catalogue called "theater nuclear weapons" in official Chinese documents.

[13] Chinese heavy bombers cannot reach continental U.S. and therefore belong to theater nuclear weapons under this paper's definition.

[14] Chinese Type 094 nuclear submarine(s), if deployed within the First Island Chain and in waters close to China, their missiles may not be able to reach continual U.S. and may only be capable of striking shorter-range regional targets.

over Taiwan. The Lieber and Press model which assumes that the U.S. would target Chinese ICBMs while leave more threatening Chinese theater nuclear weapons intact does not match with the objective of damage limitation. As a result, their calculations and conclusions are of serious problems.

The following sections of this paper, therefore, examine the likelihood that the current as well as future U.S. conventional weapons may neutralize Chinese theater nuclear forces in a preemptive attack. A summary of China's current theater nuclear weapons is provided in Table 1. In comparison, U.S. conventional precision-guided weapon systems are summarized in Table 2 and 3.

Table 1. Chinese nuclear forces, January 2010[15]

Type/Chinese designation (US designation)	**No. deployed**	**Year first deployed**	**Range (km)**	**Warhead loading**	**No. of warheads**
Land-based missiles	*134*				*134*
DF-3A (CSS-2)	12	1971	3100	1 × 3.3 Mt	12
DF-4 (CSS-3)	12	1980	5500	1 × 3.3 Mt	12
DF-21 (CSS-5)	60	1991	2100[16]	1 × 200–300 kt	60
DF-31 (CSS-10 Mod 1)[17]	~15	2006	>7200	1 × . .	15
SLBMs	(*36*)				(*36*)
JL-1 (CSS-N-3)	(12)	1986	>1770	1 × 200–300 kt	(12)
JL-2 (CSS-NX-14)[18]	(24)	(2010)	>7200	1 × . .	(24)
Aircraft	*>20*				(*40*)
H-6 (B-6)	20	1965	3100	1 × bomb	(20)

Table 2. Existing and Near-Future U.S. Conventional Precision Munitions Delivery Systems and Their Potential Payload Capacity [19]

[15] Adapted from: Shannon N. Kile, Vitaly Fedchenko, Bharath Gopalaswamy, and Hans M.Kristensen. *Chinese Nuclear Forces*, SIPRI Yearbook 2010: Armaments, Disarmament and International Security. Oxford: Oxford University Press: SIPRI, 2010. In the table, . . = not available or not applicable; ( ) = uncertain figure; SLBM = submarine-launched ballistic missile.

[16] The DF-21A (CSS-5 Mod 2) variant is believed to have a range of up to 2500 km. Source: Ibid.

[17] DF-31 missile is classified as a theater force because China defines DF-31 as a long-range ballistic missile, not an ICBM. Its range seems not long enough to reach continental U.S. It is believed not primarily targeted against the U.S., but is likely to be used for regional targeting. Also, DF-31 is generally regarded as a replacement for older DF-4 missile which only has a regional role.

[18] It is a little difficult to categorize JL-2 SLBM. On the one hand, some sources believe this missile is capable of reaching continental U.S. even when launched from waters close to China. On the other hand, the missile can certainly be also used to target nearer targets such as Guam or be used in a hypothetical regional conflict over Taiwan Strait. Ultimately, it depends on whether the U.S. would perceive JL-2 missile as a threat in a theater battlefield around Taiwan.

[19] Adapted from Yevgeny Miasnikov. "The Counterforce Potential of Precision-Guided Munitions." In *Nuclear Proliferation: New Technologies, Weapons, Treaties*, edited by Alexei Arbatov and Vladimir Dvorkin. Moscow: Carnegie Moscow Center, 2009.

Delivery Systems	**Potential Number of Delivery Systems (by 2015)**	**Maximum number of Precision Munitions Deployed**
B-2	20	320
Los Angeles-class submarine (SSN-688)	7	56
Providence-class submarine (SSN-719)	31	620
Virginia-class submarine (SSN-774)	10-12	200-240
Ohio-class ballistic missile submarine	4	616
B-52H	56	1120
Total	*128-130*	*2932-2956*

Table 3. Main Precision-Guided Weapons in the U.S. Inventory[20]

Type	**Weight (kg)**	**Penetrating Munitions**	**Range (km)**	**Guidance Systems**	**CEP (m)**	**Delivery Systems**
			Guided air bombs			
MOP (Massive Ordnance Penetrator)	13600	9000 kg Warhead		INS,[21] GPS		B-52, B-2
GBU-15	1125	BLU-109	8 - 25	Teleguidance system, INS, GPS	~ 3	F-15E
GBU-31 (JDAM)	1070	BLU-109	25	INS, GPS	< 6	B-1, B-2, B-52, F-14, F-15E, F-16, F-22, F/A-18
GBU-32 (JDAM)	450	BLU-110	25	INS, GPS	< 6	
GBU-38 (JDAM)	225	BLU-111	25	INS, GPS	< 6	
GBU-28	2115	BLU-122, BLU-113	5 - 40	Laser, GPS	< 10	B-2, F-15E
GBU-27	1070	BLU-116, BLU-109	5 - 40	Laser, GPS	< 10	F-15E, F-16

[20] Source: Yevgeny Miasnikov. "The Counterforce Potential of Precision-Guided Munitions." In *Nuclear Proliferation: New Technologies, Weapons, Treaties*, edited by Alexei Arbatov and Vladimir Dvorkin. Moscow: Carnegie Moscow Center, 2009.
[21] INS stands for Inertial Navigation System.

GBU-24	1070	BLU-116, BLU-109	5 - 40	Laser, GPS	< 10	F/A-18, F-14
GBU-10 (EGBU-10)	1070	BLU-109	3 - 25	Laser, GPS	< 10	B-52, F-14, F-15E, F-16, F/A-18
AGM-154B (JSOW)	450	BLU-108	< 130	INS, GPS		
			Guided missiles			
AGM-130	1300	BLU-109	> 65	INS, GPS, Teleguided	< 3	F-15E
SLAM-ER	230	WDU-40?B	< 280	INS, GPS, Teleguided	~ 2.5	
JASSM	450		> 320	INS, GPS		
JASSM-ER	450		> 800	INS, GPS		
			Long-rang cruise missiles			
TLAM	340	WDU-43/B	1600	INS, GPS, Automatic self-guided warhead	~ 5	
Tact Tomahawk	450	WDU-43/B	1600	INS, GPS, Automatic self-guided warhead	~ 5	
CALCM	1430	AUP	> 1000	INS, GPS	~ 2.5	

Survivability of Chinese Theater Nuclear Weapons under U.S. Conventional Precision-Guided Strikes

DF-3A

DF-3A is the oldest Chinese theater nuclear missile and is undergoing retirement. It is road-mobile and uses liquid fuel.[22] It has a range of 3,100 km and can be launched from either a permanent launch pad or a portable launch stand.[23] In one suspected but unidentified photograph, a DF-3A launch pad and storage garage can be observed in a relatively clear and easy-to-locate area. The suspected missile garage is a building that is an above-ground building next to a launch pad and that can accommodate up to two DF-3A missiles.[24] If this is a real DF-3A missile storage and launch facility, it seems very vulnerable against a potential conventional precision-guided attack. The storage garage does not seem to be heavily reinforced, and most of the precision-guided weapons in Table 3 should be able to penetrate and destroy the building. If the missile is on the launch pad, it would be even more vulnerable than in the garage,

[22] It is mobile in the sense that it is not silo-based, and can be towed to pre-designated launch pad to launch.
[23] "The Military Power of the People's Republic of China, 2000." 17. Washington DC: U.S. Department of Defense, Office of the Secretary of Defense, 2000.
[24] Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.

because the missile body is usually not protected by armors or external covers. Therefore, if DF-3A missiles are deployed in above-ground facilities that are not particularly hardened, they seem very unlikely to survive conventional precision attacks as long as the facilities are identified by the adversary.

However, it is more likely that most DF-3A missiles are deployed in much more secure facilities. As Hans M. Kristensen et al. point out, China has a large number of underground facilities, and "placing important assets underground in some form seems to be a common element of China's military planning".[25] Since the "Third Line Project" between 1964 and the mid- to late-1970s, China built a large number of underground facilities in remote and mostly mountainous regions, in order to protect its most important military and industrial assets. In the late 1970s, China made another decision to construct the so called "Great Wall Project" which is aimed at building highly secure underground facilities for Chinese nuclear forces.[26] Kristensen et al. points out that, "a rule of thumb seems to be that if the base is near a mountain, then there likely will be some form of underground facility". Kristensen's above conclusion is made about China's bomber and fighter bases, but broadly speaking, it seems true that China pays particularly high emphasis on using underground facilities to protect its nuclear forces in general. The "Great Wall Project" is a good illustration of this strategy.

The so called "Great Wall Project" is reported as an underground web of tunnels built in mountainous areas in China for the purpose of protecting missiles of the Second Artillery. Beginning from the late 1970s and early 1980s the construction of the project (or some part of the project) is reportedly completed in the 1990s. In 1995, a press report from "Jiefangjun Bao" (People's Liberation Army Daily) noted that after more than ten years' construction by tens of thousands of Second Artillery engineer troops, a major national defense project had successfully finished. This is believed the first time that the "Great Wall Project" was openly reported.[27] More than ten years later in 2008, an official TV program "Junshi Jishi" (Military Documentary) broadcasted a documentary which revealed an engineering unit of the Second Artillery successfully built new underground missile bastions in Kunlun Mountains during 2006 and 2007. This was widely interpreted by foreign analysts as a message that the "Great Wall Project" has been extended to the Qinghai-Tibet Plateau, and that strategic missiles have been deployed to that region.[28] Therefore, it is likely that the "Great Wall Project" is not a specific project at a certain location, but generally refers to a series of relatively newly built underground facilities for the purpose of concealing and protecting missiles and other strategic assets of the Second Artillery.[29] It is believed, for example,

[25] Ibid.

[26] "Binghua Huang: A Missile Designer Who Fell Down at the Missile Bastion That He Designed." *PLA Daily*, August 16 2009.

[27] Zijuan Huang. "Uncover China's "Underground Great Wall": Strategic Missile Arsenal Can Withstand Nuclear Attack." People.com, http://military.people.com.cn/GB/8221/72028/76059/78907/10568269.html.

[28] "Df 31 Missiles Deployed on Qinghai-Tibet Plateau." China Center for International and Strategic Studies, http://news.chinaiiss.org/content/2008-3-26/2610156.shtml; Zijuan Huang. "Uncover China's "Underground Great Wall": Strategic Missile Arsenal Can Withstand Nuclear Attack." People.com, http://military.people.com.cn/GB/8221/72028/76059/78907/10568269.html.

[29] The term "relatively newly built" refers to the fact that these underground facilities were designed and built during or after the 1980s.

somewhere in Northern China, more than 5,000 kilometers of underground tunnels were built in the mountains.[30]

As for DF-3A missiles, it is quite likely that a significant number of them are deployed in these underground "Great Walls". Regarding their geographical distribution, DF-3As are suspected to be deployed in at least four missile bases across six provinces.[31] Some of these missiles such as those deployed in Qinghai and Liaoning provinces are mostly likely used to target India and Russia.[32] Since the purpose of this paper is to study a hypothetical U.S. preemptive attack against China's nuclear forces, this analysis will only focus on those nuclear forces whose combat radius are long enough to cover Taiwan Strait from their location of deployment. In the case of DF-3A missiles, at least three provinces that are suspected to have DF-3A missiles are close enough to Taiwan Strait: Shandong, Anhui, and Yunnan.[33] All the three provinces, coincidentally or not, have mountains that are suitable for building underground facilities. Anhui Province, for example, is reported to have a missile base located at Huangshan which is a huge and extensive mountain made of granite and which stretches to a total area of 1,200 square kilometers.[34]

Based on the officially released images of the "Great Wall Project", the underground tunnels have sufficient room for large missile vehicles to move freely within the tunnels. Both land-mobile missile vehicles and locomotives can travel in these tunnels, as is seen in Figure 1. In some sections of the tunnel network, the tunnels are large enough to allow two locomotives or one locomotive and one land-mobile missile vehicle to travel side by side. In fact, different tunnels are reported having been built to accommodate different missiles. Physical and functional characteristics such as the size of different missile vehicles were taken into account when designing the specific shape, size, and internal structure of the tunnels.[35] In order to protect missiles from preemptive strikes, these underground facilities are reportedly built inside mountain bodies that are made of hard rock such as granite. The tunnels are usually located as deep as hundreds of meters under the surface of ground.[36] The following analysis, therefore,

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[30] Zijuan Huang. "Uncover China's "Underground Great Wall": Strategic Missile Arsenal Can Withstand Nuclear Attack." People.com, http://military.people.com.cn/GB/8221/72028/76059/78907/10568269.html.

[31] Bates Gill, James Mulvenon, and Mark Stokes. "The Chinese Second Artillery Corps: Transition to Credible Deterrence." In *The People's Liberation Army as Organization*, edited by James C. Mulvenon and Andrew N.D. Yang, 541-42. Santa Monica: RAND, 2002; Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." 61. Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.

[32] Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.

[33] Bates Gill, James Mulvenon, and Mark Stokes. "The Chinese Second Artillery Corps: Transition to Credible Deterrence." In *The People's Liberation Army as Organization*, edited by James C. Mulvenon and Andrew N.D. Yang, 541-42. Santa Monica: RAND, 2002; Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." 61. Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.

[34] Bates Gill, James Mulvenon, and Mark Stokes. "The Chinese Second Artillery Corps: Transition to Credible Deterrence." In *The People's Liberation Army as Organization*, edited by James C. Mulvenon and Andrew N.D. Yang, 541-42. Santa Monica: RAND, 2002.

[35] Jingjing Wang. ""Underground Great Wall" Guarantees the Safety and Security of China's Nuclear Forces." *Communists* no. 2 (2010): 50.

[36] Ibid.

will assess the robustness of these underground facilities against a hypothetical conventional precision-guided strike.

Figure 1. TV Snap Shot of the "Great Wall Project"[37]

An earth-penetrating weapon, no matter whether it is nuclear or conventional, works in the same way: the warhead hits the surface of ground at a very high speed, penetrates into the ground, and explodes at the deepest point it can reach. The depth of the penetration to a large extent is determined by the speed of the warhead. However, although in theory we can increase the velocity of the warhead as much as we want by either dropping it from a higher altitude or using an external propellant system, in practice there are limits on the velocity at which a warhead can hit the ground. If a warhead hits the ground at a velocity higher than what its material can withstand, it cannot survive the severe ground impact stresses and will destroy itself before it can explode as designed. At present, the maximum impact speed for the hardest steel is about 1km/s. Under such limitation, the maximum penetration depth into reinforced concrete is roughly about four times the length of the penetrator.[38] For typical conventional earth penetrators in the current U.S. arsenal, such as BLU-109 and BLU-116, their length is about 2.4 meters (8 feet),[39] which means their maximum penetration capability is about 9.6 meters into reinforced concrete. Accordingly, it

[37] "PLA 'Undergroud Great Wall' Can Withstand Nuclear Attack." http://cblog.chinadaily.com.cn/port/yixiuge/190637952720.shtml.

[38] Robert W Nelson. "Low-Yield Earth-Penetrating Nuclear Weapons." *Science and Global Security* no. 10 (2002): 1-20.

[39] Michael A Levi. "Fire in the Hole: Nuclear and Non-Nuclear Options for Counterproliferation." In *Cargenie Endowment Working papers*. Washington, DC: Cargenie Endowment for International Peace, 2002.

is reasonable to assume that 10 meters is approximately the maximum depth that a typical conventional precision-guided weapon can penetrate into reinforced concrete. After the warhead penetrates into the ground and explodes, the range of destruction is largely proportional to the cube root of the force of the explosion.[40]

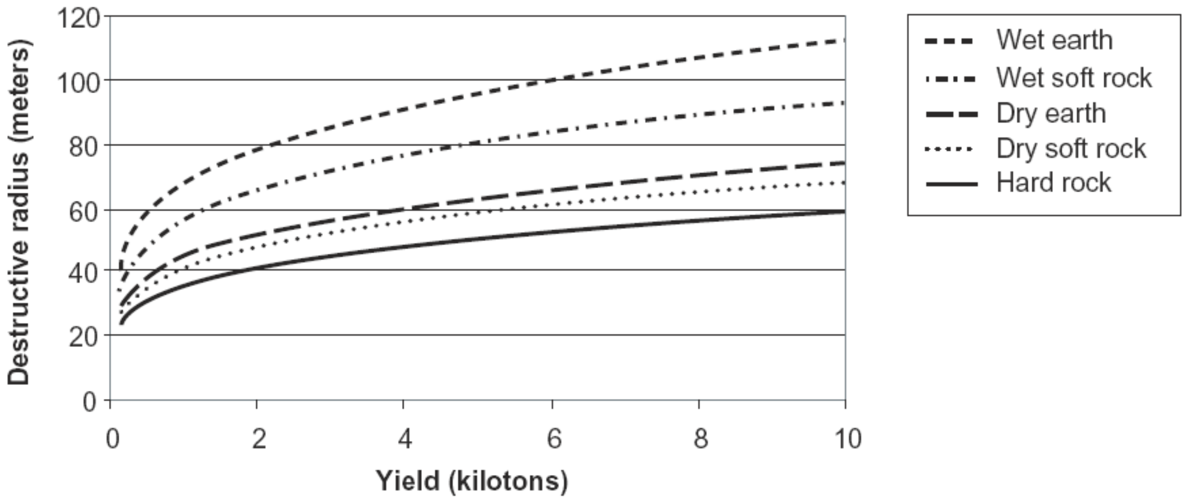

Figure 2. Range of Destruction by Weapons Detonated under 5 Meters of Granite[41]

Figure 2 shows the relationship between weapon yield and the range of destruction.[42] The detonation depth in this figure is set as 5 meters underground, different from the 10 meter maximum penetration depth that a conventional weapon can get. Such difference would not affect the analysis in a meaningful way because when detonation depth exceeds 1.5 meters or so, a further increase in detonation depth does not significantly improve the destructive capability of an explosion.[43] According to Figure 2, yields of approximately 10 kT (kiloton) are required in order to destroy facilities buried in granite 60 meters below the detonation point. As is mentioned above, the range of destruction is proportional to the yield of the warhead. Therefore, we can calculate the approximate depth of destruction by conventional precision-guided weapons, and the results are shown in Table 4.

Table 4. Approximate Destruction Ranges for Conventional Precision-Guided Weapons in Granite

[40] Ivan Oelrich, Blake Purnell, and Scott Drewes. "Earth Penetrating Nuclear Warheads against Deep Targets: Concepts, Countermeasures, and Consequences." Washington DC: Federation of American Scientists, 2005.
[41] Source: Michael A Levi. "Fire in the Hole: Nuclear and Non-Nuclear Options for Counterproliferation." In *Cargenie Endowment Working papers*. Washington, DC: Cargenie Endowment for International Peace, 2002: 14. This figure assumes a detonation in granite. The 10 meter penetration depth that we mentioned above is a penetration into reinforced concrete. However, because the density and strength of granite and reinforced concrete is almost the same, a weapon that can penetrate 10 meters into reinforced concrete can penetrate almost the same depth into granite. See, for example: Robert W Nelson. "Low-Yield Earth-Penetrating Nuclear Weapons." *Science and Global Security* no. 10 (2002): 1-20.
[42] Michael A Levi. "Fire in the Hole: Nuclear and Non-Nuclear Options for Counterproliferation." In *Cargenie Endowment Working papers*. Washington, DC: Cargenie Endowment for International Peace, 2002.
[43] See Figure 1 in Robert W Nelson. "Low-Yield Earth-Penetrating Nuclear Weapons." *Science and Global Security* no. 10 (2002): 1-20.

Weapon	Explosive Weight (kg)	Yield (kg, TNT equivalent)[44]	Range of Destruction (m, distance from detonation point)
BLU-109	243	365	14.7
BLU-116	243 or less[45]	365 or less	14.7 or less
BLU-113	N.A.	304[46]	13.8
SLAM-ER (AGM-84H)	230	345	14.4
JASSM (AGM-158A)	450	675	18
TLAM	450 or less[47]	675 or less	18 or less
CALCM (AGM-86C/D)	N.A.	1,300[48]	22.4
MOP (Massive Ordnance Penetrator)	3,500	5,250	35.7

As shown in Table 4, a typical conventional precision-guided weapon in the current U.S. inventory has a destruction range of no more than 25 meters in granite. Even the most powerful Massive Ordnance Penetrator (MOP) whose development has not yet completed has a destruction range of about 35 meters. It seems highly unlikely, even under extreme circumstances when a number of these weapons can be delivered at pinpoint precision and strike the same point on the ground repeatedly, there is any chance for conventional weapons to destroy targets that are buried hundreds of meters underground in granite, which is the reported depth of typical "Great Wall Project" tunnels.[49]

[44] The advanced explosives that BLU-109 carries are reported to have about 18% or even up to 50% increased explosive power relative to TNT. See, Keir A Lieber and Daryl G Press. "The Nukes We Need: Preserving the American Deterrent (Technical Appendix)." http://www.dartmouth.edu/~dpress/docs/Press_FA-2009-Appendix-12-post.pdf. In order not to underestimate the capacity of weapons, this study assumes that advanced explosives are used for all conventional precision-guided weapons, and these explosives are 50% more powerful than TNT.
[45] "Blu-116 Advanced Unitary Penetrator [Aup]." http://www.globalsecurity.org/military/systems/munitions/blu-116.htm.
[46] "Blu-113/B, a/B Penetrator Warhead." http://www.globalsecurity.org/military/systems/munitions/blu-113.htm.
[47] "Tomahawk Land Attack Missile." Raytheon Company, http://www.raytheon.com/capabilities/products/stellent/groups/public/documents/content/cms01_055764.pdf.
[48] Yevgeny Miasnikov. "The Counterforce Potential of Precision-Guided Munitions." In *Nuclear Proliferation: New Technologies, Weapons, Treaties*, edited by Alexei Arbatov and Vladimir Dvorkin. Moscow: Carnegie Moscow Center, 2009.
[49] Obviously, current technology does not offer such a pinpoint accuracy even for precision-guided weapons.

In fact, according to Figure 2, as destruction range increases, the required yield increases at a much more rapid rate. A yield of at least 1,000kT is required to have a destruction range of about 180 meters.[50] This seems to support both the expert estimate that "a single large yield nuclear warhead is unable to destroy the facilities by a direct hit" and the statement in a China Defense News report that "the facilities can only be destroyed under a repeated strike at the same point by a number of nuclear penetrators of hundreds of kilotons yield".[51]

In addition, even if the Chinese tunnels are not built in mountains made of granite and are simply built under wet earth, they do not seem vulnerable to conventional precision-guided strikes. Figure 2 also shows the destruction range of weapons detonated in softer materials than rock. It is clear that even in wet earth, conventional weapons with yields at the level of .1- 1.0 kiloton can only reach a depth no more than 70 meters underground. The maximum destruction range for the most powerful MOP weapon with a yield of 3.5 kiloton seems no more than 90 meters. In other words, even if the Chinese tunnels are covered simply by hundreds of meters of wet earth, not by granite as is reported, they seem pretty safe from repeated strikes by conventional precision-guided weapons.

Moreover, as tunnels go deep into mountain bodies, there is no way to detect and tell the exact locations of the tunnels. Especially for large and complicated tunnel webs of the "Great Wall Project" style which has a reported length of more than 5,000 kilometers, the entire underground tunnels can stretch to a very extensive area, making it essentially impossible to employ a barrage strategy of destroying the entire area with conventional precision-guided weapons (or even nuclear weapons, in this case) in the current U.S. inventory.

DF-4

DF-4 is a relatively old nuclear ballistic missile, having a range of about 5,500 km. It shares many physical features of DF-3A. It uses liquid fuel and is land-mobile – can be towed by other vehicles to pre-designated launch pad. Although there seemed to be a silo version of DF-4, the only operational mode today is the land-mobile rollout-to-launch version.[52]

Some previous Google images showed a number of above-ground DF-4 missile garages. The garages were located next to launch pads and seemed very vulnerable to a preemptive conventional strike.[53] This, however, may not be an adequate indication of how DF-4 missiles are deployed today. First of all, those above-ground missile garages that were identified in previous images might not be permanent facilities. If we check back at those locations we would see that those garages no longer exist today. Secondly, the so called "Great Wall Project" may have been extended to regions where DF-4 missiles are deployed. The 2008 official release about the engineering units of the Second Artillery specifically mentioned that new underground missile bastions had been recently built on the Qinghai-Tibet Plateau where some foreign

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[50] See Figure 3 in Robert W Nelson. "Low-Yield Earth-Penetrating Nuclear Weapons." *Science and Global Security* no. 10 (2002): 1-20.
[51] Jingjing Wang. "'Underground Great Wall' Guarantees the Safety and Security of China's Nuclear Forces." *Communists* no. 2 (2010): 50.
[52] Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.
[53] Ibid.

analysts believe DF-4 missiles are deployed.[54] Besides Qinghai Province, Henan Province is also suspected having DF-4 missile bases.[55] Henan Province is where Taihang Mountain and Qinling Mountain intersect, and should have plenty of places for building underground facilities.[56] It is reasonable to assume that, like DF-3A missiles, a certain proportion of existing DF-4 stockpiles are deployed in "Great Wall Project" style underground facilities. According to analysis in the previous section, it is highly unlikely that conventional precision-guided weapons are able to neutralize these DF-4 missiles.

DF-21

DF-21 is a relatively new solid-fueled medium-range ballistic missile which is believed will replace China's old DF-3A missiles. DF-21 is more accurate than its predecessors and has a higher degree of mobility – it is attached to a transporter-erector-launcher (TEL).The missile is protected by a launch canister and it needs fewer additional logistical vehicles than DF-3A and DF-4. As a result, DF-21 seems less vulnerable and more adaptable to various battlefield environments. For the same reasons, the U.S. might perceive DF-21 as a more serious security threat, and it is likely that DF-21 missiles would receive high priority on the target list in a hypothetical U.S. preemptive strike against China's theater nuclear forces.

China is suspected to have about 60 nuclear-armed DF-21 missiles. It is reasonable to assume that in peacetime China may keep a significant number of DF-21 missiles in safe and secure facilities and send a number of missiles out for patrols. Based upon analysis in previous sections, DF-21 missiles that are kept in "Great Wall Project" style underground facilities are obviously safe from any conventional precision-guided strike. The following part, as a result, will address DF-21 missile's survivability against a conventional attack when the missile is on a patrol mission.

When a conventional warhead explodes somewhere near a missile vehicle, the vehicle might be affected by the overpressure produced by the explosion. The peak value of the overpressure on the vehicle is determined by both its distance from the detonation point and the yield of the warhead. As the distance between the vehicle and the detonation point increases, the peak overpressure decreases. If the peak overpressure that the vehicle receives exceeds the maximum overpressure that vehicle can withstand, the vehicle will be destroyed. Similarly, the greater the warhead's yield is, the higher the peak overpressure will be. The peak overpressure at a given distance is usually calculated through a relation known as the *scale law*:[57] It relates the distances at which the same overpressure will be felt for different warhead yields:

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[54] Bates Gill, James Mulvenon, and Mark Stokes. "The Chinese Second Artillery Corps: Transition to Credible Deterrence." In *The People's Liberation Army as Organization*, edited by James C. Mulvenon and Andrew N.D. Yang, 541-42. Santa Monica: RAND, 2002; Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.
[55] Ibid.
[56] Both Qinling Mountain and Taihang Mountain are made of rock. Qinling Mountain, in particular, is made of granite, and seems ideal for building underground facilities. For example, the suspected Chinese nuclear warheads central storage facility is located in Qinling Mountain (although this facility is close to but not exactly in Henan Province). See, Mark A Stokes. "China's Nuclear Warhead Storage and Handling System." Arlington VA: Project 2049 Institute, 2010.
[57] "Introduction to Naval Weapons Engineering." Federation of American Scientists, http://www.fas.org/man/dod-101/navy/docs/es310/warheads/Warheads.htm.

$$d_W = d_o\, W^{1/3} \qquad (1)$$

Where d_o is the distance from which a given peak overpressure is felt by a detonation of 1 kg of TNT; d_W is the distance from which the same peak overpressure will be felt by a detonation of a warhead whose yield is W. Thanks to a vast collection of experimental data from the explosion of 1 kg of TNT, we can therefore calculate d_W of a warhead of any yield. The empirical relationship between distance and peak overpressure of the explosion of 1 kg of TNT is depicted in Figure 3.

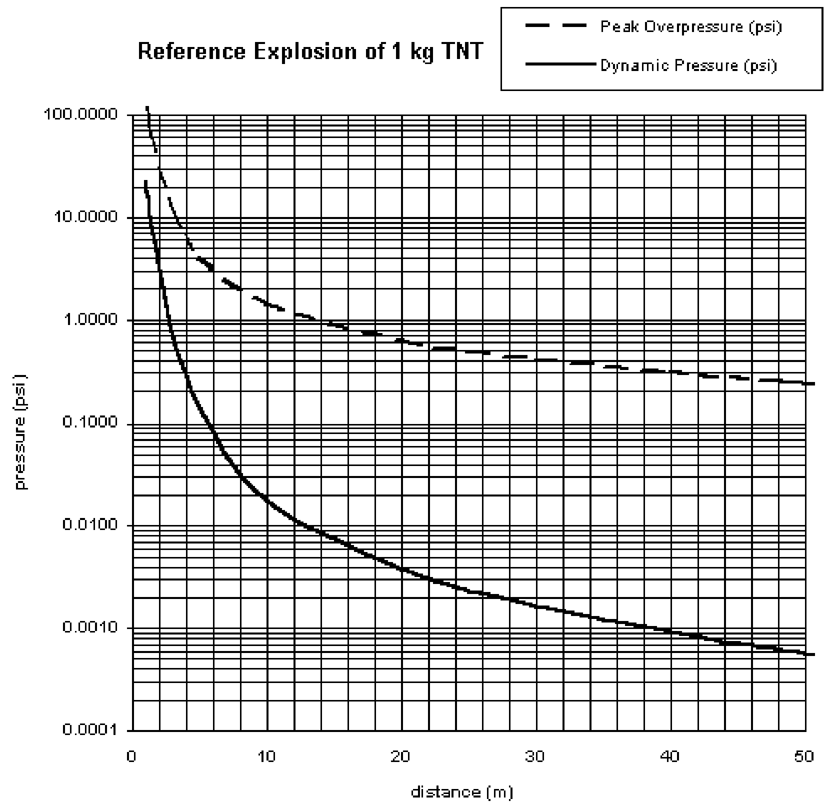

Figure 3. Peak Overpressure of Explosion of 1kg of TNT[58]

Before we can calculate the lethal radii of conventional precision-guided weapons, we need to know the maximum level of overpressure that a vehicle like DF-21 TEL can withstand. Here I will refer to a previous study on the survivability of U.S. ballistic missiles and assume that the robustness of a Chinese ballistic missile TEL is similar to the American one that is studied in the research. That means the if a maximum overpressure of about 210 kPa (or, 30 psi) is imposed upon heavy transport vehicles like DF-21 TELs they will be "severely damaged".[59]

By referring to Figure 3, we know that d_o is about 2 meters for a 1 kg TNT detonation. Putting that into Equation 1, we can get the lethal radius (LR) of any conventional warhead as long as its yield is known.

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[58] Source: "Introduction to Naval Weapons Engineering." Federation of American Scientists, http://www.fas.org/man/dod-101/navy/docs/es310/warheads/Warheads.htm.

[59] Jixiang Wang, and Lan Chang. "Assessment of American Ballistic Missile above-Ground Survivability." *Missiles and Space Vehicles Technology* no. 5 (1999).

Under such circumstances, the probability that a given warhead will be delivered within the lethal radius can be calculated by using the following equation:[60]

$$SSPK = 1 - 0.5^{(LR/CEP)^2} \quad (2)$$

Where SSPK is the so called "single shot probability of kill"; CEP is a measure of a weapon's accuracy and it stands for "circular error probable". If multiply weapons are used to strike the same target, the overall chance of destroying the target is then determined by:

$$P(n) = 1 - (1 - SSPK)^n \quad (3)$$

Where P(n) is the overall chance of destroying the target, and n is the number of weapons that are used in the strike.[61]

If a DF-21 missile vehicle is moving, the conventional precision-guided weapons need to use Global Positioning System (GPS) to receive real-time update about the location of the vehicle before it hits the ground. If GPS signal is not jammed by the Chinese and if the weapons' design accuracy can be achieved, the ultimate chance of destroying the vehicle is calculated and shown in Table 5.

Table 5. Probability of Destruction by Conventional Precision-Guided Weapons against a DF-21 Missile Vehicle

Weapon	**Yield (kg, TNT equivalent)**[62]	**Guidance system**	**CEP (m)**	**LR (m)**	**SSPK**	**P(2)**	**P(3)**
BLU-109	365	INS, GPS	< 6	14.29314	0.980	0.999	0.999
BLU-116	365 or less	Laser, GPS	< 10	14.29314	0.757	0.941	0.986
BLU-113	304[63]	Laser, GPS	< 10	13.4479	0.715	0.918	0.977
SLAM-ER (AGM-84H)	345	INS, GPS, Teleguided	~ 2.5	14.02716	1.000	1.000	1.000
JASSM (AGM-158A)	675	INS, GPS	2.4[64]	17.54411	1.000	1.000	1.000

[60] Equations (2) and (3) are from: Keir A Lieber, and Daryl G Press. "The Nukes We Need: Preserving the American Deterrent (Technical Appendix)." http://www.dartmouth.edu/~dpress/docs/Press_FA-2009-Appendix-12-post.pdf.
[61] Here I assume that U.S. conventional weapons are 100% reliable. In other words, I do not take into consideration the probability that the weapon might not function properly. Because, first of all, this probability of malfunction is generally very low; and secondly, there is no open source that accurately reveals the malfunction probability.
[62] The advanced explosives that BLU-109 carries are reported to have about 18% or even up to 50% increased explosive power relative to TNT. See, Keir A Lieber and Daryl G Press. "The Nukes We Need: Preserving the American Deterrent (Technical Appendix)." http://www.dartmouth.edu/~dpress/docs/Press_FA-2009-Appendix-12-post.pdf. In order not to underestimate the capacity of weapons, this study assumes that advanced explosives are used for all conventional precision-guided weapons, and these explosives are 50% more powerful than TNT.
[63] "Blu-113/B, a/B Penetrator Warhead." http://www.globalsecurity.org/military/systems/munitions/blu-113.htm.
[64] "Lockheed Martin Agm-158 Jassm." http://www.designation-systems.net/dusrm/m-158.html.

TLAM	675 or less	INS, GPS, Automatic self-guided warhead	~ 5	17.54411	0.999	0.999	1.000
CALCM (AGM-86C/D)	1,300[65]	INS, GPS	~ 2.5	21.82786	1.000	1.000	1.000
MOP (Massive Ordnance Penetrator)	5,250	INS, GPS	< 5[66]	34.76027	1.000	1.000	1.000

Results in Table 5 indicate that for most of the conventional precision-guided weapons in current U.S. inventory, they have a fairly good chance (more than 70%) of destroy a DF-21 missile vehicle by a single shot. If the U.S. uses up to three weapons to target one Chinese missile vehicle, the probability of causing "severe damage" would be almost 100%.

It is important to note that the above results are based on the assumption that GPS guidance device functions properly so that the warhead can receive real-time update about the exact location of the target and GPS signal is not blocked or jammed by the Chinese side. In practice, however, such assumptions may not hold under real circumstances. It is unlikely that Chinese would not make efforts to block or jam GPS signal in areas where their nuclear missile vehicles patrol, especially at a time of crisis when they understand that their adversary might contemplate a preemptive strike. In order to take this into account, the following analysis will assess the survivability of DF-21 missile vehicles when GPS signal is not available for U.S. precision-guided munitions.

For GBU-32/BLU-109, if GPS signal is effectively jammed and the weapon can only use its inertial guidance system, its accuracy decreases significantly from about 5 meter to more than 30 meter.[67] Accordingly, this study assumes that without GPS guidance most precision-guided weapons' CEP will increase as much as five-fold, if not more. Under such conditions, their destruction probability is shown in Table 6.

Table 6. Probability of Destruction by Conventional Precision-Guided Weapons (without GPS Guidance) against a DF-21 Missile Vehicle

Weapon	**Guidance system**	**CEP (m)**	**LR (m)**	**SSPK**	**P(2)**	**P(3)**	**P(4)**	**P(5)**	**P(6)**
BLU-109	INS	~ 30	14.29314	0.146	0.270	0.376	0.467	0.545	0.611
BLU-116	Laser	~ 50	14.29314	0.055	0.107	0.156	0.203	0.247	0.288
BLU-113	Laser	~ 50	13.4479	0.049	0.095	0.140	0.182	0.222	0.260
SLAM-ER (AGM-	INS, Teleguided	~ 12.5	14.02716	0.582	0.825	0.927	0.970	0.987	0.995

65 Yevgeny Miasnikov. "The Counterforce Potential of Precision-Guided Munitions." In *Nuclear Proliferation: New Technologies, Weapons, Treaties*, edited by Alexei Arbatov and Vladimir Dvorkin. Moscow: Carnegie Moscow Center, 2009.

66 "Gbu-57 Massive Ordnance Penetrator (Mop)." http://airpower.callihan.cc/post/10-gbu57.aspx.

67 Keir A Lieber, and Daryl G Press. "The Nukes We Need: Preserving the American Deterrent (Technical Appendix)." http://www.dartmouth.edu/~dpress/docs/Press_FA-2009-Appendix-12-post.pdf.

84H)									
JASSM (AGM-158A)	INS	~ 12	17.54411	0.773	0.948	0.988	0.997	0.999	1.000
TLAM	INS, Automatic self-guided warhead	~ 25	17.54411	0.289	0.495	0.641	0.745	0.819	0.871
CALCM (AGM-86C/D)	INS	~ 12.5	21.82786	0.879	0.985	0.998	1.000	1.000	1.000
MOP (Massive Ordnance Penetrator)	INS	~ 25	34.76027	0.738	0.931	0.982	0.995	0.999	1.000

Results in Table 6 show that if GPS signal is effectively jammed, single-shot destruction probability will decrease significantly. More weapons will be required to achieve a relatively high overall destruction probability. However, for some precision-guided munitions, even as many as six weapons do not seem enough to guarantee a destruction of the target.

Moreover, if the target is moving and the precision-guided weapon cannot receive GPS guidance during its final phase of flight it cannot detect where the target has moved during the time period when it is blinded by jamming. If we assume that the last thirty seconds of the flight is blinded and the target is moving at a normal velocity of 30 mph, the missile vehicle can move as far as 400 meters during the half minute. Under this scenario, the U.S. might need to consider using the barrage strategy to strike the entire area which has a radius of 400 meters. The problem is, when GPS signal is jammed, the accuracy of most conventional precision-guided weapons drops so much that their lethal radius (LR) becomes smaller than CEP, which makes them essentially impossible to effectively cover the entire area, even if a large number of weapons are used. Therefore, if GPS signal is jammed, the overall destruction probability falls significantly, and more importantly, the weapon will be no longer capable of detecting and tracking the movement of the target which further undermines the destruction probability substantially. Reliable GPS signal seems critical for conventional precision-guided weapons to have a chance to hold China's DF-21 missiles at risk.

DF-31

DF-31 is China's first solid-fueled road mobile long-range ballistic missile. This section here will not conduct a specific analysis on DF-31's survivability against U.S. conventional strikes, because the analysis in the previous section about DF-21 well applies to DF-31. Both DF-21 and DF-31 missiles are loaded on TELs and they seem to share many operational features. However, the larger size of DF-31 may make it less survivable than DF-21, for at least two reasons.

Firstly, it is uncertain whether China's underground tunnels are spacious enough to accommodate DF-31 TELs. According to open literature, the size of DF-31 TEL vehicle is about 2.5 meters wide, 18 meters long, and 3.1 meters high.[68] As Figure 1 shows, the "Great Wall Project" tunnels may be wide and high enough for DF-31 TEL vehicle to drive in, but it could be difficult for the vehicle to make turns and move

[68] Bin Li. "Tracking Chinese Strategic Mobile Missiles." *Science and Global Security* 15, (2007): 1-30.

around in the tunnels. Nonetheless, although there might be some problems to accommodate DF-31 in most tunnels, if the Chinese are determined to do so, they can certainly build particularly designed and more spacious tunnels for DF-31, and there should be no significant technical problems for doing that. If that is the case, DF-31 vehicles that are protected by underground tunnels will be highly survivable against U.S. conventional strikes.

If some of DF-31missiles are sent on portals, they may be susceptible to conventional precision-guided strikes if GPS signal is not jammed, similar to the case for DF-21. The fact that DF-31 vehicle is notably larger and more cumbersome than DF-21means that they might be more easily located and tracked by U.S. surveillance and reconnaissance systems such as space radars. Some study shows, however, if the Chinese military engages in relatively simple countermeasures, the U.S. is not likely to be capable of persistently tracking DF-31's.[69]

Nuclear Ballistic Missile Submarines

Compared to land-based nuclear forces, China's nuclear ballistic missile submarines pose a lesser threat to a forward-deployed U.S. military force. China's single Xia-class nuclear submarine (Type 092) is relatively old and no longer considered fully operational.[70] The operational status of the more advanced Jin-class submarines (Type 094) and the JL-2 submarine-launched ballistic missiles has not been confirmed yet, though it is believed that China now has about two Jin-class submarines.[71] More importantly, it is uncertain whether the Jin-class is primarily targeted at continental U.S. or it is primarily tasked with a regional role in the Asia-Pacific area. After all, it is ultimately determined by the U.S. whether they perceive China's nuclear submarines as a security concern during a regional conflict over Taiwan. It is possible that the U.S. might want to target these submarines if they believe these SLBMs might be used against them.

Existing foreign analysis on China's submarine forces indicates that submarine bases are more difficult to conceal and protect than land-based underground facilities. Foreign experts have identified underground facilities with sea entrances at some of China's submarine bases.[72] It looks like Chinese nuclear submarines are usually hidden in underground facilities. They can drive in or out of these submerged tunnels through sea entrances. According to existing analysis, these tunnels may be relatively short in length and may not extend deep into the shore, which means the distance between the top of the tunnel and the ground surface may not exceed tens of meters. Getting back to Table 4, we can see that if the submerged tunnels are built in hard rock, most of the conventional weapons will face some difficulty penetrating the rock and reaching the tunnels. Some of the most powerful weapons such as the MOP, however, have a maximum penetration capability of about thirty meters into hard rock, which might be capable of destroying these underground tunnels.

[69] Ibid.
[70] Robert S. Norris and Hans M. Kristensen. "Chinese Nuclear Forces, 2008." *Bulletin of the Atomic Scientists* 64, no. 3 (2008): 42-44, 45.
[71] See Table 1.
[72] Hans M Kristensen. "China's Nuclear Missile Submarine Base." Federation of American Scientists, http://www.nukestrat.com/china/subcave.htm; Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.

With that said, it is worth noting that it could be difficult, if not completely impossible, for the U.S. to accurately detect the actual operational status of Chinese nuclear submarines. At a time of crisis, the U.S. may not be confident about whether the submarines are in or out of the underground facilities, because the submarines can secretly leave the facility without being detected through the submerged sea entrances. When the submarines are at sea, its survivability may increase substantially, particularly if they are deployed in waters close to China where they are protected by China's airplanes and surface ships and are not susceptible to attacks by America's advanced anti-submarine systems.

Bombers

China is believed to possess a small number of nuclear-capable H-6 intermediate-range bombers, which does not seem to pose a serious threat. H-6 is becoming increasingly obsolescent as a modern bomber. It has a very limited flight range compared with modern bombers of the U.S. It also lacks an adequate penetration capability and is susceptible to adversaries' air defense systems. If not on alert, H-6 bombers can be very delicious targets for U.S. conventional precision strikes. The bombers do not seem to be protected by underground tunnels or other hardened facilities.[73] Both the aircrafts themselves and the runways can be destroyed by conventional weapons without much difficulty. The nuclear gravity bombs that are assigned to the bombers may be more difficult to destroy, because they are believed to be stored in separate facilities close to the airports. Many of China's military airports are close to mountains where underground facilities have been identified. If the nuclear bombs are stored in these underground facilities, they might not be vulnerable to any conventional precision-guided strike, according to previous analysis. However, in a preemptive strike with the purpose of damage limitation, the existence of nuclear gravity bombs might not be much of a concern, as long as the bombers that are used to deliver them can be destroyed.

Functional Defeat

Sometimes it is not entirely necessary to completely destroy targets, and a so-called functional defeat might be sufficient for achieving military objectives. This is particularly true for damage limitation operations. If the U.S. believes that China is about to use its theater nuclear forces, the most important for the U.S. is to ensure those nuclear weapons would not be used soon – whether the weapons are completely destroyed or simply functionally defeated is not that much important. Functional defeat of China's theater nuclear forces seems good enough to meet the U.S. objective of damage limitation, and at the same time it requires fewer and less powerful munitions. Therefore, this section will discuss the capability of the U.S. to conduct a functional defeat operation against China's theater nuclear forces.

For China's nuclear-capable bombers, they are already quite vulnerable. U.S. conventional strikes seem capable to destroy them once and for all without too much difficulty. The issue of functional defeat, as a result, is largely irrelevant for Chinese bombers.

As for China's nuclear ballistic missile submarines, functional defeat of submarine bases might be easier to achieve than a complete destroy. China's underground submarine facilities are mostly built by digging

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[73] Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.

into hills that are next to the seashore.[74] As the tunnels go deep into the hills, they are protected by the rock or earth above. However, the sea entrances to these tunnels seem less protected and the front-end of the tunnels that are close to the entrances may be relatively vulnerable. If the layer of rock above the entrance is in the matter of just a few meters, U.S. conventional precision-guided weapons seem capable of penetrating it. Some analysts have already pointed out that by striking the entrances it might be possible to block submarines inside the tunnels without having to destroy the entire tunnels and the submarines inside.[75]

Nonetheless, even for functional defeat operations, the U.S. still faces the difficulty of identifying whether Chinese submarines are at port in these tunnels or out in the sea, since these tunnels have sea entrances and submarines may be able to sneak in and out without being noticed. As long as the submarines are in waters close to China's mainland, they may be safe from U.S. attacking submarines and other anti-submarine striking forces.

Functional defeat strategy may be somewhat useful against China's land-based theater nuclear forces. As analyzed above, a significant number of China's land-mobile nuclear missiles seem to be deployed in hardened and deeply buried underground tunnels. Although the tunnels are extremely robust and cannot be compromised by conventional strikes, their entrances may be vulnerable. If all entrances to tunnels are blasted and destroyed by conventional precision-guided weapons, the nuclear missiles that are trapped in the tunnels may become essentially useless until the debris is cleared and the entrances re-opened, which can take a relatively long time.

Nevertheless, the Chinese seem to have already taken this scenario into consideration when designing and building their underground "Great Walls". Press release about these tunnels specifically mentioned that countermeasures have been taken to diminish the possibility that all entrances can be destroyed in a conflict. A large number of entrances have been built at various places of the tunnel network so that even if some of the entrances are blocked there will still be a number of entrances left intact. In addition, many fake targets have been created around the facilities and are intended to increase the difficulty of identifying and destroying all real entrances.[76]

On the part of the attacker, historical records show that it is very difficult to successfully identify important weapons of mass destruction (WMD) facilities. The most frequently quoted examples are the 1991 Persian Gulf War and the 2003 Iraq War. On the first occasion, a significant proportion of Iraq's WMD facilities were not identified and therefore left intact during the U.S. massive conventional bombing campaign. In the second case, a large number of suspected WMD facilities were later found having been misidentified or inactive.[77] Therefore, the efficacy of the functional defeat operations can get seriously undermined by both the adversary's countermeasures and the extreme high demand on highly accurate intelligence. Since damage limitation strategy demands a high degree of reliability in terms of

[74] Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie. "Chinese Nuclear Forces and U.S. Nuclear War Planning." Washington DC: Federation of American Scientists/Natural Resources Defense Council, 2006.

[75] Hans M. Kristensen. "New Chinese Ballistic Missile Submarine Spotted." FAS Strategic Security Blog, http://www.fas.org/blog/ssp/2007/07/new_chinese_ballistic_missile.php.

[76] Jingjing Wang. ""Underground Great Wall" Guarantees the Safety and Security of China's Nuclear Forces." *Communists* no. 2 (2010): 50.

[77] Charles L Glaser and Steve Fetter. "Counterforce Revisited: Assessing the Nuclear Posture Review's New Missions." *International Security* 30, no. 2 (2005): 84-126.

combat effectiveness, the uncertainty around the efficacy of functional defeat operation will make it essentially useless in practice.

As for striking China's DF-21 missile vehicles that are on a patrol mission, it is difficult to clearly distinguish between "complete destroy" and "functional defeat". As analyzed in previous sections, a moderate number of conventional precision-guided weapons (with the assistance of GPS guidance) would be sufficient to "severely damage" the missile vehicles by overturning the vehicle and crushing the missile canister to the extent that the missile can no longer be launched.[78] Functional defeat strategy, therefore, is not of particular significance for striking moving missile vehicles.

Future U.S. Conventional Prompt Global Strike Capability

Besides existing weapon systems, the U.S. has a range of near- to mid- term plans for future conventional prompt global strike systems. This section will provide an assessment of the potential capability of future conventional global strike systems against China's theater nuclear forces. A brief summary of proposed conventional prompt global strike systems is provided in Table 7.

Table 7. Summary of Proposed Conventional Prompt Global Strike Systems[79]

Weapon Systems	**Launch Vehicles**	**Combat Range (nm, nautical mile)**	**Munitions Payload Capacity (lb)**	**Accuracy (meter)**	**Earliest Initial Operational Capability (IOC)**
Conventional Trident Modification (CTM)	Trident: D5	> 4,000	> 1,000	3-5	2011
Submarine-Launched Global Strike Missile (SLGSM)	2-stage rocket booster	3,000	2,000	3-5	2014-2015
Conventional Strike Missile (CSM)	Minotaur II and III	> 6,000	2,000	3-5	2016-2020
Hypersonic	Launched on	2,000-3,000	1,000-2,000	3-5	2020-2024

[78] Jixiang Wang and Lan Chang. "Assessment of American Ballistic Missile above-Ground Survivability." *Missiles and Space Vehicles Technology* no. 5 (1999).

[79] Sources: "U.S. Conventional Prompt Global Strike: Issues for 2008 and Beyond." Washington DC: Committee on Conventional Prompt Global Strike Capability, Naval Studies Board, Division on Engineering and Physical Sciences, National Research Council of the National Academies, 2008; Todd C Shull. "Conventional Prompt Global Strike: Valuable Military Option or Threat to Global Stability." Naval Postgraduate School, 2005; William L. Spacy II. "Does the United States Need Space-Based Weapons?", School of Advanced Airpower Studies, Air University, 1998; Matt Bille and Rusty Lorenz. "Requirements for a Conventional Prompt Global Strike Capability." In *NDIA Missile and Rockets Symposium and Exhibition*, 2001; Amy F Woolf. "Conventional Warheads for Long-Range Ballistic Missiles: Background and Issues for Congress." In *CRS Report for Congress*. Washington, DC: Congressional Research Service, 2009; Bruce M Sugden. "Speed Kills: Analyzing the Deployment of Conventional Ballistic Missiles." *International Security* 34, no. 1 (2009): 113-46.

Cruise Missile	land, from aircraft, or from ships				
Space Operations Vehicle	Trans-atmospheric Vehicle	Global coverage	1,000	~3	Later than 2020
Space-Based Launch Platform	Rockets	Global coverage	> 2,000	~3	Later than 2020

In theory, the striking capability of conventional weapons can be improved in three ways: increasing their accuracy, shortening their response time, and providing them with a greater power of explosion. The last approach – increasing their power of explosion – generally requires a larger yield of weapons which translates into bigger warheads that carry more explosives. However, Table 7 seems to indicate that this would not be the approach that the U.S. will take. Most of the proposed near- to mid- term weapon delivery systems have relatively limited payload capacities. In comparison with existing delivery systems such as B-2A bomber which has a throw weight capacity of 40,000 lbs,[80] these proposed new delivery systems do not present a significantly greater payload capacity than existing systems.

On the other hand, however, these new systems do intend to achieve significant improvement in terms of both accuracy and responsiveness. Better responsiveness is achieved by putting reentry vehicles on high-speed delivery systems such as ballistic missiles and space operational vehicles. Therefore, the reentry vehicle can be delivered to targets in no more than two hours or even in matters of tens of minutes, depending on the specific delivery systems. However, increased reentry velocity also puts limits on strike accuracy. The higher the velocity at which reentry vehicle travels, the more difficult it becomes for the vehicle to make necessary adjustment and maneuver before it hits the ground. Also, when the vehicle travels at speeds higher than 4.6 km/s, it will be surrounded by a cloud of plasma which can completely block GPS signal and significantly undermine the weapon's accuracy.[81] Slowing down the reentry vehicle after it enters into atmosphere, therefore, might be a solution.[82] The idea to put reentry vehicles on a glider, for example, is proposed to reduce the reentry speed. After all, for all these technical difficulties and limitations, the accuracy of future weapon systems is about 3 meters, as is shown in Table 7.

According to Table 5, the lethal radius of a conventional weapon that has a yield of about 365 kg TNT is 14.3 meters, when used to strike a Chinese DF-21 missile vehicle on patrol. Employing Equations (1), (2), and (3), we can compare and see how different levels of accuracy will affect the destruction probability of the same conventional weapon (see Table 8).

Table 8. Destruction Probabilities of a Conventional Weapon with Different Levels of Accuracy

Weapon Yield (kg, TNT	**LR (m)**	**CEP (m)**	**SSPK**	**P(2)**	**P(3)**

[80] Bruce M Sugden. "Speed Kills: Analyzing the Deployment of Conventional Ballistic Missiles." *International Security* 34, no. 1 (2009): 113-46.
[81] William L. Spacy II. "Does the United States Need Space-Based Weapons?", School of Advanced Airpower Studies, Air University, 1998.
[82] The Common Aero Vehicle, for example, can operate as the reentry vehicle of Conventional Strike Missiles, space operational vehicles, and potentially other future delivery systems.

equivalent)					
365	14.3	10	0.758	0.941	0.986
365	14.3	3	1.000	1.000	1.000

Table 8 implies that as many as three weapons with yields of 365 kg TNT are needed to surely destroy an unsheltered Chinese DF-21 missile vehicle, whereas only one weapon is necessary if the accuracy of the weapon can be increased from 10 meters to 3 meters. Therefore, future advanced conventional global strike weapons will be much more capable of destroying Chinese unsheltered missile TELs. However, it is important to note that most of these advanced precision-guided weapons still rely heavily on GPS guidance, especially during the final phase of their flight. If GPS signal is jammed, their accuracy level probably will decline considerably, making their striking against Chinese missile vehicles much more difficult and unreliable, particularly so if the target is moving.

As for striking China's underground facilities, advanced conventional global strike weapons do not seem to have a higher chance of success compared with existing weapons. Accuracy is not much of a concern for striking Chinese underground facilities, because no matter how accurate the weapons are, if they cannot penetrate deeply enough into ground they will have no chance of putting the tunnels under threat. Also, Chinese underground tunnels usually stretch extensively into a wide area and precision-guided weapons are of little use in dealing with large-area targets.

In terms of penetrating capacity and explosive power, advanced weapons would not be significantly superior to existing weapons. First of all, penetrating capacity will increase as the speed at which the weapon hits the ground (impact speed) increases. However, when the speed reaches 3 km/s, the depth of penetration will be primarily a function of the square root of the density ratio of the weapon material to the target material and is no longer affected by increasing the impact speed.[83] In addition, high impact speed poses a challenge to the limit of weapon material. No matter how hard the material, it cannot survive when the impact speed exceeds certain level. The currently demonstrated maximum impact speed at which the hardest material can survive is about 1,000 m/s,[84] so the current available technology does not allow an impact speed as high as 3,000 m/s. However, this paper assumes that future technology will produce new materials that are hard enough to withstand an impact speed of 3 km/s, and calculates how deep the weapon can penetrate into hard rock such as granite under such an assumption.[85]

According to Young/Sandia penetration equations, when impact velocity $V \geq 200$ fps (feet per second), the depth of penetration (D) into rock is determined by the following equation: [86]

$$D = 0.00178\ S\ N\ (W/A)^{0.7}\ (V - 100) \tag{4}$$

[83] William L. Spacy II. "Does the United States Need Space-Based Weapons?", School of Advanced Airpower Studies, Air University, 1998.

[84] Robert W Nelson. "Low-Yield Earth-Penetrating Nuclear Weapons." *Science and Global Security* no. 10 (2002): 1-20.

[85] This is a very bold assumption and probably will greatly overestimate the capability of advanced weapons in the future. The analysis will show that even under such bold assumptions, advanced weapons will still be incapable of threatening existing Chinese underground facilities.

[86] C. W Young. "Penetration Equations." In *Contractor Report*. Albuquerque, NM: Sandia National Laboratories, 1997.

Where S is penetrability of target (dimensionless) and is determined by features of the target material; N is nose performance coefficient (dimensionless) which describes the shape and configuration of the nose of reentry vehicle; W is weight of penetrator; and A is cross sectional area. Therefore, Equation (4) shows that if holding all the other features of the target and the penetrator constant, the depth of penetration (D) has a linear relationship with impact speed (V).

Analysis in previous sections has shown that the maximum penetration capacity for existing penetrators is about 10 meters into hard rock or reinforced concrete. Therefore, if the maximum survivable impact speed for weapon materials can increase from currently 1,000 m/s to about 3,000 m/s in the future, the maximum depth of penetration for future penetrators will be about three times the penetration depth of existing penetrators. In other words, penetration depth of future weapon systems will not be more than 30 meters into hard rock.

Although new weapons may penetrate deeper into the ground, their range of destruction (the distance between detonation point and the deepest position where the explosion can reach and cause a certain level of damage) will probably not increase substantially. Because the range of destruction is proportional to the cute root of the force of the explosion, and the limited payload of new weapon delivery systems do not seem adequate to deliver conventional weapons that are of very high yields. Therefore, the overall depth of impact (depth of penetration plus the range of destruction) will not increase substantially, and new conventional weapons will not have the potential to threaten China's underground facilities. A significant proportion of China's theater nuclear forces including DF-3A, DF-4, and DF-21 will continue to be well protected by the "Great Wall Project" and will be highly survivable against advanced conventional weapons in the near- to long- term future.

Conclusion

The ability to control escalation of crises and reduce damage has been persistently pursued by U.S. decision makers as a key component of American military capability. The necessity to use nuclear weapons preemptively to prevent an imminent use of nuclear weapons by an adversary and to control further escalation of conflicts has never been ruled out by U.S. security strategists. In recent years, however, as the momentum of global nuclear disarmament movement continues to grow, the idea of preemptive use of nuclear weapons as a means of escalation control and damage limitation becomes increasingly unpopular – it seems morally indefensible and militarily impracticable. As a result, the ability to conduct conventional preemptive strikes looks increasingly attractive to U.S. policy makers. Using conventional global strike weapons to target and, if necessary, destroy China's nuclear forces for the purpose of damage limitation does not seem to be the primary objective behind American efforts to pursue conventional prompt global strike capabilities. However, the conventional counterforce preemptive strike scenario has never been excluded and has been used on many occasions by U.S. analysts to justify and advocate for the development of conventional global strike capabilities. That certainly concerns China who sees the survivability of its nuclear forces essential to its national security. The feasibility and wisdom of conducting conventional preemptive strikes against China's nuclear forces have not been seriously debated either in academia or policy circles. This paper, as a result, is aimed at providing a preliminary analysis on this important but understudied issue.

Some existing studies mistook the scenario of a preemptive strike against China by assuming that the U.S. will focus on and target China's ICBMs. This study points out that to the contrary, if the U.S. ever considers a first strike for the purpose of damage limitation, it is more likely to target China's theater nuclear forces rather than ICBMs. The study conducts a comprehensive analysis on the probability that American conventional strikes might destroy China's theater nuclear forces which include DF-3A, DF-4, DF-21, DF-31, Type 094 nuclear submarine(s), and nuclear-capable H-6 bombers. The results indicate that most China's theater nuclear forces are survivable to conventional precision-guided strikes. China's strategy to build very robust underground facilities, in particular, is very effective in protecting nuclear forces from threats of preemptive strikes. It is very unlikely that a U.S. conventional strike can destroy a significant part of China's theater nuclear forces. This study also takes into account future conventional prompt global strike systems that have been proposed. An assessment of the potential of these advanced systems is made and the analysis shows that these proposed new systems will not add much to the existing U.S. conventional preemptive strike capability against China. Even if the proposed global strike systems are successfully developed and fully deployed, China's theater nuclear forces will remain highly survivable against U.S. strikes.

This analysis does not take into consideration a number of additional factors that in reality can further undercut the efficacy of conventional strikes against China's theater nuclear forces. For example, this study does not take into account the decoys that China has created to confuse and distract enemy firepower. In assessing the survivability of China's nuclear forces against U.S. conventional threats in the future, the study does not take into consideration Chinese capabilities such as early warning, air defense, and missile defense. China currently has almost no early warning capability against potential preemptive strikes, but may make progress in obtaining that capability in the mid- to long- term future. After China gets some early warning capability, it will have the chance to deploy emergency protective measures for its nuclear forces when there is an alarm and therefore make the nuclear forces more survivable. China is also improving its air defense capability and seems to have a plan for developing missile defense systems. All these defensive capabilities will further diminish U.S. conventional threats to China's nuclear forces in the future.

It is generally believed that a preemptive strike during peacetime is more likely to succeed than a strike during a crisis, because tensions are already high after a crisis begins and the adversary can put their nuclear forces on higher levels of alert and as a result increase their survivability. Some American scholars even argue that the U.S. should warn the Chinese before they have a chance to put their nuclear forces on alert that if they raise the alert level the U.S. will launch a preemptive strike and destroy their nuclear forces[87]. In this way, as is argued, the Chinese will be deterred from raising the alert level and their nuclear forces will remain vulnerable throughout the crisis. However, under the current Chinese strategy of hiding nuclear forces underground, it is not very likely that the U.S. will be able to deter the Chinese from putting their nuclear forces on alert during a crisis. As is mentioned in previous sections, the "Great Wall Project" style facilities are comprised of networked underground tunnels in which the Chinese can conduct a series of operations including putting their missiles on different levels of alert.[88] The U.S. would not be able to tell the alert status of Chinese underground nuclear missiles. Chinese nuclear submarines are also suspected of being able to leave ports unnoticed through submerged sea entrances of underground facilities during a crisis. In comparison, Chinese nuclear-capable bombers may

[87] Keir A Lieber and Daryl G Press. "U.S. Nuclear Primacy and the Future of the Chinese Deterrent." *China Security* no. Winter (2007): 66-89.

[88] Jingjing Wang. ""Underground Great Wall" Guarantees the Safety and Security of China's Nuclear Forces." *Communists* no. 2 (2010): 50.

make the most noise if they are put on alert, but bombers are also the most obsolete and least reliable nuclear forces that China has and China probably would not consider using them in any meaningful way. In short, the way that China deploys its nuclear weapons makes it almost impossible for its adversary to know the exact level of alert of most Chinese theater nuclear forces. It is unlikely that China can be deterred from raising its nuclear alert status during a crisis.

Another serious problem with the U.S. strategy of damage limitation is uncertainty in intelligence. It could be very difficult for the U.S. to be absolutely confident that it can detect all Chinese theater nuclear weapons in the first place. The consequences of failing to identify all targets could be devastating. Furthermore, even if the U.S. can identify all Chinese theater nuclear weapons before an attack it is still extremely difficult for the U.S. to accurately assess the outcome of the conventional preemptive strike. How would the U.S. know whether all or most of Chinese theater nuclear forces have been effectively destroyed after the strike is finished? A failure to detect any survived Chinese theater nuclear weapons may embolden the U.S. to take adventurous steps that can lead to nuclear escalation. It is sometimes argued that the U.S. can try to deter Chinese retaliation by declaring immediately after the strike that if China dares to strike back by using survived nuclear forces (if there is any), the U.S. will launch another round of strike – and perhaps more intense and extensive than the first round of strike. Nonetheless, this strategy is problematic as well. Launching the first round of preemptive strike already reveals the lack of confidence on the part of the U.S. about its capability to deter China from using its nuclear weapons in the first place, so why would the U.S. be sure that China can be deterred from retaliation if it has the capacity to do so? It is likely that after the U.S. launches the first strike, it will be very concerned about the possibility of a Chinese retaliation, and as a result, it will be very attentive to what Chinese military seems to be doing or planning to do. Under such high tensions, the chances of misunderstanding Chinese behavior would not be low. It is likely that China's emergence measures for disaster relief and recovery, or China's actions to mobilize and disperse its survived nuclear forces will be misinterpreted as preparations for retaliations. If the U.S. sees China seemingly preparing for retaliatory actions, it will feel pressed to strike again to preempt the retaliation. All of these can lead to further unintended escalations. Therefore, the strategy of using conventional preemptive strikes to prevent escalation and to reduce damage can actually cause further escalations inadvertently.

In addition, the American development of missile defense systems will make preemptive strikes against China's nuclear forces increasingly unnecessary. The Obama administration's plan to focus on the development of theater missile defense capabilities, in particular, is well-suited for addressing the concern about Chinese theater nuclear forces. The Standard Missile 3 (SM-3) interceptors, both sea-based and land-based, are more useful for intercepting Chinese theater missiles than ground-based mid-term interceptors such as those deployed in Alaska and California. These SM-3 interceptors are also re-locatable. They can be deployed to waters and land close to China if there is a crisis over Taiwan. Therefore, as the U.S. develops and improves its SM-3 missile defense systems, its capability to intercept Chinese theater missiles will continue to grow and the necessity to launch preemptive strikes against China's theater nuclear forces presumably will decrease over time.

For all of these reasons, this paper concludes that it is not beneficial for the U.S. to pursue the strategy of damage limitation through the use of conventional global strike weapons against China's nuclear forces. Conventional counterforce strike against China is practically unachievable and will most likely accelerate escalation instead of prevent or control escalation. The consequences of including the scenario of using conventional weapons to attack China's nuclear forces in U.S. military planning will undermine American security interests. As a matter of fact, the possibility of U.S. conventional first strike against China's nuclear forces has already sparked internal debates in China about the wisdom of sticking to an unconditional No First Use (NFU) policy. Although there is no indication that Chinese government has any intention to change its NFU policy in the foreseeable future, the perceived conventional threats have certainly undermined the existing consensus over NFU within China's policy-making circles. If the threats loom larger in the future, no one will be sure whether China will continue to stick to NFU policy as firmly as it has been, which definitely would not serve American interests. Furthermore, if China is concerned about U.S. conventional threats, Beijing probably would not be willing to attend and play an active role in nuclear disarmament discussions. As is widely believed, after the U.S. and Russia concluded the START Follow-On Treaty, the international community will have to engage China and get China on-board on the issue of nuclear arms control if any further progress is going to be made. Addressing China's concern about the U.S. conventional strike by dropping the conventional counterforce option out of U.S. strategic thinking and military planning would obviously contribute to the course of global nuclear disarmament.

Recent events in the Asia-Pacific region seem to indicate a complex future for U.S.-China military relationship. Tensions in South and East China Seas continue to grow and U.S. positions on these issues are likely to draw the U.S. closer to potential maritime confrontations with China in these waters. China is believed making efforts developing advanced conventional weapons such as anti-ship ballistic missiles and is building its own aircraft carriers. All these advanced conventional weapons will make future conflicts between the U.S. and China more complicated and unpredictable. Taking the example of aircraft carriers, even if they are used as conventional weapon platforms, they are also important strategic assets of a country. If carriers are involved and attacked in future U.S.-China conventional conflicts, it could be very difficult to control and avoid escalation. Therefore, one of the key issues for maintaining U.S- China strategic stability in the future is to make sure that conventional conflicts will not easily escalate into nuclear wars. As a result, a proper strategy regarding the development and deployment of conventional strategic weapon system is very necessary and important. On the part of the U.S., several measures can be taken in the near term to help solve the problem.

The Way Forward

Firstly, encourage China to stick to its NFU policy. For China, when facing new threats from advanced conventional attacks, it may feel urged to reconsider its unconditional NFU policy. On the part of the U.S., contemplating a strategy of damage limitation through the use of conventional weapons against China's theater nuclear forces is be very indicative of U.S.' skepticism about and dismissal of China's NFU pledge. Although the NFU policy has often been dismissed as empty rhetoric, the general consensus in the U.S. remains a NFU pledge from China is better than an alternative Chinese policy that explicitly recognizes the necessity of first use of nuclear weapons. Thus, instead of continuing to reinforce the impression in China that its NFU pledge not only does not get it any credit but has been intentionally challenged, the U.S. should consider measures that can encourage rather than discourage China to stick to its NFU policy. In this sense, the U.S. strategy of damage limitation through means of conventional preemptive strikes is not advisable.

Secondly, consider dropping the option of nuclear or conventional preemptive strike against China's nuclear forces, even for the purpose of damage limitation. One of the rationales for developing conventional preemptive strike capability is the recognition of the increasing difficulty to use nuclear weapons firstly in a world where the public opinion is very much against any imprudent use of nuclear weapons. However, using conventional weapons to strike nuclear forces of an adversary like China for the purpose of damage limitation is not a viable option, neither. This study shows that conventional strikes by advanced precision-guided prompt global strike weapons that are developed or proposed to be developed have little chance of eliminating theater nuclear forces of a medium-sized nuclear adversary like China. More importantly, to the contrary of the purpose of damage limitation, such conventional preemptive strikes can lead to inadvertent escalation of conflicts. Therefore, keeping the option open for pursuing conventional counterforce strike capabilities will only add to existing concerns in the mind of China and other nuclear adversaries about the reliability of their nuclear retaliation forces and about the intention of the United States regarding strategic stability. Alternative strategies of damage limitation other that using conventional preemptive strikes against China's theater nuclear forces are needed. Efforts along the lines of reinforcing existing military-to-military communication mechanisms are worth pursuing.

Thirdly, clearly define the objectives of and the scenarios for developing, deploying, and using conventional prompt global strike capabilities. It is by no means argued in this paper that preemptive strike against nuclear forces is one of the main objectives of the current conventional prompt global strike programs in the U.S. However, the scenario of using conventional weapons against nuclear forces in a preemptive manner has been mentioned as a justification for such programs and has never been excluded from official planning. It is the ambiguity that keeps the option of conventional counterforce strike open that causes serious concerns in the minds of China and possibly other countries. It is in the American interests to take a serious study of the tradeoffs of conventional counterforce strike option and make an explicit decision as early as possible: if it is indeed worth pursuing, the U.S. should consider measures to mitigate its negative impact on threat perception of other countries and on strategic stability; if it is not viable or desirable, as is argued by this paper, the U.S. should officially take it off from the table.

Fourthly, be prudent about deploying theater missile defense capabilities against China. On the one hand, as mentioned in the previous section, demonstrated theater missile defense capabilities in the Asia-Pacific region can help mitigate American concerns about the threat of China's theater nuclear forces. On the other hand, however, missile defense deployment in the region can also raise concerns. Unlike Russia who has no short- to intermediate-range nuclear missiles, a great proportion of China's nuclear forces are theater oriented. The proposed advanced SM-3 systems which are mobile and can be relocated from other places to Asia-Pacific region during crises can deny the deterrence capability of China's theater nuclear forces by preventing them from retaliating upon regional targets such as Guam. In extreme cases when China was struck by a very small scale nuclear attack from the U.S., it might deem necessary to conduct a similarly limited retaliation against such regional targets. Current debate about the impact of SM-3 systems on China has been largely about their capability to intercept China's ICBMs, but in fact even if SM-3 interceptors are only capable of intercepting China's theater nuclear missiles they can still be perceived by China as a real threat to its overall nuclear deterrence capability. The current plan of Obama administration to focus on developing SM-3 missile defense systems has encountered opposition from Russia and may be potentially a much more serious concern for China.

Last but not least, begin to study the possibility and desirability of forging arms control arrangements with other countries on conventional weapon systems that have strategic significance. In the past, strategic weapons are generally used to refer to nuclear weapons, but in recent years the advancement of conventional weapons has been so dramatic that some conventional weapon systems begin to have the potential to impact strategic balance and stability between nuclear countries. The term strategic weapon has already been used to refer to some conventional weapons. It becomes a shared concern among many scholars that conventional arms race can undercut the potential benefits that nuclear disarmament talks may bring us and can undermine overall strategic stability between nuclear weapons states in spite of the progress on global nuclear reductions. Constraining the development and deployment of certain advanced conventional weapon systems that have destabilizing effects will be helpful for preventing inadvertent escalation of future conflicts and will contribute to strategic stability between major powers.