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Implications for American Security Policy

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Hypersonic Weapons Development in China, Russia and the United States: Implications for American Security Policy

Introduction

According to the *Financial Times* of 16 October 2021, "China tested a nuclear-capable hypersonic missile in August that circled the globe before speeding towards its target, demonstrating an advanced space capability that caught US intelligence by surprise."[1] The remarkable thing about the test is that the warhead was launched into orbit, orbited Earth and reentered the atmosphere, approaching its target at hypersonic speed. Such a weapon would be capable of carrying a nuclear warhead. The United States has established defenses against intercontinental ballistic missiles (ICBMs) in Alaska, but the method used to attack the target by the People's Republic of China (PRC) missile would be capable of evading fixed U.S. defenses by avoiding the expected polar ballistic trajectory that the U.S. defenses are designed to intercept.[2]

This test by China has direct influence on the Army because the U.S. Army Space and Missile Defense Command (SMDC) is responsible for detecting strategic attacks and protecting the U.S. homeland.[3] SMDC defense systems are deployed to intercept ballistic missile warheads from only one direction, using a polar, or arctic, approach.[4] Another SMDC mission is to enhance deterrence and detection of strategic attacks.[5] The hypersonic threat is not only from China; Russia has successfully tested a naval hypersonic missile, the Zircon[6], and North Korea claims to have tested a hypersonic missile.[7]

Financial Times (*FT*) sources were surprised that China achieved the capability for such a weapon because the hypersonic glide vehicle carrying the warhead stayed in low-earth orbit,[8] circling the globe before reentering the atmosphere to attack its target. Even though the warhead missed its target by a wide margin,[9] China is far ahead of the United States in developing such capabilities;[10] the United States has experienced a number of failures in developing hypersonic weapons.[11]

Why U.S. officials were so surprised by the test is a little bit of a mystery. China has been working on these missiles for decades, and the United States knew it. According to the Defense Intelligence Agency's *2019 China Military Power Report*, the Chinese People's Liberation Army (PLA) "is developing a range of technologies to counter U.S. and other countries' ballistic missile defense systems, including maneuverable reentry vehicles (MARVs), MIRVs [multiple independently targetable reentry vehicles], decoys, chaff, jamming, thermal shielding, and *hypersonic glide vehicles*" (emphasis added).[12] If senior U.S. officials were surprised, it is because the intelligence community apparently underestimated China's capabilities in this area and failed to follow or appreciate years of mentions in Chinese research reports about work on hypersonic missiles in China, and perhaps underestimated the emphasis the PLA put on their development.[13]

Although the PRC warhead in the test missed its target by a wide margin of about two dozen miles, the *FT* article quotes U.S. experts and officials as saying that "China had made astounding progress on hypersonic weapons and was far more advanced than US officials realized." As noted previously, however, U.S. officials should not have been surprised by the development of hypersonic warheads in orbit by the Chinese People's Liberation Army Rocket Forces (PLARF). China has been conducting research on such hypersonic technology and weapons for some time.[14]

Put into practical defense and security terms, this involved putting warheads into low-earth orbit and having them seek targets on Earth. The strategy is not new. The Soviet Union experimented with this type of warhead in the early 1960s. The United States called it a "Fractional Orbital Bombardment System" during the Cold War period, but the U.S.S.R. eventually moved to other forms of deterrent systems designed to threaten the United States and China.[15] Secretary of Defense Robert McNamara declared in November 1967 that the Russian Fractional Orbit Bombardment System tests did not violate the 1967 Outer Space Treaty.[16]

The PRC denied that any such test had been conducted.[17] China's Ministry of Foreign Affairs spokesperson Zhao Lijian said the August test was "a spacecraft, not a missile," according to multiple media reports.[18] U.S. officials do not believe Zhao's denial.[19]

China Fields a Hypersonic Weapon: The Dong Feng 17

On 1 October 2019, the 70th anniversary of the establishment of the People's Republic of China, in a parade that reviewed the PLA's troops and weapon systems, the PLA revealed a new hypersonic missile, the Dong Feng (DF) 17.[20] An article in the newsfeed for one of China's leading internet agencies, 163.com, described the DF-17 as a "nightmare predator" designed to attack the U.S. aircraft carrier fleet; it said that the defenses against hypersonic missiles were the weakest link in the U.S. defense system. According to the International Institute for Strategic Studies (IISS), the section of a report that discussed regional missiles in the DoD 2019 *Missile Defense Review* contained only a passing reference to "a previously unpublicized Chinese missile designated 'CSS-X-22.'"

Once the PRC's 2019 70th anniversary parade was held and the PLA showed the missile, it became obvious that this was the DF-17 medium-range, hypersonic glide vehicle that the PLA had tested in 2017.[21] The IISS analysis was that the DF-17 warhead also could theoretically be a new intermediate-range ballistic missile (IRBM) design in development. It also is probably a design related to the warhead of the hypersonic warhead that the PRC put into orbit; that is the main topic of this paper.

A review of the parade in a PRC blog devoted to military affairs described the DF-17 as a "combat ready hypersonic weapon."[22] The article also noted that both Russia and the United States were developing hypersonic weapons and had "stepped up" research on hypersonic systems. According to the article, Russia had test-fired its "Zircon" hypersonic missile several times (the article mentioned four test flights) as a naval weapon system, although the system had not yet entered active service. The last test flight was on 6 October 2020, the results of which were reported to Russian president Vladimir Putin the next day.[23] The 6 October flight test had the missile flying 450 kilometers in 4.5 minutes with speeds between 5,700 kilometers per hour and 9,500 kilometers per hour. President Putin announced that Russia also should develop a land-based version of the Zircon. The United States, according to the 163.com article on the Zircon launch, was in a "more miserable position" and was experiencing problems in the design of a hypersonic weapon.

Unfortunately, once a hypersonic missile is tracked and located, shooting it down or stopping it is not an easy task for defenses. For warheads entering from space, the heat and plasma surrounding the reentering warhead make the use of directed energy practically impossible, but the use of "kinetic interceptors that collide directly into an incoming missile, or blast-fragmentation interceptors that explode at close distance, spraying shrapnel into the hypersonic vehicle" is feasible. In the future, according to a Center for Strategic and International Studies report, "lasers, high-powered microwaves, rail guns, or particle clouds designed to disrupt hypersonic flight" are possibilities, but they are in development.[24] And what is true about the difficulties of intercepting a PRC hypersonic missile or warhead is true of a Russian system.

It appears that China may have already developed a hypersonic, ship-launched cruise missile that is similar to the Russian Zircon, making the development of defenses even more critical for the United States.[25] This ship-launched missile could also be launched from land. It is designated the CM-401 and is "intended for rapid and precision strikes against medium-size ships, naval task forces, and offshore facilities," according to a Chinese industry representative. It also appears that China has developed another version of an anti-ship cruise missile, the DF-100, designed to bolster its "counter-intervention (反介入)" strategy, keeping U.S. or other enemy forces away from its coast. This new cruise missile is "a hypersonic, regional-level anti-ship missile that will impose a new, challenging threat-vector for long-range attacks against large warships over a thousand miles of China's coastline."[26] A warhead from a ballistic missile may enter the atmosphere at speeds of Mach 22, but, depending on the size of the warhead and atmospheric conditions, it may approach its target at a speed of 16,000 kilometers per hour, or Mach 13, much faster than a hypersonic missile or warhead that is launched inside the atmosphere and travels inside the atmosphere.[27] The sea- (and land-) launched cruise missiles strengthen what the United States calls China's antiaccess/area denial strategy, which the PLA calls a counter-intervention campaign. The cruise missiles are meant to complement the already operational DF-21D and DF-26 ballistic missiles designed to attack large naval task forces or land targets.

Relationship to the U.S. Prompt Global Strike

In a critique of the United States that justifies Chinese and Russian research on hypersonic missiles and warheads, the 163.com article noted that the United States had already embarked on a weapon system that provided a global strike capability with a hypersonic ICBM warhead

called "Prompt Global Strike."[28] The U.S. designation for the system is Conventional Prompt Global Strike (CPGS), and it was described to Congress as a conventional system, not a strategic nuclear system. The description to Congress, however, does not highlight the fact that to make it a global nuclear system that fires a single ICBM against a specific target requires only changing the warhead. Both the PRC and Russia realized this as soon as the United States revealed the concept.

According to the U.S. Congressional Research Service (CRS):

> "The [U.S.] Air Force and Navy have both pursued programs that would lead to the deployment of conventional warheads on their long-range ballistic missiles. During the 2000s, the Air Force and the Defense Advanced Research Projects Agency (DARPA) sought to develop a hypersonic glide delivery vehicle that could deploy on a modified Peacekeeper land-based ballistic missile, but test failures led to the suspension of this program; research continues into a vehicle that might be deployed on air-delivered or shorter-range systems. In the mid-2000s, the Navy sought to deploy conventional warheads on a small number of Trident II submarine-launched ballistic missiles."[29]

This means that it is likely that while both China and Russia also were conducting research to develop hypersonic missile systems, they succeeded in fielding a system well before the United States. In fact, according to an article in the *War Zone*, which follows defense issues, after numerous tests of what would be a hypersonic warhead for the CPGS system, the Department of Defense is still having problems developing a hypersonic warhead.[30] The Navy and Air Force, which are working together to develop a hypersonic warhead, had earlier claimed three successful tests of the system, as noted in the article.

There are advantages to a hypersonic warhead that is fired from a ballistic missile into space, according to the article on China's 163.com. A hypersonic warhead in the atmosphere might take two hours in flight at five times the speed of sound to strike targets in China or Russia from the United States. A ballistic missile warhead, however, enters the atmosphere at 22 times the speed of sound, and a hypersonic warhead from such a ballistic missile would be four times faster than the DF-17 or the Russian Zircon, neither of which is an ICBM.[31] Further, as the article from China points out, it is difficult to defend against hypersonic systems at present. Meanwhile, the United States is working to develop defenses but appears to be experiencing as much trouble developing hypersonic missile defenses as it is in developing the warheads.[32] China is aware of the problems the United States is having with hypersonic warheads and has devoted coverage of the topic in the military newspaper *PLA Daily*.[33]

There is a certain amount of gloating in China about the success of its hypersonic missile program and the problems the United States is having.[34] In its 2019/2020 assessment of the international strategic situation and U.S. security, China's Ministry for State Security notes that there is still a possibility of a regional conflict in the Indo-Pacific region, although it assesses the likelihood of a new world war as low.[35] Whether it wishes to reassess this opinion in light of the recent Russian invasion on Ukraine remains to be seen.

China's Nuclear Posture: Is It Shifting?

The PLA has set out its nuclear posture in authoritative documents in broad outline.[36] China also has published a series of white papers on strategy and defense that help illuminate China's nuclear strategy and posture.[37] Put simply, China has maintained a strategy of maintaining

a limited nuclear force designed to deter other countries from using nuclear weapons against China and to retaliate in the event that China is attacked with nuclear weapons.[38]

China's policy, and that of the Permanent Five (P5) nations of the United Nations, was reaffirmed at the beginning of 2022, when the P5 nations issued the "Joint Statement of the Leaders of the Five Nuclear-Weapon States on Preventing Nuclear War and Avoiding Arms Races."[39] The P5 state, "The People's Republic of China, the French Republic, the Russian Federation, the United Kingdom of Great Britain and Northern Ireland, and the United States of America consider the avoidance of war between Nuclear-Weapon States and the reduction of strategic risks as our foremost responsibilities."[40] The joint statement went on to pledge that they "reaffirm the importance of addressing nuclear threats and emphasize the importance of preserving and complying with our bilateral and multilateral non-proliferation, disarmament, and arms control agreements and commitments. We [the P5 nations] remain committed to our Nuclear Non-Proliferation Treaty (NPT) obligations, including our Article VI obligation 'to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control.'"

According to the PRC-controlled English-language *China Daily*, Fu Cong , Director-General of the Department of Arms Control of the Foreign Ministry in China, reaffirmed that "China has always adopted the no first use policy and we maintain our nuclear capabilities at the minimal level required for our national security."[41] He went on to say, "We do not deny that China has taken measures to modernize our nuclear arsenal, not for other reasons, but for reliability and safety reasons." Fu dismissed claims that China is "dramatically expanding its nuclear capabilities" and told reporters that China "maintained its nuclear capabilities at the minimum level required for national defense." Ultimately, Fu blamed the United States for changing the nuclear balance by "withdrawing from some treaties, and for upgrading and modernizing its own nuclear forces." The charge by Fu that the United States had withdrawn from treaties is probably a reference to the 2019 U.S. withdrawal from the Intermediate-Range Nuclear Force (INF) Treaty with the Russian Federation.[42]

Meanwhile, China is apparently developing, with Russian help, its own ballistic missile launch early warning system that will give it notice if another nation undertakes an attack on China.[43] Developing an early warning system will help China with its confidence that another country, like the United States, has not launched a preemptory ballistic missile strike against China. And if a launch is detected, such a system would allow China's leaders to undertake decisions on its own readiness as well as how China might respond. However, the existence of such a system does not tell the PLA whether a nuclear-tipped missile was launched or if a conventional warhead was on the missile. This could prompt the leadership in China to consider the detection of a launch as a first strike and to depart from China's "no first use" policy. Thus, while launch-detection systems can be stabilizing, there is not much time to decide on retaliatory actions if a launch is detected and the trajectory is headed toward China. Missile defenses may help stop an incoming warhead, but the detection of a launch can be destabilizing. Both Russia and the United States have ballistic missile launch early warning systems.[44]

A major dilemma in strategic stability is that if a weapon already in space was in orbit and could enter the atmosphere from any direction and maneuver, it would render most current early warning systems useless. Hence the attention to the alleged test of a hypersonic warhead in orbit by China.

The Implications of the Hypersonic Warhead for China's Nuclear Posture

For decades, China's nuclear deterrence strategy depended on a limited number of nuclear weapons that could inflict heavy and unacceptable damage on an adversary if the country were attacked. However, despite claims of a limited deterrent, the number of Chinese nuclear-capable missiles has grown over the years, along with its stockpile of warheads. This growth is probably a response to improved and deployed ballistic missile defenses in the United States and other countries such as Japan. This led the PLA to develop additional technologies and systems to ensure it could maintain its deterrence posture.

In her book *Chinese Nuclear Proliferation*, Susan Turner Hopkins does an excellent job of explaining China's basic nuclear doctrine and posture.[45] She quotes Chinese sources, explaining that "China maintains a small but effective nuclear counterattacking force in order to deter possible nuclear attacks by other countries." While Fu Cong used the word *minimum* to describe China's nuclear arsenal, most analysts describe China's nuclear force as a limited deterrent capability. Turner differentiates them by explaining that, in a limited deterrence policy, a nation may treat nuclear weapons and their use as similar to conventional weapons, and that nuclear use can be limited, perhaps even regionally.[46] In section 2 of its 2021 annual report to Congress, the U.S.-China Economic and Security Review Commission raised the possibility that China may be developing a strategy of nuclear first use on a limited or regional basis.[47] This is consistent with some of the positions on nuclear counter-deterrence taken in the PLA's *The Second Artillery Corps Science of Military Strategy* (*第二炮兵战役学*) cited earlier in this paper.[48]

Among the approaches to maintain what it sees as an acceptable deterrent capability, China has developed a nuclear ballistic missile submarine force, developed nuclear-tipped cruise missiles for bombers, deployed new types of mobile ballistic missile systems with multiple warheads and equipped them with countermeasures like penetration aids to ensure they hit their targets.[49] The research and testing to develop hypersonic missiles and warheads is a natural development of the PLA's nuclear posture.[50]

For the United States to offset the hypersonic threat, it will require not only new detection capabilities but also a hybrid approach of kinetic interceptors and perhaps other non-kinetic means to intercept and destroy incoming warheads and missiles.[51] U.S. ballistic missile defenses also will probably need a new command and control architecture capable of processing data quickly enough to respond to and neutralize an incoming hypersonic threat.

Today, aspects of China's nuclear posture are changing as China develops hypersonic warheads, but the basic strategy and targeting will probably remain the same. The United States and Russia (first as the Soviet Union) started out with counter-value nuclear strategies designed to impose threats against large segments of an enemy's population. After decades of this approach, between arms-control talks and changes in strategic thinking, the United States and the Soviets shifted to a counter-force strategy designed to attack the military and missiles forces of an opponent. Deterrence strategy for the United States and Russia is still a counter-force strategy.[52] China, however, has always maintained a counter-value strategy, which requires large, high-yield nuclear detonations that threaten millions of people. Such a strategy allows China to continue what it sees as a sufficient deterrent capability without building a missiles force of thousands of warheads and missiles like the United States and the Soviet Union did. As part of that nuclear strategy and posture, the PLA believes that "hypersonic technology is the commanding height of aerospace technology."[53] Li Jun, the author of the 2017 *PLA Daily* article cited, argues that the combination of supersonic speed, a high likelihood of battle

damage, the capability to penetrate armor with conventional warheads and a high capacity to penetrate defenses for the PLA means that cruise missiles and ballistic missile warheads can attack reinforced targets and improve on the deterrent capability a nation gets from subsonic kinetic warheads.[54]

The Effect on the Army and Its Space and Missile Defense Mission

The SMDC "develops and provides current and future global space, missile defense, and high altitude capabilities to the Army, joint force, and our allies and partners, to enable multi-domain combat effects; enhance deterrence, assurance, and detection of strategic attacks; and protect the nation."[55] Ultimately, the burden of defending against the new threat posed by what appear to be maneuvering, hypersonic warheads orbiting in space falls on SMDC.

At present, SMDC has assets to defend the U.S. "homeland against long-range ballistic missile attacks" using a "sophisticated fire control system supported by an array of sensors and a ground-based, missile-launched exoatmospheric kill vehicle to track, intercept and destroy an enemy warhead in its midcourse phase of flight, outside the earth's atmosphere."[56] The dilemma for the future that SMDC faces is that its deployed interceptors are located in Alaska and designed to defend the United States against ballistic missiles and warheads that approach the U.S. homeland from over the Arctic or a northern trajectory. This dilemma is highlighted in a conservative American publication that states that "America's ballistic missile defense systems are focused on the Arctic Circle and the North Pole. Hypersonic cruise systems might completely circumvent those defenses by flying over the South Pole and Antarctica while targeting locations anywhere in the Northern Hemisphere."[57]

This means that whether such a system is employed by China, Russia or even North Korea, U.S. defenses are not deployed to intercept missiles approaching from an Antarctic or South Pole trajectory. There are ways the United States could respond to this, but it would take time and a lot of money. Thus, while the existence of hypersonic missiles may not change the nuclear balance—the United States will be able to respond to an attack with part of its triad of missiles, bombers or ballistic missile submarines—the new threat is a serious cost-imposing factor for the United States.

Congress could authorize U.S. Northern Command (USNORTHCOM) and SMDC to construct defenses somewhere in the southern United States comparable to the 49th Missile Defense Battalion (GMD), an Alaska Army National Guard unit permanently on active duty at Fort Greely, Alaska. This battalion provides "operational control and security for the nation's ground-based interceptors located at Fort Greely."[58] But constructing the necessary radar systems, programming space assets, deploying ground-based interceptors and manning the defense system with active duty or National Guard Soldiers would come at a very high cost. During the Cold War, the United States had "approximately 265 Nike missile bases . . . across the United States. . . . Many were on Army National Guard bases who continued to use the property."[59] Building seven sites in one county in Ohio alone cost $12 million in 1955 dollars.[60] It is unlikely that Congress would authorize an entire new defense system. Instead, existing retaliatory systems, policies and measures would most likely be used to deter attacks.

Another defensive approach might be to deploy a cordon of Navy Aegis ballistic missile defense cruisers and destroyers around the United States.[61] However, that would mean fewer naval combatants deployed for traditional missions. Again, the cost to build new cruisers or

destroyers, or even put the Aegis system on other naval platforms, would be very high and take a long time.

These dilemmas demonstrate why the PRC's development and test of hypersonic warheads, and particularly the test of an orbiting warhead, present new security challenges for the Army and the United States.

Conclusion

The development and deployment of hypersonic missiles challenges all U.S. missile defense systems, whether land based or naval. The speed of the missile or warhead means the process of detection, intercept and kill of an incoming warhead must be orders of magnitude faster than for one approaching a target at a lower speed.

Another problem with intercepting and killing hypersonic warheads is that because of their speed they are surrounded by a plasma heat buildup caused by friction with the air.[62] That presents a problem for missile accuracy but also presents a major problem for defenses. Directed-energy weapons would probably be ineffective in penetrating the plasma effect, so destroying a hypersonic missile requires a direct hit with a kinetic warhead.[63] That problem caused by physics and heat puts the burden for defending the United States against hypersonic missiles and warheads back on the Army and SMDC.

However, as discussed in the preceding section, it is not likely that Congress will authorize a nationwide deployment of ground-based interceptors like the Army has in Alaska to try to intercept the type of missile warhead in orbit that China tested. Instead, U.S. policy will likely focus on improved deterrent capabilities.

Clearly, the United States must succeed in developing its own hypersonic capabilities, and, if it is to maintain a counter-force strategy, the warhead has to be accurate. That means that the Army's SMDC and the other services' hypersonic missile programs need adequate funding and the programs should be of high priority. Defenses alone are not enough to deter another nation from strategic attack.

Deterrence still works, and a strategic nuclear balance can be maintained if the United States has a credible retaliatory capability. Programs to modernize the U.S. nuclear arsenal are critical to this deterrence, and that responsibility is not the Army's; it is the responsibility of the Departments of Energy and Defense.[64]

This is not to say that credible defenses are not a part of the strategic deterrence equation. Another approach for the Army and SMDC might be to work on variations of existing defense systems to make them mobile and capable against strategic missile systems. Imagine developing a strategic ballistic missile defense system like the Theater (Terminal) High Altitude Air Defense System (THAAD) system for the Army that is transportable and deployable.[65] Such an effort would take resources and time, however. For the near term, it is likely that maintaining the Army's defenses in Alaska will complement a robust, modernized and credible strategic deterrent.

Notes

[1] Demetri Sevastopulo and Kathrin Hille, "China Tests New Space Capability with Hypersonic Missile," *Financial Times*, 16 October 2021.

[2] "China Reportedly Testing Hypersonic Cruise Missile System," *Conservative America Today*, https://conservativeamericatoday.com/china-reportedly-testing-hypersonic-cruise-missile-system.

[3] U.S. Army Space and Missile Defense Command (SMDC), https://www.smdc.army.mil/about/; SMDC Fact Sheet, https://www.army.mil/smdc#org-about.

[4] "Current U.S. Missile Defense Programs at a Glance," Arms Control Association, October 2019, https://www.armscontrol.org/factsheets/usmissiledefense.

[5] SMDC, https://www.army.mil/smdc#org-about.

[6] Reuters, "Russia says Zircon hypersonic missile hit target in latest test," *CNN*, 29 November 2021; see also Oren Liebermann, "Latest US military hypersonic test fails," *CNN*, 22 October 2021.

[7] Ryan Pickrell, "North Korea says latest weapon it tested was a hypersonic missile," *Business Insider*, 28 September 2021.

[8] National Aeronautics and Space Administration fact sheet, "What Is LEO (Low-Earth Orbit)?" https://www.nasa.gov/leo-economy/faqs. According to NASA, generally a "Low-Earth orbit (often known as LEO) encompasses Earth-centered orbits with an altitude of 2,000 km (1,200 mi) or less. For the purposes of the Commercial Use Policy, low-Earth orbit is considered the area in Earth orbit near enough to Earth for convenient transportation, communication, observation and resupply. This is the area where the International Space Station currently orbits."

[9] Sevastopulo and Hille, "China Tests New Space Capability."

[10] Melissa Tan, "Frost & Sullivan Analyzes Hypersonic Technology Development in the United States," *Frost and Sullivan*, 8 June 2021.

[11] Joe Saballa, "US Hypersonic Missile Fails Anew in Third Trial," *Defense Post*, 20 December 2021; Liebermann, "Latest US military hypersonic test fails."

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[13] "China hails first test of hypersonic nuclear missile carrier," *South China Morning Post*, 15 January 2014; Li Jun (李准), "Hypersonic Weapons Allow War to Enter the 'Countdown' Era (高超声速武器让战争进入"读秒"时代)," *People's Liberation Army Daily* (hereafter cited as PLA Daily), 5 May 2017, 11.

[14] Yang Zhen (样珍), Fan Kun (范坤) et al., "Study on Dynamic Load Protection of the Supersonic Monorail Rocker Sled (超音速单轨火箭雪橇)," http://scbg.qks.cqut.edu.cn/newsinfo.aspx?id=915.

[15] Sevastopulo and Hille, "China Tests New Space Capability"; See Paul Diehl, "Ghosts of Arms Control Past," *Political Science Quarterly* 105, no. 4 (Winter 1990–1991): 597–615; Central Intelligence Agency, National Intelligence Estimate, "The Soviet Space Program," December 1962, 22.

[16] "Fractional Orbit Bombardment System (FOBS)," *Weapons and Warfare*, 23 November 2015; National Aeronautics and Space Administration, *The Outer Space Treaty of 1967*, https://history.nasa.gov/1967treaty.html. The author thanks Dr. Mark Schneider of the National Institute for Public Policy for pointing this out in his review of the manuscript.

[17] Hannah Ritchie, "China denies testing a nuclear-capable hypersonic missile, says it was a spacecraft," *CNN*, 18 October 2021.

[18] Sinead Baker, "China denied a report that it tested a nuclear-capable hypersonic missile, saying it was just a space vehicle," *Business Insider*, 18 October 2021.

[19] CNN, "Top military leader says China's hypersonic missile test 'went around the world,'" *ABC57*, 17 November 2021.

[20] "Technology Surpasses the 'Old Beauty'! Demystifying How China's Hypersonic Missiles Have Become a Nightmare for Modern Warfare Technology Surpasses the 'Old Beauty'! (技术反超老美！揭秘中国高速音速导弹， 如何成为现代战争噩梦)," 163.com, 1 October 2019, https://www.163.com/dy/article/GLTFL9HK05420NZC.html; "Old Beauty" (老美) is a reference to the United States and China's technology surpassing that of the United States. 163.com is one of China's leading internet companies that devotes a lot of news articles to military issues.]

[21] Henry Boyd, "2019 Pentagon report: China's Rocket Force trajectory," *International Institute for Strategic Studies IISS Military Balance Blog*, 15 May 2019, https://www.iiss.org/blogs/military-balance/2019/05/pla-rocket-force-trajectory.

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