SECTION 2: CHINA'S NUCLEAR FORCES: MOVING BEYOND A MINIMAL DETERRENT

Key Findings

- The People's Republic of China (PRC) is carrying out its most substantial effort to expand, modernize, and diversify its nuclear forces since first acquiring nuclear weapons in the 1960s. The People's Liberation Army (PLA) is developing a nuclear triad; fielding new, more mobile, and more accurate nuclear weapons systems; and significantly expanding its stockpile of nuclear warheads. The PLA has also enhanced its intelligence, surveillance, and reconnaissance (ISR) systems.
- China's nuclear buildup puts it on a trajectory to become a nuclear peer of the United States in qualitative terms. Qualitative nuclear parity could entail diversified, reliable, and survivable delivery systems; highly precise missiles; warheads of various yields; robust command and control processes; and sophisticated ISR, all of which enable a truly secure second-strike capability and options for calibrated, offensive nuclear use. Current public projections suggest China could also become a quantitative peer in the number of land-based strategic missiles it deploys by 2030.
- Strategic and political forces are driving China's departure from a minimalist nuclear posture. For most of its modern history, China maintained a small nuclear stockpile mainly suitable for minimal retaliation against an adversary's nuclear attack. General Secretary of the Chinese Communist Party (CCP) Xi Jinping's ambitions for great power status, combined with military objectives beyond minimal retaliation, have likely motivated the recent buildup of China's nuclear arsenal.
- At minimum, China's nuclear buildup enhances its current retaliatory strategy by better enabling its nuclear forces to deter or respond in kind to a nuclear attack. Chinese leaders may worry that innovations in other nuclear weapon states have undermined their nuclear deterrent, requiring them to make changes in order to keep up.
- The scale of China's nuclear buildup, however, suggests it could also be intended to support a new strategy of limited nuclear first use. Such a strategy would enable Chinese leaders to leverage their nuclear forces to accomplish Chinese political objectives beyond survival, such as coercing another state or deterring U.S. intervention in a war over Taiwan.
- Uncertainties created by China's nuclear buildup heighten the risk of an accidental nuclear exchange or unforeseen nuclear escalation during a regional conflict. Specific risks of nuclear es-

calation stem from entanglement between China's nuclear and conventional capabilities, its desperation to avoid losing a conventional war in the region, and false alarms that could result from its possible shift to a launch-on-warning posture.

- The PLA's growing arsenal also casts "nuclear shadows" over China's disputes with its neighbors, many of whom are U.S. allies and partners. Improved nuclear capabilities could encourage Chinese leaders to coerce or initiate a conventional conflict against U.S. allies or partners in the region if they believe their nuclear capability would deter the United States from intervening.
- China has continued to play a concerning role in the global proliferation of missile and nuclear technologies, though the manner in which this proliferation occurs has evolved over time. Whereas two decades ago the Chinese government and state-owned enterprises (SOEs) were the main source of missile and nuclear technologies, Chinese companies and private individuals now play a dominant role in the proliferation of such goods to countries of concern. The Chinese government turns a blind eye to, and in some cases tacitly supports, these illicit activities.

Recommendations

The Commission recommends:

- Congress direct the Administration to conduct an interagency review of any Chinese universities that maintain research or training arrangements with China's nuclear weapons research institutes, such as the Chinese Academy of Engineering Physics and the Northwest Institute of Nuclear Technology. The review should be led by the U.S. Department of Energy and include the U.S. Departments of Commerce, Treasury, and Defense; the Intelligence Community; and other federal departments and agencies as appropriate. The review would:
  - Assess the impact of such cooperation on China's nuclear weapons programs and capabilities;
  - Assess whether current U.S. export controls adequately address risks from the transfer and exchange of information and technologies with applications to nuclear research, particularly by researchers and departments in relevant academic disciplines at U.S. universities to these Chinese universities;
  - Identify Chinese universities and research institutes that should be added to the Entity List, based on the risks posed by their cooperation with the Chinese Academy of Engineering Physics, Northwest Institute of Nuclear Technology, and other Chinese institutions involved in nuclear weapons development, as appropriate;
  - Identify Chinese universities and research institutes that merit a presumption of denial for all export licenses involving items covered by the Export Administration Regulations; and
  - Develop and maintain a list of all academic partnerships in fields with applications to nuclear weapons development en-

tered into between Chinese universities and U.S. universities that receive federal funding for the purpose of determining whether these activities are subject to export controls.

- Congress prevent the erosion of U.S. strategic nuclear superiority and respond to China's qualitative and quantitative theater nuclear advantages by directing the Administration to continue implementation of the Obama-Trump Program of Record for nuclear modernization.
- Congress enact legislation creating an independent bipartisan commission, similar to the Quadrennial Defense Review commissions authorized in the past, to assess the Nuclear Posture Review and advise Congress about whether the current U.S. nuclear posture is sufficient to maintain deterrence against the expanding Chinese and Russian nuclear forces. The Commission should:
  - Determine how Russian and Chinese nuclear capabilities have changed between 2010 and 2022;
  - Evaluate whether the current number of U.S.-deployed strategic weapons is sufficient to deter both Russia and China over the next 20 years; and
  - Identify any further changes required to U.S. force posture, doctrine, and missile defense.
- Congress authorize funding for a comprehensive diplomatic strategy on nuclear deterrence and arms control. This comprehensive program would include:
  - Intelligence diplomacy with key allies and partners in the Indo-Pacific and in Europe to inform them of developments in China's nuclear forces;
  - Dialogue to convince these allies and partners to pressure Beijing diplomatically to enter into arms control talks and to explore these partners' willingness to host U.S. intermediate-range forces and other U.S. assets; and
  - Continued efforts to engage both Russia and China in trilateral arms control talks, including by continuing efforts with Russia to persuade China to enter into arms control discussions.

Introduction

In June 2021, independent researchers analyzing commercial satellite imagery identified the construction of 119 new intercontinental ballistic missile silos in a desert in northwestern China.[1] Their discovery provoked speculation in the expert community and alarmed U.S. officials, who had expressed concerns about China's opaque nuclear activities for years. U.S. Department of State spokesperson Ned Price told reporters the silos reflected China's growing deviation from its decades-old nuclear strategy of limiting China's nuclear forces to the "minimum" size required for deterring a nuclear attack.[2] "These reports and other developments suggest that the PRC's nuclear arsenal will grow more quickly, and to a higher level than perhaps previously anticipated," Mr. Price said.[3]

Concerns about the silos followed remarks by numerous U.S. officials in recent years about the pace, scale, and nature of ongoing changes to China's nuclear arsenal. Then director of the Defense Intelligence Agency Lieutenant General Robert Ashley told an audience at the Hudson Institute in 2019 that China would at least double its nuclear warhead stockpile "in the course of implementing the most rapid expansion and diversification of its nuclear arsenal in China's history."[4] Admiral Charles A. Richard, commander of U.S. Strategic Command, told the House Armed Services Subcommittee on Strategic Forces in April 2021 that Chinese leaders are engaged in a "breathtaking expansion" of their country's nuclear capabilities that will "backstop their conventional capability and will potentially constrain our options."[5] Their statements underscore the potential for China's nuclear buildup to presage an arms race and embolden Chinese conventional aggression toward U.S. allies. Considered together with a nuclear-armed Russia, China's nuclear forces may also pose a more complex strategic challenge to the United States than U.S. military planners have previously assumed.

This section assesses the ongoing transformation of China's nuclear arsenal as well as China's role as a supplier of nuclear and missile technologies to countries of proliferation concern. First, the section examines the modernization, expansion, and diversification of China's nuclear arsenal. Next, it explores competing interpretations of the purpose for which Chinese leaders are building a larger and more capable arsenal: to bolster their retaliatory capability in line with declared strategy or to pursue a new, more ambitious nuclear strategy that threatens or uses nuclear weapons to accomplish China's regional objectives. It then discusses ambiguity in Chinese nuclear doctrine and several scenarios in which China could either inadvertently or intentionally escalate to the threat or use of nuclear weapons during a conflict in the Indo-Pacific region. Finally, the section surveys the role of China-based companies and individuals in the proliferation of dual-use items with nuclear and missile applications to countries like Iran and Pakistan. This section is based on the Commission's June 2021 hearing on the topic as well as open source research and analysis.

China's Official Stance on Nuclear Weapons

China's official discourse about the strategy and policy behind its nuclear weapons has remained consistent since the country detonated its first atomic device in October 1964. Chinese leaders publicly adhere to a nuclear strategy focused on deterring nuclear use against China, insist that they maintain the "minimum" number of nuclear weapons required for deterrence, and assert a "no-first-use" policy.

China's declared "self-defensive nuclear strategy" achieves deterrence by maintaining the means to survive and credibly retaliate against an enemy's nuclear first strike, a strategy some scholars have described as one of "assured retaliation."*[6] Chinese leaders'

*China's 2006 defense white paper stated that China pursues a "self-defensive nuclear strategy," and subsequent white papers have repeated this formulation. Western scholars have variously characterized China's nuclear strategy as one of "existential deterrence," "limited nuclear retaliation," or "assured retaliation," making use of U.S. and European concepts of strategic deterrence to differing extents. By contrast, some Chinese scholars have argued that China's nuclear

distinctive views about the utility of nuclear weapons and their personal experience of nuclear coercion influenced the development of this strategy in the early 1960s.[7] CCP Chairman Mao Zedong's famous remark that "the atomic bomb is only a paper tiger" reflected his belief that future wars would remain conventional because nuclear weapons were too destructive to actually be used in a situation where two nuclear-armed states had achieved mutual vulnerability.[8] At the same time, Chairman Mao recognized that nuclear weapons could also be used against nonnuclear weapon states to blackmail them or inflict substantial damage in a war.[9] In the face of repeated U.S. and Soviet threats to use nuclear weapons when tensions arose over conflicts in the 1950s and 1960s, Chairman Mao and his fellow CCP leaders concluded that acquiring enough nuclear weapons to deter nuclear coercion and aggression was a "destiny-determining matter" for the nation.[10]

Subsequent Chinese leaders, defense white papers, and textbooks published by Chinese military academies have continually affirmed that China's nuclear strategy is purely "defensive" and aims only to establish a secure second-strike capability.*[11] Accordingly, the authoritative *Science of Military Strategy* describes only one campaign involving the use of nuclear weapons, a "nuclear counterstrike campaign" to be carried out against an adversary's cities after China absorbs a nuclear attack.[12] China's historical focus on targeting an adversary's cities (known as "countervalue" targeting) made sense partly because it required considerably less sophisticated technology than did the U.S. and Soviet strategies of targeting an adversary's nuclear forces and military infrastructure (known as "counterforce" targeting).†

Another important element of China's declared nuclear strategy is its focus on limiting China's nuclear forces to the "minimum" size required to deter nuclear coercion or attack. The PRC's early leaders stressed that even a small number of nuclear weapons could create a deterrent effect and that scarce financial resources should not be wasted on the development of excess nuclear weapons.[13] China simply needed what PLA Marshal Nie Rongzhen termed "the minimum

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strategy is best understood as one uniquely shaped by the country's own strategic traditions, such as the thought of Chinese military strategist Sunzi and early PRC leaders' decades of experience fighting revolutionary guerilla war. See, for example, Eric Heginbotham et al., "China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States," *RAND Corporation*, 2017, 17; Xu Weidi, "China's Security Environment and the Role of Nuclear Weapons," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 20; State Council Information Office of the People's Republic of China, *China's Military Strategy* (中国的军事战略), May 2015. Translation; M. Taylor Fravel and Evan S. Medeiros, "China's Search for Assured Retaliation," *International Security* 35:2 (Fall 2010): 50–51, 63; State Council Information Office of the People's Republic of China, *China's National Defense in 2008* (2008年中国的国防), January 2009. Translation; State Council Information Office of the People's Republic of China, *China's National Defense in 2006* (2006年中国的国防), December 2006. Translation; John Wilson Lewis and Xue Litai, *China Builds the Bomb*, Stanford University Press, 1988, 216.

*A secure second-strike capability is the ability of a nuclear state, after being struck by a nuclear attack, to strike back with nuclear weapons and cause massive damage to the adversary. Theorists of nuclear deterrence generally believe that nuclear states must have such a capability, and make their adversaries believe that capability is credible, in order to deter their adversaries from attempting to gain military advantage through a disarming first strike.

†Counterforce and countervalue targeting are generally associated with nuclear warfare and refer to the use of nuclear weapons against an enemy that possesses nuclear weapons. Counterforce involves striking an opponent's nuclear forces and military infrastructure in order to degrade its war-making capacity, whereas countervalue involves striking an opponent's population, society, industrial base, economy, or other valuable target in order to degrade its will to escalate or persist in prosecuting a war. However, some states use advanced conventional weapons to carry out counterforce and countervalue strikes.

means of reprisal," which could be launched days or even weeks after China absorbed an adversary's nuclear attack.[14] Political guidance to restrain the arsenal endured over the following decades in official statements and documents. China's 2002 defense white paper declared that the country's nuclear arsenal is "kept at the lowest level necessary for self-defense only," while defense white papers from 2006 onward described China's nuclear forces as "lean and effective."*[15] As recently as June 2021, Chinese Foreign Minister Wang Yi asserted that China limits its nuclear arsenal to "the minimum level required for national security" and "does not compete with any other country in the size or scale of nuclear force[s]."[16]

Finally, China's public stance on nuclear weapons is defined by its longstanding no-first-use policy and negative security assurances.† After successfully conducting the country's first nuclear test on October 16, 1964, the Chinese government pledged in a public statement that "China will never at any time and under any circumstances be the first to use nuclear weapons."‡[17] China also issued assurances at the UN in 1978 and 1995 that it would never use or threaten to use nuclear weapons against nonnuclear weapon states or nuclear-weapon-free zones.[18] Chinese officials have also often promised never to engage in arms races and expressed their aspiration for a future in which all nuclear weapon states totally disarm, though they refuse to participate in talks about arms control or reduction.[19] The Chinese government continues to affirm these elements in its defense white papers, authoritative military texts, press conferences, and speeches at international organizations.[20]

Provocative remarks by Chinese generals have occasionally contradicted this narrative. In 1995, General Xiong Guangkai implicitly threatened to use nuclear weapons against Los Angeles if the United States defended Taiwan in a conflict.[21] Similarly, Major General Zhu Chenghu said in 2005 that China should use nuclear weapons against the United States if the U.S. military intervenes in a conflict over Taiwan.[22]

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*According to retired PLA Major General Yao Yunzhu, keeping the arsenal "lean" means exercising "restraint" in the overall number of nuclear weapons China develops, while keeping it "effective" means ensuring China's arsenal is modern and robust enough to ensure a retaliatory second strike. The "lean and effective" concept neither imposes specific numerical limits on China's nuclear arsenal nor dictates a specific threshold of destruction the adversary should sustain, though the 2013 edition of the authoritative military text *Science of Military Strategy* notes such destruction should be "unbearable." Yao Yunzhu quoted in Eric Heginbotham et al., "China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States," *RAND Corporation*, 2017, 20; Shou Xiaosong, ed., *The Science of Military Strategy* (战略学), Military Science Press, 2013, 172. Translation; David C. Gompert and Phillip C. Saunders, *The Paradox of Power: Sino-American Strategic Restraint in an Age of Vulnerability*, National Defense University Press, 2011, 53; Yao Yunzhu, "Chinese Nuclear Policy and the Future of Minimum Deterrence," *Strategic Insights* 4:9 (September 2005): 4.

†In the context of nuclear warfare, "negative security assurances" and "positive security assurances" are statements by nuclear powers intended to reassure nonnuclear weapon states that they will not be the victims of a nuclear attack. A negative security assurance is a declaration that a country will not use nuclear weapons against a nonnuclear weapon state. A positive security assurance is one in which a nuclear weapon state pledges it will come to the aid of a nonnuclear weapon state if that state is the victim of a nuclear attack. All five of the nuclear weapon states recognized in the Treaty on the Non-Proliferation of Nuclear Weapons have issued negative security assurances, which the UN Security Council recognized in Resolution 984 in 1995. These pledges are nonbinding, however, and some nuclear weapon states reserve the right to use nuclear weapons against nonnuclear weapon states under certain conditions. Arms Control Association, "Nuclear Declaratory Policy and Negative Security Assurances," March 2018; Nuclear Threat Initiative, "Negative Security Assurances (NSAs) and Positive Security Assurances (PSAs)," 2003.

‡China is the only nuclear weapon state recognized under the Treaty on the Non-Proliferation of Nuclear Weapons that maintains an unconditional no-first-use policy. Ankit Panda, "'No First Use' and Nuclear Weapons," *Council on Foreign Relations*, July 17, 2018.

Why China Has Shunned Arms Control Negotiations

Chinese leaders have long been skeptical about nuclear arms control on the grounds that it is a "trap" intended to undermine China's nuclear deterrent and "lock in" the superpowers' nuclear advantages.[23] Whereas U.S. experts believe transparency about nuclear capabilities and behavior enhances strategic stability* by increasing predictability among nuclear powers, Chinese experts believe "transparency is a tool of the strong to be used against the weak."[24] As a result, China has divulged few details about the capabilities of its nuclear forces and shunned the efforts of every post-Cold War U.S. president to involve it in arms control mechanisms.[25] Chinese officials at the same time decried the United States' withdrawal from the Intermediate-Range Nuclear Forces (INF) Treaty in 2019 as a ruse to "free its hand and develop its missile capabilities" in East Asia.[26] They also rejected calls by the United States and Japan to join proposed negotiations about a multilateral INF Treaty, arguing the United States should further slash its own nuclear stockpile rather than shift its arms control "duties" to other countries.[27] Similarly, China's Foreign Ministry spokesperson Wang Wenbin rebuffed U.S. calls for China to join a trilateral arms control framework after the United States and Russia extended the New START Treaty in February 2021.[28] Noting the "order-of-magnitude difference" between the Chinese arsenal and those of the United States and Russia, he emphasized that China "firmly reject[s] the groundless allegation and vilification from the U.S. side."[29]

Strategic and Political Rationales for China's Nuclear Buildup

Major developments in China's security environment and international status have provided its leaders strong rationales for its nuclear buildup, raising the question of whether Chinese leaders' public statements concerning the use of nuclear weapons reflect their true position on the issue. Chinese leaders may be responding to these rationales by redefining the requirements of their current nuclear strategy and no-first-use policy. Chinese leaders also may be reacting with an undeclared departure from their nuclear strategy of assured retaliation to one that wields nuclear weapons to accomplish the country's political objectives in the region.

China's insistence that its stance on nuclear weapons has not changed over nearly six decades is notable given major developments in China's strategic environment, which Chinese scholars and strategists have argued necessitate a buildup of the country's nuclear arsenal. U.S. advancements in precision-guided conventional weapons, ballistic missile defense, and ISR since the 1990s have

*"Strategic stability" has many definitions, but at the broadest level it refers to the absence of armed conflict between nuclear-armed states. Other definitions include the ideas that: in a time of crisis, there is no incentive to be the first to use military force of any type, nuclear or otherwise (also known as "crisis stability"); in a crisis or conventional conflict, there is no incentive to be the first to use nuclear weapons ("first strike stability"); and neither side believes it can improve its relative position by building more weapons ("arms race stability"). Linton F. Brooks, "Perceptions of Sino-American Strategic Stability: A U.S. View," *Carnegie Endowment for International Peace*, November 7, 2017.

exacerbated longstanding concerns within China that its retaliatory capability is too vulnerable.[30] China's "nuclear neighborhood" has grown more complex with Russia's nuclear modernization, the emergence of Pakistan and India as nuclear powers, and North Korea's development of nuclear and missile capabilities.[31] Despite the apparent comity between the two countries, Russia's deployment of low-yield nuclear weapons to its Far East, ongoing missile defense efforts, and modernization of its already formidable arsenal challenge the survivability of China's nuclear deterrent.[32] Continued border tensions with India, a neighboring nuclear power,* underscore the potential for escalation to nuclear use in a crisis, though Chinese analysts remain dismissive of that possibility and of Indian nuclear capabilities in general.[33]

China's static public stance on nuclear weapons also stands in contrast to recent official remarks that highlight nuclear weapons' contribution to China's great power status and broader security interests. In a 2016 speech at PLA Rocket Force headquarters, General Secretary Xi described the newly elevated service† that oversees the country's land-based missiles as "the strategic support of our country's status as a major power," suggesting the Chinese leadership views nuclear weapons as an important element of China's international prestige.[34] PLA Rocket Force officers and a political commissar have argued nuclear weapons enable China to deter adversaries from threatening the country's "sovereignty," "core interests," and "development interests" in addition to "fulfill[ing] the state's political and diplomatic objectives," aims more expansive than simply deterring nuclear attacks against China.[35] Chinese leaders have readily leveraged their growing conventional capabilities to advance their interests in regional territorial disputes, raising the question of whether they might see the threat or use of nuclear weapons as appropriate means to supplement conventional methods.

China Modernizes, Diversifies, and Expands the Nuclear Forces

China's unchanging public stance on nuclear weapons raises questions in light of the significant and observable transformation of China's nuclear posture‡ underway today.§ This effort involves

*India has a stockpile of around 150 nuclear warheads and currently operates eight types of nuclear-capable delivery systems: two types of aircraft, four land-based ballistic missile systems, and two sea-launched ballistic missile systems. At least three more systems are in development and will soon be combat ready. India's nuclear-capable aircraft and land-based missiles provide a mix of strike options against China, but its current sea-launched ballistic missiles cannot yet range China's east coast. Indian nuclear capabilities are not as robust or sophisticated as Chinese nuclear capabilities. Hans M. Kristensen and Matt Korda, "Indian Nuclear Forces, 2020," *Nuclear Notebook*, July 20, 2020; Alex Lockie, "We Ranked the World's Nuclear Arsenals — Here's Why China's Came Out on Top," *Business Insider*, January 25, 2019.

†During military reforms announced in December 2015, the PLA Second Artillery Force was renamed the PLA Rocket Force and elevated from a military branch to a military service. Like its predecessor, the PLA Rocket Force oversees China's land-based missile force. It is responsible for nuclear and conventional deterrence and strike missions. Michael S. Chase, written testimony before the U.S.-China Economic and Security Review Commission, *Hearing on China's Military Reforms and Modernization: Implications for the United States*, February 15, 2018, 1.

‡A state's nuclear posture encompasses its nuclear forces' size, structure, capabilities, and readiness.

§According to Mr. Hans Kristensen, director of the Nuclear Information Project at the Federation of American Scientists, the modernization of China's nuclear forces has occurred in phases. The first phase, which occurred in the 1960s and 1970s, introduced bombers and liquid-fuel moveable medium-range ballistic missiles (the DF-1, DF-2, and DF-3). The second phase, which occurred in the 1980s and 1990s, introduced longer-range liquid-fuel moveable and silo-based

developing a viable nuclear triad;* improving the mobility, accuracy, and penetration of deployed weapons systems; and significantly expanding the country's stockpile of nuclear warheads. The PLA is also working to build up its nuclear command, control, and communications (NC3) system, which includes improved ISR capabilities that enable future missions such as rudimentary strategic early warning and ballistic missile defense. As a result, the size and capabilities of China's nuclear forces will soon clearly exceed those required for the minimum and purely retaliatory deterrent it claims to have.

If these improvements continue apace, China could become a qualitative nuclear peer of the United States in around a decade, with a similarly diversified, precise, and survivable force.†[36] Such a force will give China a truly secure second-strike capability as well as options for highly calibrated nuclear use, be that in the context of retaliation or first use. China could even become a quantitative nuclear peer if current projections for the growth of its land-based strategic missile forces bear out.[37]

China's Nascent Nuclear Triad

For most of its history, China's strategic nuclear forces‡ were land based and composed of high-yield, "city-busting" warheads mounted atop imprecise missiles.[38] Today, the Chinese nuclear forces are making significant if uneven progress toward a nuclear triad composed of submarine-launched ballistic missiles (SLBMs), land-based intercontinental ballistic missiles (ICBMs), and nuclear bombers. Many of its new sea-based and land-based weapons systems are longer range and more accurate than earlier generations, innovations that expand the number of targets within the PLA's reach and give it new options to calibrate the level of damage inflicted on adversary targets. China is also developing new technologies that will improve

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intercontinental ballistic missiles that put almost all of the United States in range. The second phase also included the first solid-fuel, road-mobile medium-range ballistic missile (the DF-21) and an experimental nuclear-powered ballistic missile submarine (the Type 092). The third phase, which occurred in the first decade and a half of the 2000s, introduced solid-fuel, road-mobile intercontinental ballistic missiles (the DF-31A), an upgrade to the liquid-fuel intercontinental ballistic missiles (the DF-5B) with multiple independently targetable warheads, and a small fleet of SSBNs (the Type 094). The fourth and current phase is ongoing. Hans M. Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 1–2.

*A nuclear triad is a tripartite nuclear force structure consisting of land-, sea-, and air-based capabilities. Nuclear missiles can be launched from platforms such as ground-based silos, road-mobile launchers, and submarines. Strategic aircraft can drop nuclear bombs and launch nuclear missiles.

†Brad Roberts, director of the Center for Global Security Research at Lawrence Livermore National Laboratory, told Commission staff in an email that he expected China to become a qualitative nuclear peer of the United States sometime during the decade 2030 to 2040. Brad Roberts, Director of the Center for Global Security Research at Lawrence Livermore National Laboratory, interview with Commission staff, August 27, 2021.

‡"Strategic" nuclear forces refer to intercontinental-range missile systems armed with high-yield warheads; historically, these were intended for use against an adversary's major urban and industrial centers. The New START Treaty signed by the United States and Russia defined the range of strategic missiles as greater than 5,500 kilometers. "Non-strategic" forces encompass missiles with ranges of less than 5,500 kilometers, potentially including short-, medium- and intermediate-range delivery systems. Medium- and intermediate-range delivery systems are often associated with China's "regional" nuclear force. Separately, "tactical" warheads are a subset of "non-strategic" weapons intended for use on the battlefield in close proximity to friendly forces; they have relatively low explosive power and are carried by very short-range delivery systems of 1,000 kilometers or less. Philip C. Saunders and David C. Logan, "China's Regional Nuclear Capability," in James M. Smith and Paul J. Bolt, eds. *China's Strategic Arsenal*, Georgetown University Press, 2021, 126–127; Arms Control Association, "The Intermediate-Range Nuclear Forces (INF) Treaty at a Glance," August 2019.

its ability to counter other countries' ISR, ballistic missile defense, and precision-strike systems. These include multiple independently targetable reentry vehicles (MIRVs), maneuverable reentry vehicles, decoys, chaff, jamming, and hypersonic glide vehicles.*[39] China's strategic forces are complemented by the PLA's growing arsenal of medium- and intermediate-range ballistic missiles (MRBMs and IRBMs) that can deliver nuclear warheads throughout the Indo-Pacific region.[40]

China's Nuclear Submarines Become a Credible Deterrent Force

China's nuclear-powered ballistic missile submarine (SSBN) fleet now constitutes what the U.S. Department of Defense (DOD) describes as a "credible" sea-based nuclear deterrent after more than six decades of incremental progress and development.[41] Before its first Jin-class (Type 094) SSBN entered service in 2014, the PLA Navy had since the 1980s operated a sole Xia-class (Type 092) SSBN that undertook a single patrol and reportedly never sailed beyond Chinese waters.[42] Today, China has four operational Type 094 SSBNs based on Hainan Island and two more in the process of being outfitted.[43] Each Type 094 carries up to 12 JL-2 nuclear SLBMs, designed to be equipped with a single warhead each.[44] DOD's annual reports on China's military capabilities, as well as other U.S. government sources, suggest China's Type 094 SSBNs have conducted "deterrence patrols" since at least 2016, though it remains unclear whether these patrols occur with nuclear warheads mated to the missiles on board.[45]

China is constructing a follow-on SSBN, the Type 096, that will enter service in the mid-2020s and improve on the Type 094's noisy design and limited range.[46] The Type 094 is much louder than the top Russian or U.S. SSBNs, making it easily detectable and vulnerable to adversaries' anti-submarine warfare capabilities.[47] Moreover, the JL-2 has a range of approximately 7,200 kilometers, which is sufficient to target Alaska, Guam, and Hawaii from waters near China but unable to reach the continental United States unless the submarine operates in the Western Pacific.[48] To reach Washington, DC, a Type 094 carrying the JL-2 would need to operate in waters north and east of Hawaii.[49] China will equip the Type 096 with the JL-3, an SLBM capable of striking targets at a range of more than 9,000 kilometers.[50] The Type 096 would allow China to target northwestern parts of the continental United States from the Bohai Sea and to hold Washington, DC, at risk if the submarines sail northeast of Japan.[51] The Type 096 could carry between 12 and 16 JL-3 SLBMs, and it is unclear at present if the JL-3s will be MIRVed.[52]

The PLA Navy exhibits conventional-nuclear "entanglement"† to the extent that it uses the same shore-based, very-low-frequency

*MIRV technology enables a single missile to carry a payload of multiple warheads, each of which can be programmed to hit a different target. Maneuverable reentry vehicle technology enables the warhead on a ballistic missile to track and home in on ground targets. Chaff refers to clouds of tiny metallic strips that aircraft or rockets can release in flight that appear as separate targets to an enemy's radar and confuse a missile sent to intercept it. A hypersonic glide vehicle is a maneuverable glide vehicle that is fired into space by rockets or a ballistic missile and then released to glide to its target along the upper atmosphere. Hypersonic glide vehicles fly at a lower altitude than ballistic missiles and can change their intended target and trajectory repeatedly during their flight.

†Geographic entanglement occurs when a state's conventional and nuclear forces are located in the same space, such as when the forces are garrisoned together during peacetime or when

transmitters to communicate with both its conventional attack submarines and its SSBNs.[53] This means any effort by an adversary to disrupt communications between a PLA theater command and at-sea conventional attack submarines during a war could risk nuclear escalation by cutting off communications with the nuclear submarines.

Land-Based Missiles Remain Central to China's Nuclear Posture

China's land-based ballistic missile force is the backbone of its nuclear deterrent and is undergoing a dramatic expansion. The PLA Rocket Force operates China's ICBMs for strategic deterrence missions and a variety of shorter-range ballistic missiles for regional deterrence missions. Up to half of the PLA Rocket Force's 40 missile brigades* may be nuclear capable.[54] The brigades operating China's nuclear missiles are dispersed at many locations across the country and assigned to six bases;† a seventh base located in Shaanxi Province is responsible for storing and handling most of the force's nuclear warheads.[55]

China's Strategic Missiles

The ICBM force is reducing its vulnerability to an adversary's surprise attack by transitioning from liquid-fuel missiles to a combination of solid-fuel silo-based missiles and road-mobile missiles.‡ There are currently about 100 ICBMs in the PLA Rocket Force's arsenal that could be assigned to various targets in the United States, Russia, and India.[56] These systems currently include the liquid-fuel, roll-out-to-launch DF-4 (range of 5,500 kilometers); the liquid-fuel, silo-based DF-5 (range of 13,000 kilometers), which has two MIRVed variants; and the solid-fuel, road-mobile DF-31, DF-31A, and DF-31AG (ranges varying from 7,000 to 12,000 kilometers).[57] A new solid-fuel, road-mobile, MIRV-capable ICBM known as the DF-41 (range of 14,000–15,000 kilometers) became operational in 2020 and has been integrated into at least two brigades.[58] DOD assess-

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they operate in the same areas during a crisis or wartime. Operational entanglement occurs when conventional and nuclear forces are operated by or rely on the same military institutions or practices, such as when these forces share personnel, command and control structures, mission sets, or maintenance and logistics infrastructure. Technological entanglement occurs when the delivery systems of conventional and nuclear forces are identical or indistinguishable, as is the case with dual-capable weapons or weapons that have both conventional and nuclear variants. David Logan, "Are They Reading Schelling in Beijing? The Dimensions, Drivers, and Risks of Nuclear-Conventional Entanglement in China," forthcoming in *Journal of Strategic Studies*, 2020, 5–6.

*The PLA Rocket Force has added ten brigades or more, an increase of more than one-third since 2017. Ma Xiu and Peter W. Singer, "What Do We Know about China's Newest Missiles?" *Defense One*, March 19, 2021.

†PLA Rocket Force "bases" are sometimes referred to as "armies" and are responsible for different geographic regions in China. PLA Rocket Force brigades are assigned to bases numbered 61 through 66; an additional base, Base 67, stores the nuclear warheads. Each base may supervise between four and seven brigades, and each brigade encompasses thousands of personnel. The structure of brigades varies depending on whether they operate conventional missiles, mobile nuclear missiles, or fixed site (silo-based or cave-rollout-to-launch-site) nuclear missiles. Conventional brigades may have up to 36 launchers with as many as six missiles per launcher (enabling up to five reloads). Mobile nuclear brigades may have between six and 12 missile launchers per brigade, while fixed site nuclear brigades may have six or fewer launchers (silos or roll-out sites) per brigade. Christopher J. Mihal, "Understanding the People's Liberation Army Rocket Force: Strategy, Armament, and Disposition," *Military Review*, July–August 2021; Decker Everleth, "Mapping the People's Liberation Army Rocket Force," *A Boy and His Blog*, July 2, 2020; David Logan, "Making Sense of China's Missiles Forces," in Phillip C. Saunders, Arthur S. Ding, and Andrew Scobell, eds., *Chairman Xi Remakes the PLA: Assessing Chinese Military Reforms*, National Defense University Press, 2019, 403–404.

‡By transitioning to solid-fuel missiles, China is improving the survivability and safety of its ICBM force. Liquid-fuel ICBMs are vulnerable to attack because they take more time to fuel before launch; liquid fuel is also dangerous to handle because it is toxic and corrosive.

es that the DF-41 could also have silo-based and rail-based launch options.[59]

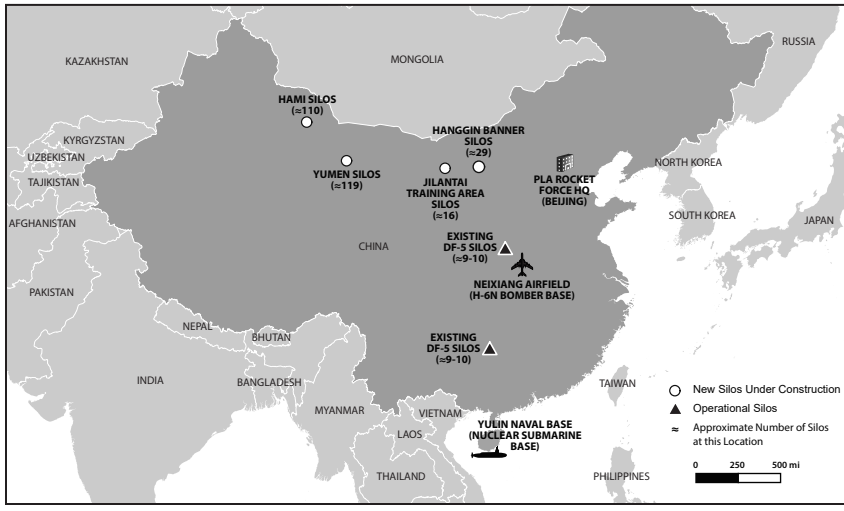
Due to increases in China's arsenal of ICBM missiles, launchers assigned to its ICBM brigades, and MIRV technology, the number of warheads that can be mounted on ICBMs threatening the United States is expanding.[60] According to Hans M. Kristensen, director of the Nuclear Information Project at the Federation of American Scientists (FAS), in 2000 China possessed 35 ICBMs, of which 20 could hit the continental United States carrying one warhead each.[61] Today, most of China's 100 ICBMs are capable of hitting the United States with a total of about 125 nuclear warheads, though they are not all necessarily assigned to U.S. targets.[62] DOD predicts that the number of warheads on China's land-based ICBMs capable of striking the United States, which make up only a portion of its total warhead stockpile, will grow to 200 by 2025.[63]

Moreover, the PLA Rocket Force is constructing more than 270 new missile silos for its ICBM force in remote regions of China that could be intended for multiple purposes. In 2021, researchers analyzing satellite imagery discovered construction underway for 16 silos near the city of Jilantai in the western reaches of Inner Mongolia, 119 new silos near the northwestern city of Yumen in Gansu Province, approximately 110 new silos near the city of Hami in Xinjiang, and at least 29 silos* in Hanggin Banner in Inner Mongolia (see Figure 1).[64] That total is more than ten times the number of silos the PLA Rocket Force currently operates, greater than the number of ICBM silos Russia operates, and more than half of the approximately 400 land-based ICBMs the United States maintains in silos today.[65] According to Roderick Lee, director of research at the China Aerospace Studies Institute, between the newly discovered silos and the PLA Rocket Force's currently operational ICBM brigades, China's projected inventory of ground-based ICBM launchers is already "close to or more than the United States' current number of deployed Minuteman III ICBMs."[66] The silo fields are in various stages of development and could take between five and ten years to become operational.[67]

The emergence of new silos—which are easily identifiable and vulnerable to precision-guided munitions—is surprising given China's emphasis in recent years on improving mobility, camouflage, and concealment for its ICBMs.[68] The PLA Rocket Force (and its predecessor, the Second Artillery) has long relied on an elaborate infrastructure to store and transport its ballistic missiles, including a vast network of underground tunnels, wheeled transporter erector launchers, and rail networks.[69] This infrastructure improves the survivability of China's nuclear forces but requires the relatively time-consuming practices of bringing ICBMs out of storage, mating them with their warheads, erecting them on mobile launchers, and connecting them to the appropriate command and control infrastructure before firing a counterstrike. By contrast, silo-based missiles are the most responsive element of a country's nuclear forces because they can be put on high alert and launched quickly.[70]

*Roderick Lee, director of research at the China Aerospace Studies Institute, estimates that this site could eventually contain up to 36 silos. Roderick Lee, "PLA Likely Begins Construction of an Intercontinental Ballistic Missile Silo Site Near Hanggin Banner," *Air University*, August 12, 2021.

Figure 1: China's Silo-Based ICBMs



Sources: Hans Kristensen, Director of the Nuclear Information Project at the Federation of American Scientists, interview with Commission staff, September 24, 2021; Roderick Lee, "PLA Likely Begins Construction of an Intercontinental Ballistic Missile Silo Site Near Hanggin Banner," *Air University*, August 12, 2021; Matt Korda and Hans Kristensen, "China Is Building a Second Nuclear Missile Silo Field," *Federation of American Scientists*, July 26, 2021; Joby Warrick, "China Is Building More than 100 New Missile Silos in Its Western Desert, Analysts Say," *Washington Post*, June 30, 2021; Hans Kristensen, "China's Expanding Missile Training Area: More Silos, Tunnels, and Support Facilities," *Federation of American Scientists*, February 24, 2021; Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 98–100; Roderick Lee, "China's Air Force Might Be Back in the Nuclear Business," *Diplomat*, September 9, 2020; Tyler Rogoway, "Image Shows Chinese Submarine Entering Mysterious Cave Facility at South China Sea Base," *Drive*, August 19, 2020.

Some observers speculate that China could deploy some of its ICBMs across the matrix of new silos while filling others with decoys in a Cold War-style "nuclear shell game" for the purpose of complicating adversary targeting.[71] Alternatively, China could fill most or all of the silos with ICBMs, which—especially if MIRVed—would improve the chances that more of China's ICBMs survive an adversary's first strike and defeat its missile defenses.[72] Finally, DOD assesses that expanding the silo-based force and putting a portion of that force on heightened alert would enable China to shift to a launch-on-warning posture, which would allow China to rapidly launch its ICBMs upon notification of an incoming attack before their silos could be destroyed.[73] Each interpretation assumes China's motive for building the silos is to secure its second-strike capability rather than to develop a first-strike capability. Large numbers of silo-based missiles can also be used to launch a preemptive nuclear strike on an adversary.

China's Regional Missiles

The PLA Rocket Force also has nuclear-capable MRBMs and IRBMs capable of hitting targets across the Indo-Pacific, such as allied capitals or U.S. military bases. These include the road-mobile, solid-fuel DF-21 MRBM (range of 2,150 kilometers) and the road-mobile, solid-fuel DF-26 IRBM (range of 4,000 kilometers).[74]

Overall, the PLA Rocket Force has assigned about 60 nuclear warheads to regional missions.[75]

The DF-26 entails unique escalation risks because it is a dual-capable missile system that is "hot swappable" or able to switch rapidly between conventional and nuclear warheads on a launch-ready missile.[76] DF-26 brigades have held drills in which units launch a conventional attack and then reload with a nuclear warhead to prepare for nuclear counterattacks.[77] This technological and operational entanglement generates pressures for escalation to nuclear use by making it difficult for an adversary to distinguish whether a warhead carried by the DF-26 is conventional or nuclear in flight and, by extension, to decide on an appropriate targeting response.[78] As DOD notes, because the DF-26 is China's first nuclear-capable missile system that can conduct precision strikes, it is the most likely weapon system to field a low-yield warhead in the near-term.[79] The DF-26's precision enables it to be used for nuclear missions targeting U.S. military assets in the Indo-Pacific, though authoritative Chinese military texts do not show that PLA doctrine has officially shifted from its traditional emphasis on countervalue targeting.

China's Bomber Force Regains a Nuclear Mission

The PLA Air Force appears to have reassumed a nuclear mission after a long period of dormancy, indicating its bombers could carry out nuclear counterstrike missions to supplement China's land- and sea-based nuclear deterrent.*[80] In 2019, the PLA unveiled a new nuclear-capable variant of the H-6 known as the H-6N that is reportedly capable of air-to-air refueling and has a modified fuselage that may allow it to carry a nuclear air-launched ballistic missile.[81] The PLA's H-6Ns are likely stationed in central China next to a hardened underground facility that could be used to store the aircraft in peacetime.[82] China is also developing a nuclear-capable long-range stealth bomber known as the H-20 that will likely enter production within the next decade.[83]

DOD assesses that the deployment of the air-launched ballistic missile on China's H-6N will "provide China for the first time with a viable nuclear triad of delivery systems," though the bombers' limited range suggests they would more likely be used for missions closer to China.[84] Mr. Lee observes that China's nuclear triad is somewhat "lopsided" because its air-launched component is relatively small and too limited in range to target the continental United States unless its bombers fly across Russian airspace or the Pacific Ocean with their accompanying tankers.[85] He argues that the PLA could be pursuing a nuclear bomber force to deter China's other nuclear-armed neighbors, for use against U.S. bases in the region, or

*The PLA Air Force delivered at least 12 of the nuclear weapons China detonated as part of its nuclear testing program in the 1960s and 1970s. The U.S. Intelligence Community assessed that some of China's bombers trained for nuclear missions in the 1970s, but the country did not have a dedicated strategic bomber force resembling that of the United States or Soviet Union. The PLA Air Force's nuclear capability is thought to have atrophied during the Cold War and its nuclear mission did not appear active until the PLA Air Force publicly revealed the H-6N as its first nuclear-capable air-to-air refuellable bomber during a 2019 military parade commemorating the PRC's 70th anniversary. Kenneth W. Allen and Cristina L. Garafola, "70 Years of the PLA Air Force," *China Aerospace Studies Institute*, 2021, 83; Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 453; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 50–51.

for the purpose of establishing nuclear competencies within the PLA Air Force.[86] Given the limited range of China's bombers and sufficiency of other legs of the triad for China's nuclear deterrent, however, some analysts believe the reactivation of the PLA Air Force's nuclear mission more likely reflects its success as a bureaucratic actor in fighting for resources than a clear strategic mission.[87]

Nuclear Warhead Stockpile Could Double by 2030

China needs more nuclear warheads to arm its new delivery systems and will significantly expand its inventory of nuclear warheads over the next decade. China currently maintains a modest stockpile of nuclear warheads similar in size to that of France or the United Kingdom, depending on the estimate used.*[88] DOD estimated in 2020 that China's operational nuclear warhead stockpile was in the low 200s.[89] DOD reports on China's military capabilities from the early 2000s do not indicate how large they assessed China's nuclear stockpile to be at that time, though they asserted the PLA planned to increase the number of nuclear warheads that could target the United States in the future.[90] Researchers at FAS placed China's 2020 stockpile at up to 350 warheads.[91] Their estimate of 350 warheads included roughly 272 operational warheads assigned for delivery by China's land-based ballistic missiles, sea-based missile forces, and nuclear-capable bombers, as well as 78 warheads to arm new land- and sea-based missiles still in the process of being fielded.[92] FAS researchers assess that the stockpile grew by roughly 118 warheads between 2000 and 2021.[93]

Projections of the future size of China's stockpile vary, but credible sources generally agree the increase will be significant. DOD estimated in 2020 that the country's operational nuclear warhead stockpile will likely double to more than 400 over the next decade.[94] Mr. Kristensen testified before the Commission that a doubling of the stockpile over the next decade is plausible given China's past and ongoing modernization efforts.[95] Admiral Richard predicted publicly in February 2021 that China's nuclear weapons stockpile could even triple or quadruple over the next decade.[96] Assuming the most extreme case of a quadrupling of DOD's estimate, China could possess up to 1,000 warheads in ten years' time, a figure equivalent to more than two-thirds of the 1,400 strategic warheads the United States deploys on ballistic missiles† and less than one-third of the total U.S. stockpile of strategic warheads.‡[97]

According to Mr. Kristensen, projections for doubling, tripling, or quadrupling China's nuclear warhead stockpile over the next decade would require significant changes to its current force structure.[98] He estimates that to field a doubled stockpile, China would need to increase the number of its DF-31AG brigades, double its road-mobile DF-41s with MIRV capabilities, deploy a new brigade of silo-based DF-41s with MIRVs, field an additional Type 096 SSBN

*According to the Federation of American Scientists, France and the United Kingdom maintain stockpiles of 290 and 225 nuclear warheads, respectively. Hans M. Kristensen and Matt Korda, "Status of World Nuclear Forces," *Federation of American Scientists*, May 2021.

†The New START Treaty caps the number of deployed U.S. and Russian strategic nuclear warheads and bombs at 1,550. Arms Control Association, "New START at a Glance," February 2021.

‡As of early 2021, the United States maintained an estimated stockpile of around 3,800 nuclear warheads. According to FAS, about 1,800 warheads are currently deployed on ballistic missiles or at strategic bomber bases. Around 2,000 are kept in storage to be used as a "hedge" as conditions warrant. Hans M. Kristensen and Matt Korda, "United States Nuclear Weapons, 2021," *Nuclear Notebook*, January 12, 2021.

with MIRVed JL-3 missiles, and field more than a dozen nuclear bombers.[99] To field a tripled stockpile, China would need to increase the number of DF-31AG and DF-41 brigades, add additional rail-based DF-41s, field two Type 096 SSBNs, and double the number and weapons capacity of its nuclear bombers.[100] Mr. Kristensen estimates that to field a quadrupled stockpile, China would require a large number of additional road-mobile and rail-based missiles, more nuclear DF-26 units, more bombers, and more MIRVed payloads on its DF-41 ICBMs.[101]

China's Warhead Stockpile Can Grow without New Fissile Material Production

China could vastly increase its stockpile of nuclear warheads without producing additional fissile material. According to Harvard University Belfer Center research associate Hui Zhang, China halted production of highly enriched uranium and plutonium for nuclear weapons in the 1980s and maintains military stockpiles of 14 ± 3 tons* of highly enriched uranium and 2.9 ± 0.6 tons of plutonium from that time.[102] Mark Hibbs, nonresident senior fellow at the Carnegie Endowment for International Peace, testified before the Commission that China could produce between 200 and 800 additional nuclear weapons using its existing plutonium inventory, depending on how many kilograms of plutonium one estimates is necessary for Chinese nuclear weapons designs.[103]

If Chinese leaders wished to generate additional weapons-grade plutonium for even more warheads, Mr. Hibbs said, they could build a new plutonium production reactor, repurpose an existing Chinese research reactor to produce weapons-grade plutonium, or operate fast reactors as part of their civil nuclear power program to "breed" plutonium.[104] At present, there is no evidence China intends to use its fast reactors for nuclear weapons production, and neither of its two 600-MW reactors are yet operational.[105] Given the sufficiency of China's existing inventories of fissile material, Chinese leaders may see little need to make use of these additional pathways.

Recent construction activity at China's testing and weapons production facilities may offer additional evidence China is expanding its production of nuclear warheads. Commercial satellite images of China's longtime nuclear weapons testing site at Lop Nur taken between 2019 and 2021 showed construction of a probable drill site, a probable underground facility, an excavated recess, and new roads that could be a part of the support facilities required to conduct new nuclear tests.[106] Satellite imagery of Pingtong nuclear facility, which manufactures Chinese nuclear weapons components, also shows new and renovated buildings for steam production and electricity consumption constructed between 2010 and 2020 that may increase its capacity to produce larger numbers of finished nuclear weapons.[107]

China May Pursue Low-Yield Warheads in the Future

DOD assesses that China may complement its stockpile of strategic nuclear warheads with the production of low-yield warheads for tactical nuclear weapons in the future.[108] Most of China's nuclear

*± is a notation used to measure uncertainty and is read "plus or minus."

warheads have large yields ranging from several hundred kilotons to more than one megaton; they are designed to be delivered across a region or continents and to inflict large-scale damage on their targets.[109] By contrast, low-yield weapons can range from 5 kilotons to 150 kilotons and are useful for calibrating damage to smaller targets, such as military bases or aircraft carriers.[110]

There is little publicly available evidence that China has deployed tactical nuclear weapons, but U.S. Intelligence Community estimates from the 1970s and 1980s noted "circumstantial evidence" the country could have developed low-yield warheads, perhaps for use in small bombs or depth charges.[111] The PLA also held several military exercises in the early 1980s simulating the use of tactical nuclear weapons, though simulations themselves do not prove development or deployment.[112]

Chinese commentators have argued in recent years that China requires lower-yield nuclear weapons to enhance deterrence and to expand the PLA's options for engaging U.S. forces in a regional war.[113] Moreover, a 2017 article that originally appeared in the overseas edition of the *People's Daily* cited an interview with retired PLA Rocket Force Senior Colonel Yang Chengjun in which he mentioned that the PLA would develop "smaller tactical nuclear warheads to attack the enemy" and limit collateral damage to civilian targets.[114] China reportedly carried out a secret test at its Lop Nur facility in 2019 that the State Department and some observers say was consistent with testing a low-yield weapon.[115]

China Enhances Nuclear Command, Control, and Communications

China has made substantial progress over the last two decades toward improving the survivability of its NC3, or the systems and processes for directing strategic forces to alert or employ nuclear weapons.*[116] According to Phillip C. Saunders, director of the Center for the Study of Chinese Military Affairs at the National Defense University, between the 1980s and early 2000s China had an "underdeveloped" NC3 system and no strategic ISR systems that could provide warning of an incoming attack.[117] Since then, China's NC3 system and the ISR that supports it have improved substantially. The PLA's situational awareness now enables more rapid retaliation against a nuclear strike and forms the basis for a nascent ballistic missile defense system. This progress is consistent with goals for China's nuclear force modernization identified by its 2015 white paper, which called for "improved strategic early warning, command and control… and rapid reaction."[118]

China's Shifting Readiness and Nascent Triad Complicate Command and Control

China's NC3 system has historically emphasized centralization and strict controls to prohibit the unauthorized use of nuclear weapons. Authority to decide whether to use nuclear weapons is reserved

*According to DOD, NC3 includes detecting and characterizing incoming attacks, facilitating decision-making, transmitting orders to alert or use nuclear weapons, and directing the strategic forces. It therefore requires excellent ISR to provide situational awareness of incoming attacks and redundant communications to ensure strategic forces carry out orders to use nuclear weapons. U.S. Department of Defense, *Nuclear Posture Review*, 2018, XIII.

to China's top leaders in the Politburo Standing Committee.[119] The Central Military Commission (CMC), headed by General Secretary Xi, handles the execution of Chinese nuclear operations.[120] The PLA Rocket Force is commanded directly by the CMC rather than indirectly through the geographical Theater Commands that oversee the other services, an arrangement reflecting the importance China's leaders place on controlling the nuclear forces.[121] China may have several practices in place to prevent the unauthorized use of nuclear weapons, including storing warheads and delivery systems separately in peacetime, installing technical-use controls on the weapons themselves, and enacting a "two-man rule" prohibiting access to or control of the weapons by any single person.[122]

The PLA Rocket Force appears to be putting portions of its forces on heightened alert in an effort to improve its readiness. China keeps the majority of its nuclear forces on a peacetime status with separated launchers, missiles, and warheads, DOD notes, but nuclear and conventional PLA Rocket Force brigades conduct "combat readiness duty" and "high-alert duty," which include assigning a missile battalion "to be ready to launch" and rotating to standby positions as often as monthly for "unspecified periods of time."[123] These periods of combat readiness and high-alert duty presumably involve temporarily mating warheads and delivery systems and could be part of what DOD assesses is an impending move by some portions of China's nuclear forces to a launch-on-warning posture.[124]

The PLA Rocket Force's growing numbers of mobile launchers and dual-use missiles could complicate its NC3 process. China's leaders maintain redundant means of communication and command pathways, including the ability to skip echelons of command, to ensure their orders reach the firing units responsible for carrying out nuclear strikes.* Dr. Saunders notes that the NC3 system may struggle to adequately track China's growing number of mobile ICBMs since all of those mobile launchers will be dispersed from garrison to concealed locations during a crisis or conflict.[125] Another NC3-related complication that may arise is whether the PLA Rocket Force brigades operating the hot-swappable DF-26 missile will answer to orders directly from the PLA Rocket Force, which oversees nuclear missions, or from the Theater Commands, which oversee conventional missions.[126]

Little information is available about the NC3 processes for China's SSBN fleet and strategic bomber force, which may pose their own challenges for command and control. During a crisis or conflict, the CMC will presumably relay orders to alert or use nuclear weapons to PLA Navy headquarters and PLA Air Force headquarters,

*According to George Washington University assistant professor Fiona Cunningham, the CMC will transmit orders to alert or use nuclear weapons to the CMC Joint Operations Command, PLA Rocket Force Headquarters, the missile bases, and then down the chain of command to the missile launch companies. China's leaders can relay orders directly to missile brigades, battalions, or launch companies during a crisis (the so-called "skip echelon" system). The PLA Rocket Force's communications brigades operate redundant means of communication, including radio, fiber-optic cables, and satellites, to ensure CMC orders are successfully transmitted to operational units. The PLA Rocket Force also operates an automated command system that may be interoperable with that of other PLA services and include support for its mobile missile force. Bates Gill, "Organization of China's Strategic Forces," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 171; Fiona Cunningham, "Nuclear Command, Control, and Communications Systems of the People's Republic of China," *Nautilus Institute*, July 18, 2019; Yu Xijun, ed., *The Science of Second Artillery Campaigns* (第二炮兵战役学), People's Liberation Army Publishing House, 2004, 168. Translation.

which will then convey those orders to the submarines on patrol and the nuclear bombers, respectively.[127] Dr. Saunders observes that each branch must "develop [its] own operational doctrine, personnel reliability systems, and nuclear warhead handling facilities to support… nuclear operations," but the details are currently unknown.[128] The SSBN fleet may have difficulty maintaining contact with its command authority while operating in deep ocean waters on patrol, though media reports in 2018 indicated China had built a massive experimental antenna that could transmit messages to submerged submarines via extremely low-frequency waves.*[129] Moreover, China's SSBNs cannot replicate the PLA Rocket Force's practice of keeping nuclear warheads separated from their missiles. The PLA will need to discard this practice for its SSBNs to carry nuclear weapons on patrol, which will remove a traditional barrier to unauthorized use.[130]

ISR Capabilities Will Enable Multiple Missions

China's ISR systems improve targeting and situational awareness for China's nuclear forces, enabling missions such as strategic early warning and ballistic missile defense. An overlapping network of radars and sensing satellites, most of which the PLA Strategic Support Force likely operates in direct support of the CMC and PLA Rocket Force headquarters, are the most important elements.[131] Together, these capabilities improve Chinese leaders' situational awareness and could enable them to move to a launch-on-warning posture, whereby the PLA would launch nuclear weapons in retaliation for an incoming strike that has been detected by ISR systems but not yet detonated on Chinese territory.

China's ground-based radars, which include large-phased array radars, over-the-horizon radars, and radars that detect low-flying targets, enable the PLA to detect threats from different trajectories. The Strategic Support Force now operates four large-phased array radars that can detect and track incoming ballistic missiles at the apex of their trajectory up to 5,000 kilometers away.†[132] Moreover, China has two over-the-horizon radar systems that can detect ballistic missile launches up to 2,500 kilometers away from the southeast, giving China radar coverage over neighboring countries in the East China Sea and much of the Western Pacific.[133] China also has a high-frequency surface wave radar as well as radars associated with

*Submerged submarines are unable to communicate with their command authorities at ordinary radio frequencies, which do not travel well through saltwater. Submarines can surface and raise an antenna above sea level to use ordinary radio transmissions for communication, but this makes them vulnerable to anti-submarine warfare. Such vulnerability is problematic because submerged submarines need to be able to receive their launch orders in the event of a nuclear war. Technological innovations during the Cold War led to several methods for underwater communication, such as the use of very low frequency radio waves at shallow depths and extremely low frequency radio waves at depths up to hundreds of meters. Extremely low frequency transmitters are technically difficult to construct and only the United States, Russia, China, and India are known to use them. Ryan White, "How Do Submarines Communicate with the Outside World?" *Naval Post*, May 3, 2021.

†The north-facing large-phased array radar at Huanan can detect and track ICBMs launched from the United States and Russia on a polar trajectory, while the large-phased array radars at Yiyuan and Longgangzhen face southeast toward Taiwan and the South China Sea for the possible purpose of bolstering Chinese conventional strikes on targets in those areas. The large-phased array radar at Korla can face west, south, southeast, or east and may be utilized for tracking satellite launch and missile intercept tests. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 115–116.

indigenous and Russian-made surface-to-air missile (SAM) systems that can detect low-flying stealth aircraft and cruise missiles from hundreds of kilometers away.[134]

China is developing infrared satellites to detect ballistic missiles from space, though the extent to which it may already have such satellites is unclear. China has built a constellation of infrared early warning satellites named Shaobing akin to the United States' Defense Support Program satellites in geosynchronous orbit, according to a 2018 article in *Science and Technology Daily*, the official newspaper of China's Ministry of Science and Technology.[135] Secret Chinese satellite launches in 2015, 2017, and 2020 provoked speculation that the country was establishing a constellation of early warning satellites in geosynchronous orbit similar to the United States' Space-Based Infrared System, but it is not clear if this constellation is the Shaobing constellation or something else.[136] In 2019, Russian President Vladimir Putin said Russia is helping China build an early warning system, cooperation that could include assistance on space-based sensors.[137] China's Yaogan electro-optical satellite constellation provides broad coverage of ships and aircraft operating in the Pacific Ocean.[138]

China has intermittently researched and tested technologies required for ballistic missile defense since the 1960s, even though it formally opposes U.S. ballistic missile defense.[139] Dr. Saunders testified that China already has a "limited capability against tactical and medium-range ballistic missiles" enabled by its Russian-built and indigenous SAM systems, advanced interceptors, and ISR capabilities.[140] For example, DOD assesses that China's domestic HQ-9 long-range SAM system "likely has a limited capability to provide point defense against tactical ballistic missiles."[141] China has also tested its HQ-19 mid-course interceptor, which may be able to intercept ballistic missiles within a 3,000-kilometer range, similar to the U.S. Terminal High Altitude Area Defense system.[142] Dr. Saunders notes the PLA "has some capability to engage both short-range and medium-range ballistic missiles," though the speed of its interceptors and its launch detection capabilities may limit its ability to intercept longer-range missiles.[143]

China's Modernized Nuclear Forces Enable Changes in Strategy and Heighten Nuclear Risks

The observable transformation of China's nuclear posture and the projections for its expansion over the next decade raise questions about changes in China's nuclear strategy. Recent qualitative and quantitative improvements in the nuclear forces clearly allow Chinese leaders to pursue a more ambitious nuclear strategy if they wish to do so. Regardless of the strategic intent behind these changes, China's buildup creates new capabilities that an increasingly risk-tolerant Chinese leadership could someday feel emboldened to employ either for threats or for limited use during a regional conflict.

Moreover, the risks of a nuclear exchange between China and the United States are higher today than in the past. The entanglement of China's conventional and nuclear forces creates risks of accidental nuclear escalation during a conventional war triggered by Chi-

na's aggression in the Indo-Pacific. If Chinese leaders have already changed their strategy without declaring they have done so, they could be much more likely to intentionally threaten or use nuclear weapons to achieve their regional objectives, such as deterring or degrading intervening U.S. forces in a conventional war over Taiwan they fear they could lose. Finally, if Chinese leaders choose to shift their land-based missile force to a launch-on-warning posture, the difficulties associated with learning to operate such a system could generate false alarms about nonexistent incoming nuclear attacks, potentially triggering a nuclear exchange between China and the United States.

Competing Interpretations of China's Nuclear Buildup

The available evidence about China's nuclear buildup is consistent with multiple interpretations of Chinese leaders' intent. Chinese leaders could simply be upgrading their nuclear forces to ensure they can survive and retaliate against an adversary's first strike without altering China's current nuclear strategy. Alternatively, many of these advances could enable a shift to a launch-on-warning posture. A third possibility is that Chinese leaders could be transforming their nuclear forces to support a strategy involving the limited use of nuclear weapons against conventional military targets in the Indo-Pacific, such as U.S. aircraft carriers and bases, while continuing only to target an adversary's major cities in retaliation for a nuclear attack China sustains first. These explanations are not mutually exclusive; Chinese leaders could intend to keep their current retaliatory strategy for now but reserve the option to adopt a new nuclear strategy in the future should conditions warrant.

China's Buildup Aims to Create a Survivable Retaliatory Force

One interpretation is that China may be building up its nuclear forces in order to improve or restore its second-strike capability, which was arguably never truly secure but has been undermined in recent years by technological advances in other nuclear weapon states China considers a threat.[144] Chinese scholars and some U.S. analysts identify the United States' development of ballistic missile defense and conventional long-range strike capabilities for "damage limitation"* as the main impetus for changes in China's nuclear posture.[145]

The PLA's emerging nuclear triad, growing warhead stockpile, and increasing reliance on mobile platforms make it more difficult for an adversary to disarm China in a nuclear first strike, increasing what George Washington University assistant professor Fiona Cunningham and Massachusetts Institute of Technology political science professor M. Taylor Fravel call the "assuredness" of retal-

*"Damage limitation" refers to the ability to significantly reduce the damage an adversary can inflict against the U.S. homeland in an all-out nuclear retaliatory attack. During the Cold War, the United States interpreted damage limitation as denying the Soviet Union an "assured destruction capability" against the United States, which then Secretary of Defense Robert McNamara defined as a state's ability to destroy 20 to 25 percent of another country's population and 50 percent of its industrial base in retaliation after an attack on its nuclear forces. Damage limitation requires robust ISR to track incoming missiles, capable ballistic missile defense to intercept missiles in flight, and long-range weapons (conventional or nuclear) that can destroy a state's nuclear forces on land and at sea, as well as its nuclear command and control infrastructure. Charles L. Glaser and Steve Fetter, "Should the United States Reject MAD? Damage Limitation and U.S. Nuclear Strategy toward China," *International Security* 41:1 (Summer 2016): 54, 55, 62.

iation.[146] MIRV technology on China's ICBMs and the ability to launch enough missiles to impose unacceptable damage on an adversary's cities helps China complicate the U.S. approach to damage limitation and advance a de facto—if not political*—state of mutual vulnerability.[147] Growing numbers of missile silos improve the likelihood that more of China's ICBMs survive an attack, since they are hardened and could be filled with a mix of decoys and real warheads.[148] Viewed through this lens, a decision by China to adopt a launch-on-warning posture could also be consistent with the retaliatory aspect of its current nuclear strategy.[149]

China's Buildup Enables a Transition to Launch-on-Warning

Chinese leaders might also intend their nuclear buildup to support the adoption of a launch-on-warning posture. Such a posture, which is technologically sophisticated and greatly increases the speed with which China can retaliate against an incoming attack, arguably supersedes the requirements of minimum deterrence if adopted across the ICBM force. The very short time frame for decision-making created by a launch-on-warning posture could lead Chinese leaders to launch a second strike with overwhelming force, before they are able to assess the scale of the damage sustained by a target as a result of the adversary's first strike. Such a posture thus creates the possibility that China could impose disproportionate damage on an adversary that struck it first in a more limited fashion, behavior that would be inconsistent with the proportionality and relaxed response time emphasized by China's historical nuclear strategy. More importantly, a transition to launch-on-warning heightens the risks of accidental or erroneous nuclear escalation (for more, see "China's Shift to Launch-on-Warning Could Result in Accidental Nuclear Launch").[150]

China's Buildup Enables a More Ambitious Nuclear Strategy

China's nuclear posture could also support a more ambitious nuclear strategy that envisions the limited first use of nuclear weapons as a legitimate means of achieving China's political objectives in the region. Such a strategy would be consistent with important, if officially marginalized, Chinese intellectual debates that took place in the past over how China could use nuclear weapons to prevail in wars and whether it should discard the no-first-use policy. Chinese leaders today could be more receptive to the PLA's perennial push for additional strategic options as they consider how best to achieve their expanding political interests.

According to Dr. Saunders, PLA theorists have repeatedly raised the possibility of a shift toward a more ambitious nuclear doctrine that might include nuclear warfighting,† only to have CCP leaders

*The United States does not publicly acknowledge a mutual vulnerability relationship with China. The nuclear forces of China and the United States can hold each other's countries at risk, but not to the same extent given the greater size and sophistication of the U.S. arsenal as well as U.S. ballistic missile defense capabilities.

†Nuclear warfighting strategies, often described as "flexible" or "limited" nuclear option approaches, purportedly enable military commanders to limit the effects of a nuclear war by targeting an enemy state's nuclear forces and military infrastructure (counterforce targeting) rather than its major population centers (countervalue targeting). Concepts of nuclear warfighting assume that nuclear weapons can be deployed with discrimination and flexibility to accomplish political objectives without resulting in escalation to all-out nuclear war. Nuclear warfighting strategies are distinct from strategies that envision the only function of nuclear weapons as

end the discussion.[151] In the 1980s, for example, Chinese strategists debated the possibility of a shift to "limited deterrence,"* an approach that envisioned a mix of counterforce and countervalue tactical, theater, and strategic nuclear forces to deter escalation to war or compel an adversary to back down if war broke out.[152] Christopher P. Twomey, associate professor at the Naval Postgraduate School, notes that passages in the 2004 authoritative text *Science of Second Artillery Campaigns* discuss "distinct waves of [nuclear] retaliation," suggesting the text's authors saw nuclear weapons as a tool to be employed in a graduated way to control further escalation† during a war that had already gone nuclear.[153]

More recently, writings by Chinese strategists and passages in authoritative texts over the past 20 years reflect an officially quashed debate over whether China should abandon or otherwise qualify no first use.[154] Some PLA officers have argued that China should use nuclear weapons first if an enemy's conventional attack threatens the survival of China's nuclear forces or of the CCP itself.[155] The aforementioned *Science of Second Artillery Campaigns* describes threatening nuclear use—though not actually employing nuclear weapons—in response to conventional attacks against high-value targets within China.[156] The 2020 *Science of Military Strategy* discusses launching nuclear weapons in "demonstration strikes," presumably on China's territory or the open ocean, to signal resolve during a crisis.[157]

Nuclear Use against Regional, Conventional Military Targets to Deter or Degrade Adversary Forces

If Chinese leaders decide to adjust their nuclear strategy, they are most likely to adopt one involving the limited first use of low-yield, more precise nuclear weapons against select conventional military targets in the Indo-Pacific region.[158] Chinese leaders may believe such a strategy would deter U.S. intervention or confer significant military advantages if it enables them to destroy assets critical to U.S. military operations, such as U.S. aircraft carriers or the bases

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deterring an enemy from launching a nuclear attack. Nuclear warfighting strategies generally require many accurate, reliable, and survivable nuclear weapons; robust ISR; and efficient command and control processes, though the quantities may depend on the enemy state's nuclear capabilities. Bulletin of Peace Proposals, "Nuclear Deterrence, Nuclear War-Fighting and Nuclear Disarmament," *Arms and Disarmament SIPRI Findings*, 17:3/4 (1986): 391.

*According to Harvard University professor Alastair Iain Johnston, Chinese writings outlining limited deterrence identified as appropriate targets an enemy's strategic missile, naval and air forces, nuclear weapons stockpiles, command and control, early warning systems, transportation hubs, military industrial targets, and political and economic centers, among others. Hitting these targets and successfully suppressing escalation to higher levels of nuclear violence would require additional numbers of accurate and survivable ICBMs, SLBMs, tactical and theater nuclear weapons, ballistic missile defense, space-based early warning, and anti-satellite weapons. Chinese strategists believed a limited deterrent should be able to respond proportionately to any level of nuclear use, from tactical to strategic, and enable China to "entertain war-winning possibilities." China did not have the capabilities to implement limited deterrence when it emerged in the 1980s, however, and its core concepts were not reflected in policy or authoritative military texts published afterward. Alastair Iain Johnston, "China's New 'Old Thinking': The Concept of Limited Deterrence," *International Security* 20:3 (Winter 1995–1996): 5–6, 17–20.

†Nuclear weapons can theoretically be used to control substantial military escalation during an ongoing war, a concept known as "intrawar deterrence" or "transwar deterrence." Intrawar deterrence can be achieved by threatening to use nuclear weapons should the adversary escalate a conflict beyond a particularly important threshold. Christopher Twomey, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 3–4; Keith B. Payne, "The Great Divide in U.S. Deterrence Thought," *Strategic Studies Quarterly* (Summer 2020): 24; W. Andrew Terrill, *Escalation and Intrawar Deterrence during Limited Wars in the Middle East*, U.S. Army War College Press, 2009, xi.

on Guam and Okinawa.[159] They could signal restraint at the strategic level by keeping their ICBM force de-alerted and communicating directly that China would continue only to target an adversary's major cities with large-yield warheads in retaliation for a nuclear first strike on the Chinese Mainland.

Several technological developments within China's nuclear forces make this shift in strategy possible. Caitlin Talmadge, associate professor of security studies at Georgetown University, testified before the Commission that the precision, range, and hot-swappable character of the DF-26 suggest the system is "designed to be used for something other than a countervalue second strike" and "well suited to limited nuclear use against U.S. military targets in the Pacific."[160] Chinese commentators have described the future development and deployment of lower-yield nuclear weapons as means to destroy U.S. aircraft carriers and bases and to manage escalation.[161] Improvements to China's NC3 system and ISR would also better position China's theater nuclear forces to identify and successfully target U.S. forces during a regional conflict.[162] All of these capabilities support Admiral Richard's observation in February 2021 that China can now adopt "any plausible nuclear employment strategy regionally" with its nuclear forces.[163]

Chinese leaders could believe this strategy of limited nuclear use is unlikely to provoke further nuclear escalation because of the imbalance of nuclear forces at the theater level. The United States was unable to deploy nuclear or conventional intermediate-range missiles in the Indo-Pacific between 1987 and 2019 due to its participation in the now-defunct INF Treaty.[164] During the same period, China—which was not party to the treaty—rapidly expanded the intermediate-range missile arsenal that is now foundational to its conventional military strategy and developed several intermediate-range nuclear variants of these systems.[165] Brad Roberts, director of the Center for Global Security Research at Lawrence Livermore National Laboratory, told the Commission that as a result, the balance of Chinese and U.S. ground-based nuclear forces deployed in the Indo-Pacific is "roughly a thousand missiles to zero."[166] This imbalance means the United States lacks proportionate ground-based options to respond to a limited use of nuclear weapons by China at the theater level.

PLA Capabilities to Engage in Limited Nuclear Counterforce against the U.S. Homeland

China's military today may be capable of shifting to counterforce strategies* involving the very limited use of nuclear weapons

*One strategy might involve a limited "demonstration" of nuclear use, such as detonating a nuclear weapon to create an electromagnetic pulse on the open ocean water near a U.S. military installation. Chinese leaders could employ this strategy during a crisis to shock U.S. political leaders and demonstrate their resolve to escalate to higher levels of nuclear violence should the United States fail to "back down" over the issue at hand. The second strategy could involve using a low-yield nuclear weapon against one or more of the radars associated with U.S. missile defense, such as those located at military bases in Alaska. This strategy too would aim to intimidate U.S. leaders into accepting Chinese political objectives during a crisis, but it would have the added benefit of degrading U.S. NC3 and missile defense capabilities that would be relevant in the next stage of a war. Both strategies rely on highly questionable assumptions that the U.S. leadership would either not retaliate at all, for fear of inviting further nuclear attacks, or inflict a "tolerable," proportionate level of damage with a limited nuclear strike against a similar target in China. There is no evidence in Chinese military texts indicating Chinese leaders intend to adopt either strategy. Phillip C. Saunders, Director of the Center for the Study of Chinese Military Affairs at

against targets on the U.S. homeland with its highly precise DF-41 ICBM and lower-yield warheads potentially under development, but these strategies would be unable to manage escalation to all-out nuclear war. China remains technologically incapable of launching a disarming first strike against the United States. China's nuclear forces are not large enough or sophisticated enough to destroy most or all of the United States' nuclear forces. It is true China is developing highly accurate missiles, MIRVs, better ISR, the ability to launch rapidly, and ballistic missile defense, all of which are theoretically useful for destroying an adversary's nuclear forces and limiting any damage China could sustain in response. But to target and degrade large portions of the U.S. nuclear arsenal, the PLA would need vast quantitative increases and qualitative improvements in each of these capabilities. Even if it were to destroy many of the United States' silo-based ICBMs or strategic air bases, the PLA would almost certainly be unable to destroy U.S. SSBNs before they inflicted massive and unacceptable retaliation on the Chinese Mainland.

New Risks of Nuclear Escalation in a Competitive U.S.-China Relationship

Technological changes within China's nuclear forces and the growing chance of a conventional conflict in the Indo-Pacific theater increase the risks of escalation to a limited nuclear exchange between China and the United States. This section discusses specific risks associated with the PLA's entanglement of nuclear and conventional systems, the possibility China might use nuclear weapons to reverse the outcome of a conventional war it was losing, and the adoption of a launch-on-warning posture. It also assesses the risk that China's more credible nuclear deterrent could give Chinese leaders the confidence to pursue coercion or conventional aggression against U.S. allies and partners in the Indo-Pacific.

A U.S. Attack on "Entangled" PLA Assets Results in Nuclear Escalation

Growing entanglement between the PLA's conventional and nuclear forces, specifically in its intermediate-range missile systems and submarine forces, creates risks of accidental or unforeseen nuclear escalation. It is not clear whether the PLA has intentionally entangled these capabilities to heighten the risks it poses to its adversary, thereby enhancing deterrence, or whether it has done so to enhance operational efficiency.[167] Using the same designs for nuclear and conventional missile variants also saves costs associated with research and production, creating economies of scale.[168]

The PLA's entanglement of its conventional and nuclear forces increases the possibility that the United States could unintentionally degrade components of China's nuclear arsenal or its associated NC3 systems during a conventional war in ways that precipitate Chinese nuclear escalation. Dr. Talmadge describes this escalation pathway as "conventional counterforce" and notes it is most like-

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the National Defense University, interview with Commission staff, July 19, 2021; Christopher P. Twomey, Associate Professor at the Naval Postgraduate School, interview with Commission staff, July 20, 2021.

ly to emerge amid the fog of war and worst-case thinking during an armed conflict over Taiwan.[169] "If Beijing interprets the erosion of its sea- and land-based nuclear forces as a deliberate effort to destroy its nuclear deterrent through conventional counterforce, or perhaps even as a prelude to a nuclear counterforce, it might see limited nuclear escalation as a way to force an end to the conflict," she observes.[170] Similarly, Dr. Saunders agrees "U.S. strikes which inadvertently destroy a handful of Chinese ICBMs or severely degrade [PLA Rocket Force] strategic command and control systems could significantly heighten Chinese threat perceptions and create 'use or lose' pressures that encourage nuclear use."[171]

China Threatens or Uses Nuclear Weapons to Avoid Losing a War over Taiwan

Chinese leaders might also consider purposefully threatening the use of or actually using nuclear weapons as a means to reverse the outcome of a conventional war they were losing, such as a war over Taiwan. Consistent with methods of strategic deterrence described in the *Science of Military Strategy*, China could attempt to deter the United States from intervening in a conflict over Taiwan by threatening the use of nuclear weapons through escalatory signaling practices. These methods include adjusting the deployments of China's nuclear weapons, raising readiness levels, publicly revealing its prepared nuclear weapons, or carrying out warning strikes involving nuclear weapons (presumably on the open ocean), any of which could cause unintended escalation if mistaken by an adversary as preparations for a nuclear first strike.[172]

Alternatively, Dr. Talmadge argues that China could engage in "asymmetric escalation" by actually using nuclear weapons against U.S. military targets during a war over Taiwan.[173] "Given the island's political importance, it is not inconceivable to think that Chinese leaders losing a war over Taiwan could engage in asymmetric nuclear escalation to try to get the United States to back down or simply to halt the U.S. conventional campaign," she said.[174] China's use of nuclear weapons against conventional U.S. forces and bases during a Taiwan contingency would obviously constitute a violation of its no-first-use pledge, but in Dr. Talmadge's view would be comparable to the scenarios in which countries facing the loss of territory during a land war have historically threatened asymmetric nuclear escalation.*[175]

Chinese leaders' decision to escalate to nuclear use would rely on the potentially erroneous assumption that the United States would back down because it "cares less" about the outcome of a Taiwan

*Dr. Talmadge points out that China engaged in highly escalatory behavior during a border crisis with the Soviet Union in 1969. "China started a skirmish that risked war and initially believed that nuclear weapons would be irrelevant, even though the Soviet arsenal was several orders of magnitude larger than China's, just as the U.S. arsenal dwarfs China's today," she observed. After learning that the Soviets had discussed with other countries plans to attack China with nuclear weapons, Chinese leaders became deeply concerned that a nuclear attack was imminent despite having no evidence the Soviets intended to follow through on their threat. China tested a thermonuclear weapon at Lop Nur and placed the country's nuclear forces on a months-long alert for the first and only time in China's history, a risky move given that at the time the PLA relied on liquid-fueled missiles and rudimentary command and control procedures. Caitlin Talmadge, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 116; Caitlin Talmadge, "Would China Go Nuclear? Assessing the Risk of Chinese Nuclear Escalation in a Conventional War with the United States," *International Security* 41:4 (Spring 2017): 88–90.

conflict than does China. "The point of nuclear saber rattling in a Taiwan conflict for them would be to awaken us to the asymmetry of stake," Dr. Roberts told the Commission.[176] He argued that Chinese leaders may not fully appreciate the importance the United States places on Taiwan as a testament to democracy in Asia and as a bellwether for its extended deterrence commitments.[177] "That's a large stake and that's not wished away by the nuclear shadow," Dr. Roberts said.[178]

China's Shift to Launch-on-Warning Could Result in Accidental Nuclear Launch

A decision by China to adopt a launch-on-warning posture for its nuclear forces increases the risk of accidental nuclear use. Disarmament advocates generally regard launch-on-warning as destabilizing because it can produce false alarms about nonexistent attacks and trigger a nuclear exchange.[179] Admiral Richard called China's potential shift to launch-on-warning "unsettling" before the Senate Committee on Armed Services in April 2021 given what he described as "the immature nature of Chinese strategic forces and compressed timelines needed to assess and frame a response," which increase "the potential for error and miscalculation."[180]

Moreover, a shift to launch-on-warning could require the predelegation of launch authority to General Secretary Xi or to the CMC since there would be too little time to build consensus within the Politburo Standing Committee over whether to launch in response to potentially false reports of an incoming missile. The abandonment of consensus decision-making over nuclear retaliation, a dynamic that has already occurred in other policy areas, would mean General Secretary Xi's risk tolerance could play an outsized role in determining whether China uses nuclear weapons. While DOD assesses that China will keep at least a portion of its force on a launch-on-warning posture, Dr. Saunders told the Commission he does not believe a force-wide shift is likely given CCP leaders' historical distrust of the military and their concern that such a posture could heighten the risks of escalation or accidental nuclear conflict.[181]

Increased Potential for Coercion or Conventional Aggression

China's growing nuclear arsenal could embolden it to pursue coercion or conventional aggression against U.S. allies and partners if Chinese leaders believe their nuclear arsenal will deter the United States from intervening on these countries' behalf. This logic, known in political science as the "stability-instability paradox," holds that because nuclear adversaries cannot afford to fight for fear of mutual destruction, neither will initiate nuclear war (creating "stability"), but that because of this, conventional war remains a viable option (creating "instability").[182] Abraham Denmark, director of the Asia Program at the Wilson Center, argued in testimony before the Commission that U.S. allies and partners are concerned China's nuclear modernization could affect the willingness of the United States to provide extended deterrence in the long term because the potential costs of defending them from conventional aggression against a more capable nuclear-armed China will be higher than before.[183]

Chinese conventional aggression is most plausible against Taiwan and Japan. Mr. Denmark described in testimony one scenario in which China could attempt to quickly seize Taiwan and present the United States with a fait accompli, threatening nuclear use should U.S. forces attempt to roll back its gains.[184] Other analysts, especially those in Japan's strategic community, have argued that China could extend its presence around or even seize the Senkaku Islands.[185]

China's Proliferation Activities: An Added Nuclear Threat

China continues to facilitate the global proliferation of nuclear and missile technologies today, presenting the United States and its allies with another nuclear-related threat. Whereas decades ago the Chinese government and SOEs dominated the trade of prohibited nuclear and missile technologies,* today Chinese private individuals and companies are the most important vectors for proliferation to countries of concern, and the goods they export are dual-use rather than those with pure military applications.[186] "The Chinese government has adopted an, at best, passive response to this trade, neither actively preventing nor punishing private entities for such exports or re-exports," Valerie Lincy, executive director of the Wisconsin Project on Nuclear Arms Control, testified to the Commission.[187]

U.S. government reports in recent years allege that "China-based entities" proliferate technologies and materials with nuclear and missile applications to other countries, and that the Chinese government turns a blind eye to their activities. For example, the 2021 version of the State Department's annual report, *Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments*, stated, "Chinese entities continued to supply [Missile Technology Control Regime]-controlled† goods to missile programs of proliferation concern in 2020," though it referred readers to a classified annex for details.[188] The report noted that the U.S. government had raised a number of cases with the Chinese government concerning transfers of missile-related goods and technology by Chinese entities to countries of concern throughout 2020. "Although the United States has asked that China inves-

*In the 1980s and 1990s, Chinese SOEs made strategically significant transfers of technology and knowhow—including the complete design for a nuclear weapon and multiple missile systems—to Pakistan, Iran, and North Korea, among others. China made the transfers despite these countries variously refusing to sign the Treaty on the Non-Proliferation of Nuclear Weapons, violating their treaty commitments, or withdrawing entirely from the treaty. The Chinese government began to observe some nuclear nonproliferation norms and multilateral export control regimes in the mid-1990s, which U.S. government sources at the time assessed led to improvement in the export practices of SOEs and an end to confirmed transfers of nuclear-capable missiles. China acceded to the Treaty on the Non-Proliferation of Nuclear Weapons in 1992, joined the Zangger Committee in 1997, and joined the Nuclear Suppliers Group in 2004. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 3–11; Congressional Research Service, *Chinese Nuclear and Missile Proliferation*, May 17, 2021, 1; White House, *A Report Relating to the Approval and Implementation of the Agreement for Nuclear Cooperation between the United States and the People's Republic of China, Pursuant to 42 U.S.C. 2153(d)*, January 12, 1998.

†The Missile Technology Control Regime is a multilateral export control regime that restricts the proliferation of missiles, complete rocket systems, unmanned air vehicles, and related technology for systems capable of carrying a 500-kilogram payload at least 300 kilometers as well as systems intended for the delivery of WMD. China agreed to apply some of the Missile Technology Control Regime's guidelines for curbing missile proliferation despite the rejection of its formal application for Mission Technology Control Regime membership in 2004 on the grounds that it failed to meet the group's nonproliferation standards. Wade Boese, "Missile Regime Puts Off China," *Arms Control Association*, November 2004.

tigate and put a stop to such activities, most of these cases remain unresolved," the report asserted.[189] The report also assessed that China "has failed to adhere" to a pledge it reportedly made to the United States in November 2000 that it would not assist "in any way, any country in the development of ballistic missiles that can be used to deliver nuclear weapons."[190]

The U.S. government continues to sanction China-based entities for their facilitation of nuclear and missile proliferation. On at least two occasions in 2020, for example, the State Department announced sanctions in accordance with the Iran, North Korea, and Syria Nonproliferation Act on a number of Chinese individuals and firms for transferring sensitive technology and items to Iran's missile programs.[191] More broadly, the U.S. government has placed numerous Chinese SOEs, firms, and individuals involved in China's nuclear weapons program and proliferation activities on the U.S. Department of Commerce's Entity List.[192] Several Chinese individuals have been prosecuted in recent years for conspiring to illicitly transfer U.S.-origin technologies with nuclear and missile applications to China.[193]

Proliferation of Dual-Use Items to Iran

China-based individuals and private enterprises have played a dominant role in publicly documented cases of proliferation to Iran over the last decade.* In some cases, Chinese nationals have engaged in elaborate schemes to transfer dual-use items from China to Iran. The most notorious of these individual proliferators is Li Fangwei (also known as Karl Lee), a China-based businessman whom the United States has sanctioned 12 times since 2010, including most recently in 2019, for transferring sensitive dual-use technologies such as gyroscopes, accelerometers, high-strength alloys, and graphite cylinders to Iran.[194] According to a 2019 statement by the National Security Council's senior director for weapons of mass destruction (WMD), Mr. Li's transfers "contributed to Iran's development of more advanced missiles with improved accuracy, range, and lethality."[195] Mr. Li remains at large in China despite U.S. requests to extradite him and a $5 million reward the U.S. government has offered for information leading to his arrest or conviction.[196] Another prominent example of a Chinese individual enabling proliferation to Iran is Cheng Sihai, a Chinese businessman who provided Iran with titanium sheets and tubes, seamless steel tubes, pressure valves, bellows, flanges, and U.S.-origin pressure transducers for the country's uranium enrichment program.[197] Mr. Cheng was arrested

*Affiliates or subsidiaries of Chinese SOEs have sometimes been implicated in recent proliferation activities that benefit Iran's WMD activities. For example, China's Wuhan Sanjiang Export and Import Co. Ltd. was sanctioned by the U.S. Department of the Treasury in 2017 for selling more than $1 million worth of technology, including radars and missile guidance equipment, to a subsidiary of Iran's Ministry of Defense and Armed Forces Logistics. Wuhan Sanjiang Export and Import Co. Ltd. is a subsidiary of the large enterprise China Sanjiang Space Group, which is in turn a subsidiary of the SOE China Aerospace Science and Industry Corporation. In the 1980s and 1990s, the Chinese governemnt reportedly helped Iran explore for uranium, provided the design for the conversion plant at Isfahan, and made transfers that aided Iran's development of a solid-fuel ballistic missile. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9; U.S. Department of the Treasury, *Treasury Designates the IRGC under Terrorism Authority and Targets IRGC and Military Supporters under Counter-Proliferation Authority*, October 13, 2017; Foreign Trade Online, "Wuhan Sanjiang Import & Export Co., Ltd."

by U.S. authorities in 2014 and sentenced in 2016 to nine years in prison.[198]

In other cases, Iranian individuals and companies have operated from inside China to arrange transfers of dual-use items. Ms. Lincy highlighted the case of Ghobad Ghasempour, an Iranian-born Canadian national who set up front companies in China with the help of a Chinese partner to transship U.S.-origin items with applications to missile guidance systems—such as a precision lathe machine, thermal imaging cameras, and an inertial guidance system—to an Iranian state-controlled engineering company.[199] Mr. Ghasempour was arrested in the United States in 2017 and sentenced in 2018 to 42 months in prison, but his accomplice remains at large, presumably in China.[200]

SOEs Share Civil Nuclear and Missile Technologies with Pakistan

Beijing was instrumental in helping Pakistan develop its nuclear program in the early 1980s, and Chinese SOEs continue to export dual-use technologies to Pakistan that could further its nuclear and missile programs.* Chinese SOEs support a variety of projects linked to China's provision of fuel and services for nuclear power plants it has built in Chashma and Karachi.[201] In 2012, China National Nuclear Corporation subsidiary China Zhongyuan Engineering Corporation moved ahead with a plan to build two new civil nuclear reactors in Chashma in addition to the two it had built there prior to China joining the Nuclear Suppliers Group in 2004.† Chinese officials made this decision despite the fact that Nuclear Suppliers Group guidelines‡ prohibit such assistance to Pakistan because it is neither a member of the Treaty on the Non-Proliferation of Nuclear Weapons nor does it have all of its nuclear facilities under International Atomic Energy Agency safeguards.§[202] One of the SOEs constructing the Karachi plants, the China Nuclear Energy Industry Corporation, reportedly supplied fuel assemblies and core components to the Pakistan Atomic Energy Commission, the main Pakistani counterpart for the project that has been on the U.S. Department of Commerce's Entity List since 1998 due to proliferation concerns.[203] Trade data reviewed by the Wisconsin Project

*In the 1980s and 1990s, China provided Pakistan with the complete design of a tested nuclear weapon; a supply of weapons-grade uranium to fuel that design; the solid-fuel short-range DF-11 ballistic missile system, which likely formed the basis for Pakistan's Shaheen missile system; and 5,000 ring magnets necessary for centrifuges used in uranium enrichment. Shirley A. Kan, "China and Proliferation of Weapons of Mass Destruction and Missiles: Policy Issues," *Congressional Research Service*, February 26, 2003, 4–5.

†China built two nuclear reactors at Chashma as a result of agreements struck in 1991 and 2003. When China joined the Nuclear Suppliers Group in 2004, it informed fellow member states that apart from these two reactors at Chashma, it would not supply any further reactors to Pakistan. In 2011, however, Beijing asserted that it would "grandfather" a new deal to build two reactors into the 2003 agreement, which was concluded before China's entry into the Nuclear Suppliers Group. Jeff M. Smith, "China and Pakistan's Nuclear Collusion," *Wall Street Journal*, April 2, 2013; Sharad Joshi, "The China-Pakistan Nuclear Deal: A Realpolitique Fait Accompli," *Nuclear Threat Initiative*, December 11, 2011.

‡The Nuclear Suppliers Group is a group of nuclear supplier countries that implements two sets of guidelines for nuclear exports and nuclear-related exports in order to curb the proliferation of nuclear weapons. China joined the Nuclear Suppliers Group in 2004. Nuclear Suppliers Group, "About the NSG;" Nuclear Suppliers Group, "Guidelines;" Nuclear Suppliers Group, "Participants."

§While Pakistan has International Atomic Energy Agency safeguard agreements in force for all its Chinese-built civil nuclear reactors, its nuclear weapons facilities in Islamabad do not have such safeguards. Congressional Research Service, *Chinese Nuclear and Missile Proliferation*, May 17, 2021, 2.

shows that in 2014 and 2017, Wuhan Sanjiang Import and Export Co. Ltd., which is ultimately subordinate to the SOE China Aerospace Science and Industry Corporation,* shipped items with applications to missile transporters and launchers to Pakistani entities associated with the country's ballistic missile work.[204]

Nuclear relations between China and Pakistan remain "extensive and problematic," Ms. Lincy told the Commission.[205] China's civil nuclear cooperation with Pakistan allows the country to devote more of its unsafeguarded nuclear infrastructure to fissile material production for nuclear weapons and provides it access to advanced nuclear technologies that could ultimately benefit the unsafeguarded program.[206]

Chinese Finance Benefits North Korea's WMD Programs

Private actors in China indirectly support North Korea's acquisition of dual-use goods for its nuclear and missile programs by facilitating its access to the foreign currency required to fund these programs.† [207] Ms. Lincy argues this support entails hosting agents for North Korean financial networks that process illicit transactions to finance North Korea's nuclear and ballistic missile programs as well as North Korean nationals who remit income ultimately used for the same purposes.[208] Then Deputy Assistant Secretary of State and current Commissioner Alex Wong said in a November 2020 speech that "China hosts no less than two dozen North Korean WMD and ballistic missile procurement representatives and bank representatives" despite a UN Security Council resolution requiring the expulsion of North Korean diplomats and representatives who assist in the evasion of sanctions related to the country's nuclear and missile programs.[209] "The United States has provided China with ample actionable information on the ongoing UN-prohibited activities occurring within its borders," Deputy Assistant Secretary Wong noted, "but Beijing has chosen not to act."[210] North Korean workers also continue to reside in China and earn income for North Korea's nuclear weapons program. For example, North Korean information technology workers linked to a UN-sanctioned entity that oversees North Korea's nuclear and missile programs—the Munitions Industry Department—have established Chinese companies and sponsored visas for North Korean workers.[211]

*Wuhan Sanjiang Export and Import Co. Ltd. has been sanctioned by the Treasury Department for its sales of technology with missile applications to Iran; it is not on the Entity List maintained by the U.S. Department of Commerce. The company is also not on the Non-SDN Chinese Military-Industrial Complex Companies List (NS-CMIC List), presumably because it is not publicly traded. U.S. Department of Commerce Bureau of Industry and Security, *Supplement No. 4 to Part 744 - ENTITY LIST*, July 19, 2021; U.S. Department of the Treasury Office of Foreign Assets Control, "Non-SDN Chinese Military-Industrial Complex Companies List," June 16, 2021; Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9–10.

†In the 1990s, Chinese SOEs provided technology and knowhow that furthered North Korea's ballistic missile program. For example, in 1998 the Chinese SOE China Academy of Launch Vehicle Technology, a subsidiary of China Aerospace Corporation, allegedly helped North Korea's space program develop satellites that were later used for the North Korean Taepodong-1 MRBM. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 10.

Implications for the United States

The rapid buildup of China's nuclear arsenal signals a clear departure from the country's historically minimalist nuclear posture. It suggests Chinese leaders are more expansively redefining the requirements of their assured retaliation strategy and potentially even contemplating a more ambitious strategy envisioning the first use of nuclear weapons to accomplish China's regional objectives. As Dr. Roberts observes, the significance of China's buildup for the United States "depends, in part, on China's answer to the question, 'How much is enough?'" and that so far, "China has given us no answer."[212]

China's nuclear buildup puts it on a path to become a qualitative nuclear peer of the United States in around a decade, with a similarly diversified, precise, and survivable force.[213] Such a force would give China a truly secure second-strike capability as well as options for highly calibrated nuclear use that could support both their current assured retaliation strategy and a new strategy of limited nuclear first use in the region. China could even become a quantitative nuclear peer if projections for the growth of the land-based leg of the nuclear triad are correct. Regardless of what the future holds, however, several troubling implications are already apparent.

First, China's growing nuclear capabilities create uncertainty and raise the risk of accidental or unforeseen nuclear escalation during a regional conflict. Because some of the PLA's conventional and nuclear forces and supporting infrastructure are either comingled or indistinguishable, the United States might accidentally attack nuclear capabilities in the course of attacking nonnuclear capabilities during a conventional war in the Indo-Pacific. Such a situation could lead to "crisis instability" whereby China resorts to nuclear first use in order to preserve its nuclear deterrent, which it believes to be in serious danger. Reducing the risks stemming from entanglement in the PLA will be challenging because Chinese leaders may worry they will undermine deterrence or reduce operational efficiency if they agree to reduce entanglement.[214] Moreover, Chinese leaders may not believe that accidental nuclear escalation is a serious concern. The belief that inadvertent escalation is unlikely actually makes it more probable, however. As several nuclear experts affiliated with the Carnegie Endowment for International Peace argue, this view "leaves political and military leaders less inclined, in peacetime, to take steps that could mitigate the risks and more inclined, in wartime, to interpret ambiguous events in the worst possible light."[215] Similar risks of unintentional nuclear escalation could stem from a launch-on-warning posture, which is prone to false alarms.

Second, China's growing nuclear capabilities raise the risks that a conventional conflict in the Indo-Pacific could escalate to a deliberate nuclear exchange, though these risks are still small in absolute terms. The expansion, modernization, and diversification of China's nuclear forces give the PLA greater flexibility, resiliency, and capacity to use its nuclear weapons. According to Dr. Roberts, the result of these changes "will be a China that's more confident in running risks, military and political, and more risk for the United States in defending its interests in a conflict over Taiwan or elsewhere in the region with China."[216] In a high-stakes conventional war, Chinese

leaders could conceivably decide to threaten or engage in limited nuclear use against U.S. conventional forces and bases for fear of losing the conflict or their grip on power.

Third, China's growing nuclear capabilities could strain U.S. extended deterrence by emboldening conventional aggression or nuclear coercion against U.S. allies and partners. As China's nuclear arsenal grows, Dr. Roberts observes, Chinese leaders could become confident in their "ability to suppress escalatory responses by the United States because of the long shadow of nuclear weapons."[217] With stability achieved at the strategic level, Chinese leaders may feel more confident in their ability to use conventional force to resolve territorial disputes over Taiwan, the East China Sea, or the South China Sea. They could also stop short of using force and instead rely on their nuclear arsenal for coercion. Chinese leaders' possible interest in threatening nuclear use to deter Japanese involvement in a Taiwan contingency seemed evident in the decision by a municipal Chinese government authority to repost on social media a video threatening Japan with nuclear war in July 2021 after Japanese leaders made statements indicating they could come to Taiwan's defense.[218]

Fourth, improvements in China's nuclear forces could complicate U.S. nuclear deterrence planning in the future even if they do not presently threaten the survivability of U.S. nuclear forces. Never before has the United States faced two peer nuclear-armed adversaries at the same time. The pace of China's nuclear modernization, the expansion of its nuclear warhead stockpile, and the extent to which it cooperates with Russia may require the United States to reexamine its deterrence strategies and force posture. Dr. Roberts told the Commission the major challenges for the United States in the decades ahead are "whether, as China's nuclear force grows . . . we need a strategic force of our own that's larger as well" and "whether [China and Russia] are an additive problem or whether China remains a lesser-included problem because it's a smaller force."[219]

Fifth, China's expanding nuclear arsenal raises the specter of an arms race. China's longstanding refusal to engage in arms control inhibits deeper arms reductions by the United States, exacerbates the anxiety of U.S. allies, and prompts other countries to hedge in their nuclear strategies.[220] Chinese leaders may be uninterested in creating mechanisms for crisis communication and management because, as Mr. Denmark observes, "the way they make decisions, the way they share information, does not lend itself well to those sorts of communications."[221] Without China's participation in arms control, an unbridled arms race between the world's major nuclear powers could develop and U.S. allies and partners in the Indo-Pacific could decide to pursue their own nuclear deterrents.

Finally, the Chinese government's tolerance for Chinese companies and individuals' proliferation of dual-use technologies undermines the global nonproliferation regime and poses a different type of nuclear threat to U.S. allies and partners. The nuclear and ballistic missile technologies provided by various Chinese entities to Iran, North Korea, and Pakistan over the years will continue to threaten the security of U.S. allies and partners such as Israel, Saudi Arabia, South Korea, Japan, and India. Combined with the direct threat

posed by the PLA's growing nuclear arsenal, the indirect threat posed by such proliferation will increase the pressures on U.S. allies and partners to develop missile defenses and credible second-strike capabilities of their own.

ENDNOTES FOR SECTION 2

1. Joby Warrick, "China Is Building More than 100 New Missile Silos in Its Western Desert, Analysts Say," *Washington Post*, June 30, 2021.
2. Ned Price, "Department Press Briefing—July 1, 2021," U.S. Department of State, July 1, 2021.
3. David Brunnstrom and Daphne Psaledakis, "U.S. Calls Build-Up of China's Nuclear Arsenal 'Concerning,'" *Reuters*, July 2, 2021; Ned Price, "Department Press Briefing—July 1, 2021," U.S. Department of State, July 1, 2021.
4. Robert Burns, "Pentagon Says China Planning Big Increase in Nuclear Arsenal," *Associated Press*, September 1, 2020.
5. "Cheney Highlights China's Unprecedented Nuclear Threat & The Need to Defend the U.S.," website of Congresswoman Liz Cheney, April 21, 2021.
6. M. Taylor Fravel and Evan S. Medeiros, "China's Search for Assured Retaliation," *International Security* 35:2 (Fall 2010): 49–51.
7. M. Taylor Fravel, *Active Defense: China's Military Strategy since 1949*, Princeton University Press, 2019, 237; John Wilson Lewis and Xue Litai, *China Builds the Bomb*, Stanford University Press, 1988, 11, 34–37.
8. M. Taylor Fravel, *Active Defense: China's Military Strategy since 1949*, Princeton University Press, 2019, 246–247; Xu Weidi, "China's Security Environment and the Role of Nuclear Weapons," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 24–25.
9. M. Taylor Fravel, *Active Defense: China's Military Strategy since 1949*, Princeton University Press, 2019, 244–245; Xu Weidi, "China's Security Environment and the Role of Nuclear Weapons," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 24–25.
10. John Wilson Lewis and Xue Litai, *China Builds the Bomb*, Stanford University Press, 1988, 11, 34–37; Xu Weidi, "China's Security Environment and the Role of Nuclear Weapons," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 22.
11. Xiao Tianliang, ed., *The Science of Military Strategy* (战略学), Military Science Press, 2020, 128, 386. Translation; M. Taylor Fravel, *Active Defense: China's Military Strategy since 1949*, Princeton University Press, 2019, 244–246; State Council Information Office of the People's Republic of China, *China's National Defense in the New Era* (新时代的中国国防), July 2019. Translation; State Council Information Office of the People's Republic of China, *China's Military Strategy* (中国的军事战略), May 2015. Translation; State Council Information Office of the People's Republic of China, *The Diversified Employment of China's Armed Forces* (中国武装力量的多样化运用), April 2013. Translation; State Council Information Office of the People's Republic of China, *China's National Defense in 2010* (2010年中国的国防), March 2011. Translation; State Council Information Office of the People's Republic of China, *China's National Defense in 2008* (2008年中国的国防), January 2009. Translation; State Council Information Office of the People's Republic of China, *China's National Defense in 2006* (2006年中国的国防), December 2006. Translation; Yu Xijun, ed., *The Science of Second Artillery Campaigns* (第二炮兵战役学), People's Liberation Army Publishing House, 2004, 297–316. Translation.
12. Xiao Tianliang, ed., *The Science of Military Strategy* (战略学), Military Science Press, 2020, 128, 386. Translation.
13. M. Taylor Fravel, *Active Defense: China's Military Strategy since 1949*, Princeton University Press, 2019, 238–239; Sun Xiangli, "The Development of Nuclear Weapons in China," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 82–83.
14. Sun Xiangli, "The Development of Nuclear Weapons in China," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 83.
15. State Council Information Office of the People's Republic of China, *China's National Defense in 2006* (2006年中国的国防), December 2006. Translation; State Council Information Office of the People's Republic of China, *China's National Defense in 2002* (2002年中国的国防), February 2002. Translation.
16. Ministry of Foreign Affairs of the People's Republic of China, *Wang Yi Delivers a Video Speech at the Conference on Disarmament in Geneva*, June 11, 2021.
17. Wilson Center History and Public Policy Program Digital Archive, "Statement of the Government of the People's Republic of China," October 16, 1964.
18. United Nations, "Letter Dated 7 June 1978 from the Permanent Representative of China to the United Nations Addressed to the Secretary-General," June 7, 1978; United Nations, "Letter Dated 6 April 1995 from the Permanent Representative of China to the United Nations Addressed to the Secretary-General," April 6, 1995.

19. David Logan, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 1–2; John Dotson, "Beijing Rejects Any Involvement in Nuclear Arms Limitation Talks," *China Brief* 20:19 (October 2020); *Reuters*, "China Says It Won't Take Part in Trilateral Nuclear Arms Talks," May 6, 2019; Pan Zhenqiang, "China's No First Use of Nuclear Weapons," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 64–65.

20. Ministry of Foreign Affairs of the People's Republic of China, *Wang Yi Delivers a Video Speech at the Conference on Disarmament in Geneva*, June 11, 2021; Embassy of the People's Republic of China in the United States of America, "Foreign Ministry Spokesperson Zhao Lijian's Regular Press Conference on April 14, 2021," April 14, 2021; State Council Information Office of the People's Republic of China, *China's National Defense in the New Era* (新时代的中国国防), July 2019. Translation; Shou Xiaosong, ed., *The Science of Military Strategy* (战略学), Military Science Press, 2013, 172. Translation.

21. Barton Gellman, "U.S. and China Nearly Came to Blows in '96," *Washington Post*, June 21, 1998.

22. Joseph Kahn, "Chinese General Threatens Use of A-Bombs if U.S. Intrudes," *New York Times*, July 15, 2005.

23. Henrik Stålhane Hiim and Magnus Langset Trøan, "Hardening Chinese Realpolitik in the 21st Century: The Evolution of Beijing's Thinking about Arms Control," *Journal of Contemporary China* (2021), 6–7, 14.

24. Nancy Gallagher, "China on Arms Control," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 201; Wu Riqiang, "How China Practices and Thinks about Nuclear Transparency," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 232; Pan Zhenqiang, "China's No First Use of Nuclear Weapons," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 67; James Mulvenon and David Finkelstein, eds., *China's Revolution in Doctrinal Affairs: Emerging Trends in the Operational Art of the Chinese People's Liberation Army*, Center for Naval Analysis, 2005, 131; Kevin Pollpeter, *U.S.-China Security Management: Assessing the Military-to-Military Relationship*, RAND Corporation, 2004, xiv.

25. Henrik Stålhane Hiim and Magnus Langset Trøan, "China's Atomic Pessimism and the Future of Arms Control," *War on the Rocks*, June 21, 2021; Brad Roberts, "U.S. Perspective," in Patricia M. Kim, ed., *Enhancing U.S.-China Strategic Stability in an Era of Strategy Competition: U.S. and Chinese Perspectives*, United States Institute for Peace 172 (April 2021), 11–12; Emma Farge, "U.S. Says China Is Resisting Nuclear Arms Talks," *Reuters*, May 18, 2021.

26. China's Ministry of Foreign Affairs, "Briefing by Mr. Fu Cong, Director General of the Department of Arms Control and Disarmament of Ministry of Foreign Affairs," August 6, 2019.

27. *Xinhua*, "China Reiterates Opposition to Multilateralization of INF Treaty," July 30, 2019.

28. China's Ministry of Foreign Affairs, *Foreign Ministry Spokesperson Wang Wenbin's Regular Press Conference on February 5, 2021*, February 6, 2021.

29. China's Ministry of Foreign Affairs, *Foreign Ministry Spokesperson Wang Wenbin's Regular Press Conference on February 5, 2021*, February 6, 2021.

30. Hu Gaochen, "An Analysis of China-U.S. Asymmetric Nuclear Stability and the U.S. Strategic Opportunism" (中美不对称核稳定与美国战略机会主义论析), *Journal of International Security* 2 (2021). Translation; Zhang Jingquan, "On the Weakening of Nuclear Deterrence Effect in Northeast Asia and Its Countermeasures" (东北亚"核威慑效应弱化"及其应对思考), *Asia-Pacific Security and Maritime Affairs* 3 (2020). Translation; Xu Weidi, "China's Security Environment and the Role of Nuclear Weapons," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 35.

31. Christopher Twomey, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5; Eric Heginbotham et al., "China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States," *RAND Corporation*, 2017, 78–90.

32. Christopher Twomey, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5; Eric Heginbotham et al., "China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States," *RAND Corporation*, 2017, 73–74, 78.

33. Christopher Twomey, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5;

Rajesh Basrur, "The India-China Nuclear Dynamic: India's Options," *ORF Issue Brief* 430 (December 2020); Toby Dalton and Tong Zhao, "At a Crossroads? China-India Nuclear Relations after the Border Clash," *Carnegie Endowment for International Peace*, August 19, 2020.

34. *People's Liberation Army Daily*, "Solidly Develop Strategic Capabilities: Conscientiously Study and Implement Chairman Xi's Important Speech during His Inspection of the Rocket Force" (扎扎实实把战略能力搞上去—认真学习贯彻习主席视察火箭军机关时重要讲话), September 27, 2016. Translation.

35. Zhang Changwei, He Tianjin, and Ge Song, "The Rocket Force Convenes the Fourth Changying Forum in Beijing: Deeply Studying the Issue of Building the Rocket Force's Strategic Deterrence and Actual Fighting Capabilities, Providing Scientific Theory Support for the Building, Development and Implementation of the Strategic Force" (火箭军第四届长缨论坛在京举行: 深化对火箭军战略威慑和实践能力建设问题研究, 为战略力量建设发展与运用提供科学理论支撑), *Rocket Forces Newspaper*, September 26, 2017. Translation; Wan Huilan and Lue Xuejuan, "Firmly Bear in Mind the Sacred Missions, Forge the Nation's Potent Force" (牢记神圣使命铸就国之重器), *Rocket Forces Newspaper*, September 23, 2017. Translation.

36. Brad Roberts, Director of the Center for Global Security Research at Lawrence Livermore National Laboratory, interview with Commission staff, August 27, 2021; Brad Roberts, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4–5.

37. Roderick Lee, "PLA Likely Begins Construction of an Intercontinental Ballistic Missile Silo Site Near Hanggin Banner," *Air University*, August 12, 2021.

38. David Logan, "Making Sense of China's Missiles Forces," in Phillip C. Saunders, Arthur S. Ding, and Andrew Scobell, eds., *Chairman Xi Remakes the PLA: Assessing Chinese Military Reforms*, National Defense University Press, 2019, 395; Christopher Cowan, "Getting from Megatons to Kilotons," *ASPI Strategist*, October 8, 2018.

39. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress,* 2020, 87.

40. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 102.

41. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 45, 86; Renny Babiarz, "China's Nuclear Submarine Force," *China Brief* 17:10, July 21, 2017.

42. Kyle Mizokami, "Underwater Dud: China's First Nuclear Submarine Failed Miserably," *National Interest*, July 15, 2021; Renny Babiarz, "China's Nuclear Submarine Force," *China Brief* 17:10, July 21, 2017.

43. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 86; Renny Babiarz, "China's Nuclear Submarine Force," *China Brief* 17:10, July 21, 2017.

44. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 451; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 86; Renny Babiarz, "China's Nuclear Submarine Force," *China Brief* 17:10, July 21, 2017.

45. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 45; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2019: Annual Report to Congress*, 2019, 65–67; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2018: Annual Report to Congress*, 2018, 76–77; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2017: Annual Report to Congress*, 2017, 60–61; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2016: Annual Report to Congress*, 2016, 26; Cecil Haney, "Transcript: Admiral Cecil Haney, Commander STRATCOM, Defense Writers Group," *Defense Writers Group*, October 22, 2015, 16–17.

46. Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4.

47. Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 3; Sebastien Roblin, "China's Underwater 'Nukes': Country-Killers or Paper Tigers?" *National Interest*, July 28, 2018.

48. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 452.

49. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 86.

50. Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4; Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 452.
51. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 452–453.
52. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 453.
53. Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 6.
54. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 97–100.
55. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 98–101; Bates Gill, "Organization of China's Strategic Forces," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 170.
56. Hans M. Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 2–3; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 56.
57. Decker Everleth, "China's Mobile ICBM Brigades: The DF-31 and DF-41," *A Boy and His Blog*, July 2, 2020; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 56, 58, 86; Missile Defense Project, "DF-4 (Dong Feng-4 / CSS-3)," *Center for Strategic and International Studies*, November 26, 2019; Missile Defense Project, "DF-5 (Dong Feng-5 / CSS-4)," *Center for Strategic and International Studies*, November 18, 2019; Missile Defense Project, "DF-31 (Dong Feng-31 / CSS-10)," *Center for Strategic and International Studies*, October 8, 2019.
58. Admiral Charles A. Richard, testimony before the Senate Armed Services Committee, April 20, 2021; Missile Defense Project, "DF-41 (Dong Feng-41 / CSS-X-20)," *Center for Strategic and International Studies*, October 8, 2019.
59. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 56.
60. Hans M. Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 2; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 56; Henry Boyd, "2019 Pentagon Report: China's Rocket Force Trajectory," *International Institute for Strategic Studies*, May 15, 2019.
61. Hans M. Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 2.
62. Hans M. Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 2–3.
63. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 56.
64. Roderick Lee, "PLA Likely Begins Construction of an Intercontinental Ballistic Missile Silo Site Near Hanggin Banner," *Air University*, August 12, 2021; Matt Korda and Hans Kristensen, "China Is Building a Second Nuclear Missile Silo Field," *Federation of American Scientists*, July 26, 2021; Joby Warrick, "China Is Building More than 100 New Missile Silos in Its Western Desert, Analysts Say," *Washington Post*, June 30, 2021; Hans Kristensen, "China's Expanding Missile Training Area: More Silos, Tunnels, and Support Facilities," *Federation of American Scientists*, February 24, 2021.
65. Matt Korda and Hans Kristensen, "China Is Building a Second Nuclear Missile Silo Field," *Federation of American Scientists*, July 26, 2021; Hans M. Kristensen and Matt Korda, "United States Nuclear Forces, 2020," *Nuclear Notebook*, January 13, 2020; U.S. Department of Defense, "America's Nuclear Triad." *https://www.defense.gov/Multimedia/Experience/Americas-Nuclear-Triad/*.
66. Roderick Lee, "PLA Likely Begins Construction of an Intercontinental Ballistic Missile Silo Site Near Hanggin Banner," *Air University*, August 12, 2021.
67. Hans Kristensen, Director of the Nuclear Information Project at the Federation of American Scientists, interview with Commission staff, August 27, 2021.
68. U.S.-China Economic and Security Review Commission, *2012 Annual Report to Congress*, November 2012, 180.

69. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 91; Mark A. Stokes, "China's Nuclear Warhead Storage and Handling System," *Project 2049*, March 12, 2010, 8.
70. Matthew E. Dillow, "Nuclear Hell on Wheels: Examining the Need for a Mobile ICBM," *U.S. Airforce Center for Unconventional Weapons Studies*, June 2015, 1–2.
71. Joby Warrick, "China Is Building More than 100 New Missile Silos in Its Western Desert, Analysts Say," *Washington Post*, June 30, 2021.
72. Lin Yang, "U.S. Concerned about Report China Is Expanding Missile Silos," *Voice of America*, July 2, 2021.
73. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 90.
74. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 86; Missile Defense Project, "DF-21 (Dong Feng-21 / CSS-5)," *Center for Strategic and International Studies*, January 2, 2020; Missile Defense Project, "DF-26 (Dong Feng-26)," *Center for Strategic and International Studies*, June 23, 2020.
75. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 447.
76. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress, 2020*, 56; Joshua Pollack and Scott LaFoy, "China's DF-26: A Hot-Swappable Missile?" *Arms Control Wonk*, May 17, 2020.
77. Gerald C. Brown, "Understanding the Risks and Realities of China's Nuclear Forces," *Arms Control Association*, June 21, 2021; Joshua Pollack and Scott LaFoy, "China's DF-26: A Hot-Swappable Missile?" *Arms Control Wonk*, May 17, 2020.
78. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5–6; Joshua Pollack and Scott LaFoy, "China's DF-26: A Hot-Swappable Missile?" *Arms Control Wonk*, May 17, 2020.
79. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 88.
80. Roderick Lee, "China's Air Force Might Be Back in the Nuclear Business," *Diplomat*, September 9, 2020; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 50–51; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2018: Annual Report to Congress*, 2018, 75–77.
81. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 453; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 87.
82. Roderick Lee, "China's Air Force Might Be Back in the Nuclear Business," *Diplomat*, September 9, 2020.
83. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 453.
84. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 87; Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9.
85. Roderick Lee, "China's Air Force Might Be Back in the Nuclear Business," *Diplomat*, September 9, 2020.
86. Roderick Lee, "China's Air Force Might Be Back in the Nuclear Business," *Diplomat*, September 9, 2020.
87. David Logan, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9.
88. Hans M. Kristensen and Matt Korda, "Status of World Nuclear Forces," *Federation of American Scientists*, May 2021.
89. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 85.
90. U.S. Department of Defense, *Annual Report on the Military Power of the People's Republic of China*, 2004, 37; U.S. Department of Defense, *Annual Report on the Military Power of the People's Republic of China*, 2003, 31.
91. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 443.
92. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2020," *Nuclear Notebook*, December 10, 2020, 443.

93. Dataset provided via email by Hans M. Kristensen, Director of the Nuclear Information Project at the Federation of American Scientists, July 22, 2021.
94. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 85.
95. Hans M. Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 6.
96. Charles A. Richard, "Forging 21st-Century Strategic Deterrence," *U.S. Naval Institute Proceedings*, February 2021, 12–14, 3.
97. Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 10; Hans M. Kristensen and Matt Korda, "United States Nuclear Weapons, 2021," *Nuclear Notebook*, January 12, 2021.
98. Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 6–7.
99. Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 6.
100. Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 6.
101. Hans Kristensen, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 6–7.
102. Hui Zhang, "China's Fissile Material Production and Stockpile," *International Panel of Fissile Materials*, 2017, 2–3, 19, 38.
103. Mark Hibbs, written testimony before the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9.
104. Mark Hibbs, written testimony before the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 10.
105. *Al Jazeera*, "Concerns Grow over China Nuclear Reactors Shrouded in Mystery," May 19, 2021.
106. AllSource Analysis, "China: New Nuclear Test Area Activity, Lop Nur, 2019–2021," June 18, 2021, 5.
107. AllSource Analysis, "Expansion at China's Pingtong Nuclear Facility, 2002–2020," November 12, 2020.
108. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 88.
109. Christopher Cowan, "Getting from Megatons to Kilotons," *ASPI Strategist*, October 8, 2018.
110. Phillip C. Saunders and David C. Logan, "China's Regional Nuclear Capability," in James M. Smith and Paul J. Bolt, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 126; Chen Feng, "If the United States Resumes Nuclear Testing, What Will China Do?" (如果美国恢复核试验, 中国怎么办?), *Guancha*, June 15, 2020. Translation.
111. Phillip C. Saunders and David C. Logan, "China's Regional Nuclear Capability," in James M. Smith and Paul J. Bolt, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 127; Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie, *Chinese Nuclear Forces and U.S. Nuclear War Planning*, Federation of American Scientists and the Natural Resources Defense Council, November 2006, 98–99; U.S. Central Intelligence Agency, *PRC Defense Policy and Armed Forces*, National Intelligence Estimate 13–76, November 11, 1976, 16, 51. *https://www.cia.gov/readingroom/docs/DOC_0001097855.pdf.*
112. Hans M. Kristensen, Robert S. Norris, and Matthew G. McKinzie, *Chinese Nuclear Forces and U.S. Nuclear War Planning*, Federation of American Scientists and the Natural Resources Defense Council, November 2006, 99.
113. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 88; Chen Feng, "If the United States Resumes Nuclear Testing, What Will China Do?" (如果美国恢复核试验, 中国怎么办?), *Guancha*, June 15, 2020. Translation; *Global Times*, "China Should Seriously Study the Option of Openly Developing Low-Yield Nuclear Weapons" (中国应认真研究公开发展低当量核武器的选项), February 5, 2018. Translation.
114. *People's Daily*, "China's Dongfeng-41 Technology Surpasses the United States and Russia: Longer Range and Higher Accuracy" (中国东风41部分技术超过美俄: 射程更远 精度更高), November 24, 2017. Translation.
115. Julian Borger, "China May Have Conducted Low-Level Nuclear Test, U.S. Claims," *Guardian*, April 16, 2020; Jonathan Landy, "U.S. Says China May Have Conducted Low-Level Nuclear Test Blasts," *Reuters*, April 15, 2020.
116. Congressional Research Service, "Nuclear Command, Control, and Communications (NC3) Modernization," December 8, 2020.

117. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 2.
118. State Council Information Office of the People's Republic of China, *China's Military Strategy* (中国的军事战略), May 2015. Translation.
119. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces,* June 10, 2021, 1–2; Fiona Cunningham, "Nuclear Command, Control, and Communications Systems of the People's Republic of China," *Nautilus Institute*, July 18, 2019.
120. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 1–2; Fiona Cunningham, "Nuclear Command, Control, and Communications Systems of the People's Republic of China," *Nautilus Institute*, July 18, 2019.
121. Fiona Cunningham, "Nuclear Command, Control, and Communications Systems of the People's Republic of China," *Nautilus Institute*, July 18, 2019.
122. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 2, 4; Fiona Cunningham, "Nuclear Command, Control, and Communications Systems of the People's Republic of China," *Nautilus Institute*, July 18, 2019; Federation of American Scientists, "Command and Control," June 23, 2000. *https://fas.org/nuke/guide/china/c3i/*.
123. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 88.
124. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 88.
125. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4.
126. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4.
127. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 3.
128. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4.
129. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 3; Stephen Chen, "China's New Antenna Is Five Times the Size of New York City, but Some Fear It Could Be a Cancer Risk," *South China Morning Post*, December 31, 2018.
130. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4.
131. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4.
132. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 115–116; *Sohu*, "This Kind of Early Warning Radar Must Be Large, with a Detection Distance of More than 5,000 Kilometers" (我国这种预警雷达一定要大, 探测距离超过5000公里, 美日韩躺枪), October 12, 2017. Translation.
133. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 116.
134. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 116; Liu Zhen, "China's New High-Frequency Radar System Could Spot Stealth Aircraft from a Long Distance, Creator Says," *South China Morning Post*, June 11, 2019.
135. Zhang Qian, "Space-Based Infrared Early Warning Satellites: The Never Tired Space 'Sentinel'" (天基红外预警卫星 永不疲惫的太空 "哨兵"), *Science and Technology Daily*, February 7, 2018. Translation. *http://webcache.googleusercontent.com/search?q=cache:nrScasxTo6oJ:www.xinhuanet.com/mil/2018-02/07/c_129808061.htm+&cd=1&hl=en&ct=clnk&gl=us*.
136. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 117; Stephen Clark, "China's First Launch of 2020 Lofts Mystery Payload," *Spaceflight Now*, January 7, 2020.
137. Minnie Chan, "Vladimir Putin Says Russia Is Helping China Build a Missile Early Warning System," *South China Morning Post*, October 4, 2019; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 89.

138. Hans M. Kristensen, "China's Strategic Systems and Programs," in James M. Smith and Paul J. Bolts, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 117; *Business Standard*, "China's Eye in the Sky: An Analysis of China's Satellite Surveillance," October 30, 2019.

139. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 8.

140. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 8.

141. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 73.

142. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9; U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 73.

143. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9.

144. David Santoro, "China: The Forgotten Nuclear Power No More," *Pacific Forum*, July 14, 2021; Christopher Twomey, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4–5; Gerald C. Brown, "Understanding the Risks and Realities of China's Nuclear Forces," *Arms Control Association*, June 2021; Fiona S. Cunningham and M. Taylor Fravel, "Assuring Assured Retaliation: China's Nuclear Posture and U.S.-China Strategic Stability," *International Security* 40:2 (Fall 2015).

145. Christopher Twomey, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4–5; David Logan, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 8; Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 12–13; Hu Gaochen, "An Analysis of China-U.S. Asymmetric Nuclear Stability and the U.S. Strategic Opportunism" (中美不对称核稳定与美国战略机会主义论析), *Journal of International Security* 2 (2021). Translation; Zhang Jingquan, "On the Weakening of Nuclear Deterrence Effect in Northeast Asia and Its Countermeasures" (东北亚"核威慑效应弱化"及其应对思考), *Asia-Pacific Security and Maritime Affairs* 3 (2020). Translation; Fiona S. Cunningham and M. Taylor Fravel, "Assuring Assured Retaliation: China's Nuclear Posture and U.S.-China Strategic Stability," *International Security* 40:2 (Fall 2015): 16, 19; Xu Weidi, "China's Security Environment and the Role of Nuclear Weapons," in Li Bin and Tong Zhao, eds., *Understanding Chinese Nuclear Thinking*, Carnegie Endowment for International Peace, 2016, 34–35.

146. David Santoro, "China: The Forgotten Nuclear Power No More," *Pacific Forum*, July 14, 2021; Fiona S. Cunningham and M. Taylor Fravel, "Assuring Assured Retaliation: China's Nuclear Posture and U.S.-China Strategic Stability," *International Security* 40:2 (Fall 2015): 10.

147. David Santoro, "China: The Forgotten Nuclear Power No More," *Pacific Forum*, July 14, 2021; Caitlin Talmadge, "China and Nuclear Weapons," *Brookings*, September 2019, 2.

148. Brad Lendon, "China Is Building a Sprawling Network of Missile Silos, Satellite Imagery Appears to Show," *CNN*, July 2, 2021; Hans Kristensen, "China's Expanding Missile Training Area: More Silos, Tunnels, and Support Facilities," *Federation of American Scientists*, February 24, 2021.

149. Tong Zhao, "Strategic Warning and China's Nuclear Posture," *Diplomat*, May 28, 2015.

150. Tong Zhao, "Modernizing without Destabilizing: China's Nuclear Posture in a New Era," *Carnegie-Tsinghua Center for Global Policy*, August 25, 2020.

151. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9.

152. Alastair Iain Johnston, "China's New 'Old Thinking': The Concept of Limited Deterrence," *International Security* 20:3 (Winter 1995–1996): 5–6, 17–20.

153. Christopher P. Twomey, written testimony before the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4; Christopher Twomey, "Nuclear Doctrine and Deterrence Concept," in James M. Smith and Paul J. Bolt, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, 2021, 55.

154. David C. Logan, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021; Christopher Twomey, "Nuclear Doctrine and Deterrence Concept," in James M. Smith and Paul J. Bolt, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, 2021, 52;

U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 86; State Council Information Office of the People's Republic of China, *China's National Defense in the New Era*, July 2019; Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Cyber and Nuclear Capabilities*, March 26, 2012, 4–5; Larry M. Wortzel, "China's Nuclear Forces: Operations, Training, Doctrine, Command, Control, and Campaign Planning," *U.S. Army War College Strategic Studies Institute*, 2007, 26–27.

155. U.S. Department of Defense, *Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress*, 2020, 86.

156. Yu Xijun, ed., *The Science of Second Artillery Campaigns* (第二炮兵战役学), People's Liberation Army Publishing House, 2004, 294–296. Translation.

157. Xiao Tianliang, ed., *The Science of Military Strategy* (战略学), Military Science Press, 2020, 138. Translation.

158. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 9–10; Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 3; Christopher Twomey, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4; James Samuel Johnson, "Chinese Evolving Approaches to Nuclear 'War-Fighting': An Emerging Intense US–China Security Dilemma and Threats to Crisis Stability in the Asia Pacific," *Asian Security* (2018): 3–4; Eric Heginbotham et al., "China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States," *RAND Corporation*, 2017, 135–137.

159. Christopher P. Twomey, Associate Professor at the Naval Postgraduate School, interview with Commission staff, July 20, 2021.

160. Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 3.

161. Chen Feng, "If the United States Resumes Nuclear Testing, What Will China Do?" (如果美国恢复核试验, 中国怎么办?), *Guancha*, June 15, 2020. Translation; *Global Times*, "China Should Seriously Study the Option of Openly Developing Low-Yield Nuclear Weapons" (中国应认真研究公开发展低当量核武器的选项), February 5, 2018. Translation.

162. Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 3–4.

163. Charles A. Richard, testimony before the Senate Armed Services Committee, April 20, 2021, 6.

164. Jacob Stokes, "China's Missile Program and U.S. Withdrawal from the Intermediate-Range Nuclear Forces (INF) Treaty," *U.S.-China Economic and Security Review Commission*, February 4, 2019, 2.

165. Jacob Stokes, "China's Missile Program and U.S. Withdrawal from the Intermediate-Range Nuclear Forces (INF) Treaty," *U.S.-China Economic and Security Review Commission*, February 4, 2019, 3–4.

166. Brad Roberts, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 215.

167. Phillip C. Saunders, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 62–63; David Logan, "Are They Reading Schelling in Beijing? The Dimensions, Drivers, and Risks of Nuclear-Conventional Entanglement in China," forthcoming in *Journal of Strategic Studies* (2020): 33.

168. Gerald C. Brown, "Understanding the Risks and Realities of China's Nuclear Forces," *Arms Control Association*, June 21, 2021; Phillip C. Saunders, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 62; David Logan, "Are They Reading Schelling in Beijing? The Dimensions, Drivers, and Risks of Nuclear-Conventional Entanglement in China," forthcoming in *Journal of Strategic Studies* (2020): 33.

169. Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5–6; Caitlin Talmadge, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 104–105; Caitlin Talmadge, "Would China Go Nuclear? Assessing the Risk of Chinese Nuclear Escalation in a Conventional War with the United States," *International Security*, No. 41, April 1, 2017, 70–73.

170. Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 8.

171. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 7.

172. Xiao Tianliang, ed., *The Science of Military Strategy* (战略学), Military Science Press, 2020, 136–138. Translation.
173. Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4–5.
174. Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5.
175. Caitlin Talmadge, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5.
176. Brad Roberts, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 211.
177. Brad Roberts, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 211.
178. Brad Roberts, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 211.
179. Daryl G. Kimball, "Nuclear False Warnings and the Risk of Catastrophe," *Arms Control Association*, December 2019; Alan Phillips, "No Launch-on-Warning," *Nuclear Age Peace Foundation*, May 1, 2002.
180. Admiral Charles A. Richard, testimony before the Senate Armed Services Committee, April 20, 2021, 7.
181. Phillip C. Saunders, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 10.
182. Rajesh Basrur, "China-India: The Stability-Instability Paradox," *RSIS Commentary* 128 (June 23, 2020): 2.
183. Abraham Denmark, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 6–7.
184. Abraham Denmark, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 6.
185. Patricia Kim, "Washington's Allies and Partners Weigh in on U.S.-China Competition," *United States Institute of Peace*, June 3, 2021; Sugio Takahashi, "Strategic Stability and the Impact of China's Modernizing Strategic Strike Forces," in James M. Smith and Paul J. Bolt, eds., *China's Strategic Arsenal: Worldview, Doctrine, and Systems*, Georgetown University Press, 2021, 63–64, 79; Scott W. Harold et al., "The U.S.-Japan Alliance and Deterring Gray Zone Coercion in the Maritime, Cyber, and Space Domains," *RAND Corporation*, 2017, 30–31.
186. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 2; Daniel Salisbury and Lucy Jones, "Exploring the Changing Role of Chinese Entities in WMD Proliferation," *China Quarterly* 225 (March 2016): 55–56.
187. Valerie Lincy, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 178.
188. U.S. Department of State, *Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments*, April 2021, 44.
189. U.S. Department of State, *Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments*, April 2021, 44.
190. U.S. Department of State, *2021 Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments*, April 15, 2021, 44.
191. U.S. Department of State, *New Sanctions under the Iran, North Korea, and Syria Nonproliferation Act (INKSNA)*, November 27, 2020; *Reuters*, "U.S. Sanctions 13 Foreign Entities for Supporting Iran Missile Program," February 25, 2020; "Imposition of Nonproliferation Measures against Foreign Persons, Including a Ban on U.S. Government Procurement," *85 Federal Register 8618–8619* (February 14, 2020).
192. U.S. Department of Commerce Bureau of Industry and Security, *Supplement No. 4 to Part 744 - ENTITY LIST*, July 19, 2021.
193. U.S. Department of Justice, "Electrical Engineer Sentenced to More than Five Years in Prison for Conspiring to Illegally Export to China Semiconductor Chips with Military Uses," July 22, 2021; U.S. Department of Justice, "Four Chinese Nationals and Chinese Company Indicted for Conspiracy to Defraud the United States and Evade Sanctions," July 23, 2019.
194. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 15; "Imposition of Nonproliferation Measures against Foreign Persons, Including a Ban on U.S. Government Procurement," *84 Federal Register 23627*, May 14, 2019.
195. Joel Gehrke, "White House Blames China for Iranian Missile Threat," *Washington Examiner*, May 8, 2019.
196. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 16; Eric Tucker,

"Chinese Man Charged with Avoiding U.S. Sanctions," *AP News*, April 30, 2014; U.S. Department of State, *Li Fangwei*.

197. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 15; U.S. Department of Justice, "Extradited Chinese National Sentenced to Nine Years for Providing U.S. Goods to Iran to Support Its Nuclear Program," January 27, 2016.

198. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 15; U.S. Department of Justice, "Extradited Chinese National Sentenced to Nine Years for Providing U.S. Goods to Iran to Support its Nuclear Program," January 27, 2016; U.S. Department of Justice, "Indicted Chinese National Lands at Boston's Logan Airport to Face Federal Prosecution for Supplying Iran with Nuclear Production Parts," December 5, 2014.

199. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 17; Iran Watch, "Illicit Procurement Network Used Firms in China, Portugal, and Turkey to Supply Iran," October 31, 2018.

200. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 17; U.S. Department of Justice, "Canadian Sentenced to 3+ Years in Prison for Conspiracy to Export Restricted Goods and Technology to Iran," August 22, 2018.

201. Rohan Joshi, "China, Pakistan, and Nuclear Non-Proliferation," *Diplomat*, February 16, 2015; Ananth Krishnan, "China Involved in Six Nuclear Projects in Pakistan, Reveals Official," *India Today*, February 8, 2015.

202. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, January 10, 2021, 5; Kelsey Davenport and Marcus Taylor, "Assessing Progress on Nuclear Nonproliferation and Disarmament: Updated Report Card 2010–2013," *Arms Control Association*, April 2013, 15.

203. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4–5.

204. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5–6.

205. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4.

206. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 5.

207. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 12.

208. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 12.

209. U.S. Department of State, *Deputy Special Representative for North Korea Delivers Keynote Address at CSIS Conference on North Korea's Economy*, November 30, 2020; United Nations Security Council, "Resolution 2270 (2016)," March 2, 2016, 3–4.

210. U.S. Department of State, *Deputy Special Representative for North Korea Delivers Keynote Address at CSIS Conference on North Korea's Economy*, November 30, 2020.

211. Valerie Lincy, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 13.

212. Brad Roberts, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 188.

213. Brad Roberts, Director of the Center for Global Security Research at Lawrence Livermore National Laboratory, interview with Commission staff, August 27, 2021; Brad Roberts, written testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 4–5.

214. James M. Acton, Tong Zhao, and Li Bin, "Reducing the Risks of Nuclear Entanglement," *Carnegie Endowment for International Peace*, September 12, 2018.

215. James M. Acton, Tong Zhao, and Li Bin, "Reducing the Risks of Nuclear Entanglement," *Carnegie Endowment for International Peace*, September 12, 2018.

216. Brad Roberts, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 188.

217. Brad Roberts, "Taking Stock: U.S.-China Track 1.5 Nuclear Dialogue," *Lawrence Livermore National Laboratory*, December 2020, 51.

218. Emily Clark, "'Military Fanboys' Shared a Video Threatening Nuclear War. This Is Why China Allowed It," *ABC News*, July 19, 2021.

219. Brad Roberts, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 217.

220. Brad Roberts, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 140.
221. Abraham Denmark, oral testimony for the U.S.-China Economic and Security Review Commission, *Hearing on China's Nuclear Forces*, June 10, 2021, 214.