Atlantic Council

SCOWCROFT CENTER
FOR STRATEGY AND SECURITY

ISSUE BRIEF

Russian and Chinese strategic missile defense: doctrine, capabilities, and development

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Introduction

The purpose and composition of the United States' homeland and regional missile defenses has long been the subject of a divisive public debate. In 1973, just a year after the landmark Anti-Ballistic Missile (ABM) Treaty was signed, noted strategic forces scholars Bernard and Fawn Brodie wrote that the "whole ABM question touched off so intense and emotional a debate in this country as to be virtually without precedent on any issue of weaponry."[1] This debate continued through the Strategic Defense Initiative (SDI), the passage of the 1999 National Missile Defense Act, the George W. Bush administration's subsequent withdrawal from the ABM Treaty, and has now received renewed attention in the recently released report of the Congressional Commission on the Strategic Posture of the United States.[2]

The primary point of contention in this debate—besides the cost and effectiveness of missile defense programs—has been the reaction of the United States' main nuclear-armed strategic rivals, Russia and China. Critics have argued that US defenses against intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs) could generate an arms-race dynamic either by forcing adversaries to increase their nuclear arsenals or by engendering fears of a US preemptive first strike, which could indirectly create

1 Bernard Brodie and Fawn M. Brodie, *From Crossbow to H-Bomb*, rev. and enl. ed. (Bloomington and Indianapolis, IN: Indiana University Press, 1973).

2 Madelyn R. Creedon et al., *America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States*, Institute for Defense Analyses, October 2023, https://www.ida.org/research-and-publications/publications/all/a/am/americas-strategic-posture.

This paper focuses on strategic ballistic missile defense (BMD), defined as systems of interceptors, sensors, and supporting infrastructure designed to defeat medium- to intercontinental-range ballistic missiles, especially those carrying nuclear warheads. This definition preferences medium-range ballistic missiles (MRBMs), intermediate-range ballistic missiles (IRBMs), and ICBMs, as opposed to short-range ballistic missiles (SRBMs), cruise missiles, and unmanned aerial vehicles (UAVs) for several reasons. While these latter systems can certainly have strategic implications due to their range, precision, and ability to deliver weapons of mass destruction, they can be defeated by far less sophisticated air defense systems which may not necessarily be designed specifically for a missile defense role. Developing the capability to intercept long-range ballistic missiles represents a far greater technical barrier and indicates a clearer interest in strategic defense by a given state. This paper will, however, address systems with limited capability against long-range ballistic missiles as a technological steppingstone in strategic BMD.

crises.[3] Similar statements have been expressed by Russian and Chinese officials, who have leveraged complaints that US ballistic missile defenses undermine the efficacy of their states' nuclear deterrents and therefore their security.[4]

Often missing from this debate is the context of Russian and Chinese efforts to develop their own strategic missile defense systems, their reasons for doing so, and the implications for US strategy. There is a need for more open-source treatments of both countries' missile defense programs, especially as their development has accelerated and even begun deployment in recent years.[5] This research annex follows Matthew R. Costlow and Robert M. Soofer's paper, *US Homeland Missile Defense: Room for Expanded Roles*, and seeks to inform debates about missile defense policy by placing arguments that US ballistic missile defenses are uniquely destabilizing in the context of efforts by Russia and China to deploy similar systems.[6]

Russia

Introduction

This section outlines the historical missile defense programs of the Soviet Union, the current development by the Russian Federation, and the broader trends in Russian thinking on missile defense. Of particular note are the A-135 anti-ballistic missile systems around Moscow and new mobile missile defense systems such as the S-500. With regard to doctrine, Russia orients its air and missile defense strategy around defeating a US-led aerospace strike campaign that Moscow believes could include a full spectrum of threats from aircraft to strategic missiles.

Doctrine

The defense of the homeland against strategic air and missile attack has featured heavily in Russian military planning and doctrine since the early Cold War. This focus likely emerged from the experience of suffering massed German air attacks in World War 2 and continued into the twenty-first century due to a perceived advantage of the United States in the air and space domains.[7] During the 1950s and 1960s, the Union of Soviet Socialist Republics (USSR) sought to defend its airspace against US strategic bombers by deploying hundreds of early generation surface-to-air (SAM) missile batteries across its territory. Later, with the advent of ICBMs, the USSR developed a missile defense system around Moscow. The Soviet Union's primary goals in developing strategic defenses were to protect party leadership, prevent a decapitation of nuclear command and control,

3 Leah Matchett, "Debating Missile Defense: Tracking the Congressional Record," Arms Control Association, March 2021, https://www.armscontrol.org/act/2021-03/features/debating-missile-defense-tracking-congressional-record#endnote_bio.

4 For a Russian view see: "Deputy Foreign Minister Sergey Ryabkov's Opening Remarks at a Briefing at the Rossiya Segodnya International Information Agency on Arms Control and Strategic Stability," Ministry of Foreign Affairs of the Russian Federation, February 11, 2021, https://www.mid.ru/en/foreign_policy/news/1415641. For Chinese responses see: Jing-dong Yuan, "Chinese Responses to U.S. Missile Defenses: Implications for Arms Control and Regional Security," *Nonproliferation Review*, Spring 2023, https://www.nonproliferation.org/wp-content/uploads/npr/101yuan.pdf.

5 One excellent recent treatment of the issue is conjoined papers in Tong Zhao and Dmitry Stefanovich, *Missile Defense and the Strategic Relationship among the United States, Russia, and China* (Cambridge, MA: American Academy of Arts and Sciences, 2023).

6 Matthew R. Costlow and Robert M. Soofer, *US Homeland Missile Defense: Room for Expanded Roles*, Atlantic Council, November 2023, https://www.atlanticcouncil.org/wp-content/uploads/2023/11/Costlow-Soofer-Homeland-Missile-Defense.pdf.

7 Victor Gobarev, "The early development of Russia's ballistic missile defense system," *Journal of Slavic Military Studies* 14, no. 2 (2001): 29–48, https://doi.org/10.1080/13518040108430478.

An older S-300 air defense system on display during a 2009 Russian Victory Day Parade. Source: Vitaly V. Kuzmin

and limit damage in a strategic exchange.[8] It also likely saw a need to compete technologically with the United States for reputational reasons, especially after the highly public announcement of the SDI in 1983.[9]

Since 1991, following observation of US air campaigns, Russian doctrine has emphasized the need to defend against complex threats in the air and space domain, especially a massed aircraft and missile attack by the United States and NATO that would incapacitate Russian military and civilian leadership.[10] To integrate Russia's capabilities across these domains, then Russian president Dimitry Medvedev authorized the creation of the Aerospace Defense Forces in 2011, which was ultimately merged with the Russian Air Force in 2015 to form the Russian Aerospace Forces (VKS). This move demonstrated the Russian military's focus on developing an integrated approach to a wide array of offensive long-range strikes, including strategic nuclear attack, as well as conventional aircraft, cruise, and ballistic missile defense. Russian military analysts often cite the US pursuit of concepts such as Conventional Prompt Strike as indicative of the need to address strategic missile attacks across the nuclear and conventional spectrum.[11] The VKS is organized into several "Air Force and Air Defense Armies," including both aviation and ground-based elements, with one typically being subordinated to each Military District of Russia.[12] These armies provide aerospace domain awareness to, and are coordinated by, military and political lead-

8 Sayre Stevens, "Ballistic Missile Defense in the Soviet Union," *Current History* 84, no. 504 (1985): 313–316, https://doi.org/10.1525/curh.1985.84.504.313.

9 Ibid.

10 Michael Kofman et al., *Russian Military Strategy: Core Tenets and Operational Concepts*, CNA, August 2021, 56, https://www.cna.org/CNA_files/pdf/Russian-Military-Strategy-Core-Tenets-and-Operational-Concepts.pdf.

11 Mikhail N. Kumakshev and Aleksandr V. Kravtsov, "ПРОТИВОРАКЕТНАЯ ОБОРОНА КАК СОСТАВЛЯЮЩАЯ СИСТЕМЫ СТРАТЕГИЧЕСКОГО СДЕРЖИВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ" [Missile defense as a component of the strategic deterrent of the Russian Federation], *Военное Мысль* [*Military Thought*] 12 (December 2021): 21–26.

12 Thomas Withington, "Defending Mother Russia's Skies," RUSI (Royal United Services Institute), July 13, 2022, https://rusi.org/explore-our-research/publications/commentary/defending-mother-russias-skies.

ership through the National Defense Management Center, which serves as the primary command-and-control center for the Russian Ministry of Defense and General Staff.[13]

Moscow's thinking on missile defense prioritizes protecting Russian leadership, critical command and control, and nuclear forces, with BMD capabilities being a critical component. In the Russian Defense Ministry journal, *Военное Мысль* (*Military Thought*), Mikhail N. Kumakshev and Aleksandr V. Kravtsov write: "The main direction of further development of the ПРО [missile defenses] of the Russian Federation is the creation of a layered system covering not only the high levels of leadership, but also the positions of the СЯС [strategic nuclear forces]."[14] Furthermore, the Russian Ministry of Defense has officially stated that:

> The main purpose of the missile defense system is to deter threats of use of missile weapons against Russia and to ensure the protection of state and military facilities, groups of troops, administrative and industrial centers, environmentally hazardous facilities and the civilian population from missile attacks.[15]

While this definition is expansive, the relative ordering of priorities is indicative of the weight placed on protecting civil-military leadership. Furthermore, the US Department of Defense assesses that "Russia is developing a layered missile defense to enhance its anti-access/area denial capabilities, preserve its nuclear deterrent, and ensure regime survival."[16] While defending political leadership and nuclear forces are clearly the primary roles for missile defenses, developing this technology may also have broader benefits from the perspective of the Russian government. It may view its own development of BMD capabilities as necessary not only to keep pace with the United States and NATO allies technologically, but also to defend against possible future contingencies involving Iran, China, North Korea, or even non-state actors.[17]

Historical capability development

The Soviet Union's development of BMD began with the experimental "System A," which was developed and tested between 1957 and 1961 at the Sary-Shagan test site in Soviet Kazakhstan. This served as a proof of concept for the possibility of a missile defense system, and Sary-Shagan continues to serve as the main test area for new missile defense technology.[18] The experiments with System A led to the deployment of the Soviet Union's first early warning radar network. These also influenced the decision to develop the A-35 anti-ballistic missile system designed to protect Moscow over various other prospective BMD projects. The A-35 system became operational fitfully, with various phases being completed between 1967 and 1972; however, ultimately, it did not live up to the expectations of Soviet leaders, helping spur the signing of the ABM Treaty.[19]

In 1989, the A-35 system was upgraded and replaced with the A-135 system, which was based around the Don-2N radar; sixty-eight short-range, endoatmospheric 53T6 "Gazelle" interceptors; and sixteen 51T6 "Gorgon" long-range, exoatmospheric interceptors, both armed with nuclear warheads.[20] These warheads were likely enhanced-radiation weapons, or neutron bombs, designed to use the radiation from their detonations to cause nearby incoming warheads to undergo partial fission and fail to detonate. In 1985, before the deployment of the A-135 system, Soviet official Vitalii Leonidovich Kataev described its capability as providing protection from "1-2 modern ICBMs and up to 35 Pershing 2-type intermediate-range missiles."[21] Kataev also described a planned A-235 follow-on system,

13 Kofman et al., *Russian Military Strategy*, 39.

14 Kumakshev and Kravtsov, "ПРОТИВОРАКЕТНАЯ ОБОРОНА."

15 *Soviet Military Power 1990*, US Department of Defense, 1990, 56–59, http://edocs.nps.edu/2014/May/SovietMilPower1990.pdf, cited in: Peppino DeBiaso, "Russia and Missile Defense: Toward an Integrated Approach," National Institute for Public Policy Information Series no. 512 (2022): 4, https://nipp.org/information_series/peppino-debiaso-russia-and-missile-defense-toward-an-integrated-approach-no-512-january-18-2022/#_edn7.

16 US Department of Defense, "Chinese and Russian Missile Defense: Strategies and Capabilities," 2020, https://media.defense.gov/2020/Jul/28/2002466237/-1/-1/1/CHINESE_RUSSIAN_MISSILE_DEFENSE_FACT_SHEET.PDF.

17 Jana Honkova, *Current Developments in Russia's Ballistic Missile Defense*, George C. Marshall Institute, 2013, https://web.archive.org/web/20140426201121/httpc://missilethreat.wpengine.netdna-cdn.com/wp-content/uploads/2013/04/Russian-BMD-April-13.pdf.

18 Victor Gobarev, "The early development of Russia's ballistic missile defense system," *Journal of Slavic Military Studies* 14, no. 2 (2001): 33, https://doi.org/10.1080/13518040108430478.

19 Ibid.

20 Honkova, *Current Developments*.

21 Pavel Podvig, "Very modest expectations: Performance of Moscow missile defense," *Russian Strategic Nuclear Forces* (blog), October 23, 2012, https://russianforces.org/blog/2012/10/very_modest_expectations_sovie.shtml.

A Don-2n radar supporting the A-135 anti-ballistic missile system through targeting and early warning data. Source: Yuriy Shipilov

which would be effective against eight to twelve ICBMs. The use of enhanced-radiation weapons for BMD suggests that this system was primarily for the protection of military and political leadership in the city's center, given that these systems' detonations could spread dangerous radiation across much of the countryside and outskirts of Moscow itself.[22]

In the 1980s, due to concern about the increasing accuracy of US ICBMs and intermediate-range weapons, the Soviet Union also experimented with developing terminal defenses to increase the survivability of its missile silos. These terminal defenses involved launching a canister of metal balls or rods above the silos to disrupt an incoming reentry vehicle.[23] These projects, alternatively referred to as "Sambo," "Mozyr," or "Active Defense Complex," were cancelled after the fall of the Soviet Union in 1991, but there is some indication that the Russian government may be considering resuming development of a similar capability.[24] In the 1980s and 1990s, the Soviet Union, and later Russia, also continued to upgrade its network of national SAM sites, including deploying the S-300 (SA-10) air defense system, with some early versions having limited terminal defense capabilities against MRBMs.[25] One notable aspect of the Soviet Union's and later Russia's approach to building missile defenses was a tendency to develop and deploy systems with initially relatively limited capabilities that could later be upgraded over time or abandoned if progress proved unfeasible.[26] As discussed below, this

22 Jim Garamone, "Missile Defense Becomes Part of Great Power Competition," DOD News, July 28, 2020, https://www.defense.gov/News/News-Stories/Article/Article/2291331/missile-defense-becomes-part-of-great-power-competition.

23 "ОКР Мозырь/Изделие 171/Камчатская ПРО" [R&D Mozyr/Product 171/Kamchatka missile defense], MilitaryRussia, November 15, 2011, http://militaryrussia.ru/blog/topic-604.html; BDM Federal Inc., "Soviet Intentions 1965-1985 Volume II: Soviet Post-Cold War Testimonial Evidence," National Security Archive, eds. John G. Hines, Ellis M. Mishulovich, and John F. Shull, George Washington University, September 22, 1995, accessed August 4, 2023, https://nsarchive2.gwu.edu/nukevault/ebb285/vol%20II%20Kalashnikov.PDF.

24 Alexey Mikhailov and Dmitry Balburov, "Последний рубеж ПРО вооружат стрелами и шариками" [The last line of BMD will be armed with arrows and pellets], Izvestia, December 11, 2012, https://iz.ru/news/541076.

25 DeBiaso, "Russia and Missile Defense."

26 Stevens, "Ballistic Missile Defense."

pattern appears to hold true today, either by design or due to the capacity limitations of the Russian defense industry.

Current capabilities & future development

Today, Russia deploys several systems that can provide layered missile defense across its territory. The A-135 system deployed around Moscow is currently Russia's only system designed specifically to defend against ICBMs. The system is based around the Don-2N radar, which receives data from Russia's wider early warning system.[27] The Don-2N provides targeting data for the sixty-eight silo-based 53T6 "Gazelle" endoatmospheric interceptors, which are based at five sites around Moscow. As noted previously, the system was originally composed of both endo- and exoatmospheric interceptors; however, the sixteen 51T6 "Gorgon" exoatmospheric interceptors were retired between 2006 and 2007.[28] The Gazelle interceptors were, until recently, equipped exclusively with nuclear warheads. As such, they likely suffered from the drawback that these warheads were stored separately from the missiles, reducing their readiness.[29] The A-135 is operated by the 1st Special Purpose Air and Missile Defense Army of the VKS, which is responsible for the air defense of the Moscow region.[30]

According to interviews with Col. Andrei Cheburin, the commander of the missile defense wing of the VKS, and retired Col. Gen. Viktor Yesin, a former chief of Russia's Strategic Missile Forces, Russia is reportedly embarking on a process of overhauling the entire A-135 system.[31] This redesigned system has been referred to as A-235 and, while it is unclear if this structure is still reflective of current Russian planning, it was described as including three layers of defense:

- A long-range exoatmospheric interceptor (replacing the 51T6) with an intercept range of 1,500 km and altitude of 800 km;
- A medium-range interceptor with a range and altitude of 1,000 km and 120 km, respectively; and
- A short-range interceptor with a maximum range and altitude of 350 km and 40-50 km, respectively.[32]

This plan also includes an upgrade of the Don-2N radars and the Elbrus-2 battle-management computer associated with the system, as well as the activation of the Razvyazka space monitoring radar.[33] In 2018, Russia began deploying the short-range missile envisioned in this plan, an upgraded version of the Gazelle interceptors termed the PRS-1M/53T6M, which can reportedly use either a conventional warhead or a nuclear one.[34] These missiles are reported to have the 350 km range described above and have either replaced the previous generation of interceptors or are deployed alongside them in the formerly mothballed 51T6 silos.[35] If the range reported for these interceptors is to be believed, then they could provide some capability to defend the Russian ICBM sites of the 28th Rocket Division headquartered in Kozelsk and 54th Rocket Division in Teykovo (some 200 km southwest and northeast of Moscow, respectively).[36]

Russia is also reportedly still developing the long-range exoatmospheric midcourse defense component of the A-235 system, which will be the successor to the 51T6.[37] While it is unclear what systems will specifically fill that role, the PL-19 "Nudol" direct-ascent anti-satellite (ASAT) weapon, which Russia tested in November of 2021, may be

27 Sean O'Connor, *Russian/Soviet Anti-Ballistic Missile Systems*, *Air Power Australia*, December 12, 2009, updated April 2012, https://ausairpower.net/APA-Rus-ABM-Systems.html#mozTocId700952.

28 Honkova, *Current Developments*.

29 Hans M. Kristensen and Matt Korda, "Russian nuclear weapons 2022," *Bulletin of the Atomic Scientists* 78, no. 2 (2022): 98–121, https://doi.org/10.1080/00963402.2022.2038907.

30 Maxim Starchak, "Russia to upgrade Moscow's missile defenses by year's end," *DefenseNews*, March 29, 2023, https://www.defensenews.com/land/2023/03/29/russia-to-upgrade-moscows-missile-defenses-by-years-end.

31 Vadim Matveyev, "New missile defences being developed," Russia Beyond, February 3, 2016, https://www.rbth.com/economics/defence/2016/02/03/new-missile-defences-being-developed_564505.

32 Ibid.

33 Starchak, "Russia to upgrade."

34 Nikolay Surkov and Alexey Ramm, "Москва получит новую противоракетную защиту" [Moscow to receive new missile defenses], Izvestia, February 21, 2018, https://iz.ru/710845/nikolai-surkov-aleksei-ramm/moskva-poluchit-novuiu-protivoraketnuiu-zashchitu.

35 Lukas Andriukaitis, "#PutinAtWar: New Russian Anti-Ballistic Missile," Digital Forensic Research Lab, Atlantic Council, December 1, 2017, https://medium.com/dfrlab/putinatwar-new-russian-anti-ballistic-missile-4a4194870e0d.

36 Kristensen and Korda, "Russian nuclear."

37 Garamone, "Missile Defense."

the basis of the interceptor that will eventually fill that role.[38] In the 2021 test, the PL-19 impacted a defunct Soviet satellite at an altitude of around 480 km, placing it within the described range for the A-235 exoatmospheric interceptor.[39] There is also evidence of a program for a midcourse interceptor referred to as "Aerostat," being developed by the same company, Almaz-Antey, but with a different subcontractor than the PL-19.[40]

The other recent development in Russian missile defenses is the first deployment of the S-500 missile system, which was delivered to the 1st Special Purpose Air and Missile Defense Army (tasked with the defense of the Moscow area) in 2021.[41] The S-500 is Russia's latest mobile air and missile defense system, and is designed to target IRBMs, early warning aircraft, and satellites in low-Earth orbit.[42] In February of 2024, the Russian Ministry of Defense announced that it had successfully tested the weapon against a hypersonic target representative of an ICBM reentry vehicle.[43] The system was previously tested at a range of 481 km and has a claimed flight ceiling of 100-200 km, which may indicate that it fills the medium-range role envisioned for the A-235 project.[44] As currently deployed, it will complement the A-135 system and, in the future, could provide regional terminal ICBM defense across Russia or form the basis of a future sea-based missile defense capability.[45] The S-500 is designed to use the new 77N6 family of interceptors when engaging ballistic missiles that likely have a kinetic energy hit-to-kill warhead, which is more effective against ballistic missile targets than the blast-fragmentation warheads of interceptors used by the S-400 and S-300 variants.[46] However, the first operational version of the S-500 reportedly has reduced capabilities, and the further ten units which were slated for production in 2022 have not yet been delivered.[47] Members of the Russian defense industry have already begun discussing a planned upgrade, the S-550, which will be solely optimized for missile defense and be more capable against ICBMs.[48] Despite setbacks to the S-500, there have been several proposals for a national mobile nonstrategic missile defense system composed of S-500s, S-400s, and S-300VMs to protect cities and industrial centers from regional missile attacks.[49] One other notable Russian strategic capability is "Peresvet," a mobile, high-powered laser system designed to blind imaging satellites in orbit. Peresvet has been based near mobile ICBM bases, such as the one at Teykovo, suggesting that it is intended to inhibit targeting of those missiles.[50] Peresvet could also potentially be used to prevent adversaries from tracking mobile BMD systems, like the S-500.

Russia fields a number of systems, including the S-400 as well as the S-300 PMU-2 and S-300VM variants, that have some capability against MRBMs but are primarily designed to defend against airbreathing cruise missiles, aircraft, and SRBMs.[51] The VKS had an estimated 584 S-300 launchers of various types and over 248 S-400 launchers in inventory before the invasion of Ukraine on February 24,

38 Ankit Panda, "Russia Conducts New Test of 'Nudol' Anti-Satellite System," *Diplomat*, April 2, 2018, https://thediplomat.com/2018/04/russia-conducts-new-test-of-nudol-anti-satellite-system/.

39 Ankit Panda, "The Dangerous Fallout of Russia's Anti-Satellite Missile Test," Carnegie Endowment for International Peace, November 17, 2021, https://carnegieendowment.org/2021/11/17/dangerous-fallout-of-russia-s-anti-satellite-missile-test-pub-85804.

40 Bart Hendrickx, "Aerostat: a Russian long-range anti-ballistic missile system with possible counterspace capabilities," *Space Review*, October 11, 2021, https://www.thespacereview.com/article/4262/1.

41 "First regiment of S-500 air defense systems to defend Moscow — source," TASS, October 12, 2021, https://tass.com/defense/1348691.

42 "S-500 Prometheus," Missile Threat, Missile Defense Project, Center for Strategic and International Studies, July 1, 2021, https://missilethreat.csis.org/defsys/s-500-prometheus/.

43 "ВС РФ протестировали С-500 на способность сбивать гиперзвуковые цели" [The Russian Armed Forces tested the S-500's ability to shoot down hypersonic targets], *Izvestia*, February 27, 2024, https://iz.ru/1656259/2024-02-27/vs-rf-protestirovali-s-500-na-sposobnost-sbivat-giperzvukovye-tceli.

44 Miko V. Vranic, "Russia begins series production of S-500 air-defence system," Janes, April 27, 2022, https://www.janes.com/amp/russia-begins-series-production-of-s-500-air-defence-system/ZnlJK3dHVU9mZ28xajRJVkc5dVI5VFp1cVMwPQ2.

45 Yuri Smityuk, "New-generation missile destroyer under development in Russia," TASS, October 21, 2014, https://web.archive.org/web/20141024041212/http://en.itar-tass.com/russia/755539.

46 "S-500 Prometheus," Missile Threat; Zhao and Stefanovich, *Missile Defense*.

47 Maxim Starchak, "Where is Russia's S-500 air defense system?" *Defense News*, October 5, 2023, https://www.defensenews.com/industry/2023/10/05/where-is-russias-s-500-air-defense-system/.

48 "Источники Раскрыли Особенности Новой Зенитной Ракетной Системы С-550" [Sources Reveal Features of New Anti-Air Missile System], РИА Новости [RIA Novosti], November 13, 2021, https://ria.ru/20211113/s-550-1758871100.html.

49 Zhao and Stefanovich, *Missile Defense*.

50 Bart Hendrickx, "Peresvet: a Russian mobile laser system to dazzle enemy satellites," *Space Review*, June 15, 2020, https://www.thespacereview.com/article/3967/1.

51 Garamone, "Missile Defense."

A Peresvet laser weapon in its combat configuration. Source: Russian Ministry of Defense

2022.[52] Furthermore, the S-300F variant is integrated into many Russian Navy surface combatants, with newer ships being equipped with the "Redut" air defense system that shares the same 9M96E interceptors with fragmentation warheads as the S-400.[53]

The Russian VKS is also in the process of modernizing its space-based early warning and ground-based tracking capabilities. The current Soviet-era "Oko" early warning satellite constellation is slated to be replaced by the Единая космическая система (EKS) [Unified Space System] often referred to as "Kupol." The system was planned to be completed by 2020; however, currently only six of the ten highly elliptical orbit "Tundra" satellites for the constellation have been placed in orbit, and none of the planned geostationary satellites have been launched.[54] Experts have attributed the lengthy timeline to production delays caused by sanctions and Russia's ongoing war in Ukraine.[55] Russia's ground-based radar modernization has fared better, with nine 77Ya6 "Voronezh" radar early warning and tracking sites having been constructed around Russia's borders and five 69Ya6 "Rezonans" radar systems deployed within the Arctic Circle specifically to monitor ICBM launches.[56] In late May 2024, two Voronezh radar sites were targeted in attacks by Ukrainian UAVs, raising concerns about potential escalation risks by some experts.[57]

52 International Institute for Strategic Studies, *The Military Balance* (London: Routledge, 2022), 201.

53 Honkova, *Current Developments*.

54 Maxim Starchak, "Sanctions further delay Russian missile early warning program in space," *Defense News*, March 12, 2023, https://www.defensenews.com/space/2023/03/12/sanctions-further-delay-russian-missile-early-warning-program-in-space/https://www.defensenews.com/space/2023/03/12/sanctions-further-delay-russian-missile-early-warning-program-in-space/.

55 Ibid.

56 Naqi Wasif, "Hammer and shield: Russia's modernized radar and early warning systems," Janes, February 25, 2022, https://www.janes.com/defence-news/news-detail/hammer-and-shield-russias-modernised-radar-and-early-warning-systems.

57 James Acton, "The United States should not further loosen its prohibition on Ukraine's using U.S.-supplied weapons to strike Russia," Carnegie Endowment for International Peace, June 6, 2024, https://carnegieendowment.org/posts/2024/06/ukraine-prohibition-us-weapons-strike-russia?lang=en&center=india.

One bottleneck in Russia's ability to produce advanced capabilities is the capacity of its defense industry, particularly Almaz-Antey, which produces most of its air defense systems. Almaz-Antey has struggled with meeting delivery dates and production quantities in the past, and it can only be assumed that these problems will increase due to export restrictions on critical components resulting from Russia's invasion of Ukraine.[58] It is also worth noting that, following the invasion, Ukraine has launched several attacks on the Moscow region with various types of UAVs. Although these attacks were not officially acknowledged by the Ukrainian government, they raise questions about the effectiveness of Moscow's air defenses against small, low-flying targets. In March of 2023, then Russian defense minister Sergei Shoigu announced that the air and missile defenses of Moscow would be upgraded by the end of the year, likely referencing the threats of drones and cruise missiles, rather than ballistic missiles.[59]

While relatively effective against Ukrainian aircraft, Russian tactical air and missile defense systems seem to have a mixed record in combat since Russia's February 2022 invasion. So far, Russia has claimed interception of approximately a dozen Ukrainian Soviet-era Tochka-U SRBMs; however, Ukraine has also used the same missile for several successful strikes, including sinking a Russian landing ship in the opening months of the war.[60] More recently, Ukraine has used US-supplied Army Tactical Missile System (ATACMS) SRBMs in several successful strikes, including a pair of attacks on airfields, which destroyed approximately fourteen Russian helicopters.[61] Russia has claimed to have shot down three US-supplied ATACMS SRBMs in a coordinated strike; however, this claim has been disputed with evidence that some of the missiles reached their target.[62] Regardless, Russian effectiveness against ATACMS missiles will likely increase, even if slowly, over the course of the conflict, as Russia trains air defense crews to address the threat.[63]

A MGM-140 ATACM being fired from a HIMAR. Source: US Army Acquisition Support Center

Despite a mixed record in Ukraine and severe resource constraints due to sanctions, Russia is moving to develop more advanced missile defense systems and modernize existing ones. Key metrics for assessing Russian progress will be further development of a midcourse interceptor, confirmation of a hit-to-kill capability for the existing Moscow defense system, or wider deployment of the S-500.

58 Pavel Luzin, "Russia's Mystery of Missile Defense," *Eurasia Daily Monitor* 20, no. 49, 2023, https://jamestown.org/program/russias-mystery-of-missile-defense/.

59 Starchak, "Russia to upgrade."

60 "Russian air defenses intercept 8 Tochka-U, two S-200 missiles, 34 MLRS rockets," TASS, January 3, 2023, https://tass.com/russia/1729035; "Russia salvages landing ship hit by Ukraine missile fire," BBC, July 2, 2022. https://www.bbc.com/news/world-europe-62022476.

61 Elen Mitchell, "14 Russian helicopters likely destroyed by US-provided ATACMS missiles in Ukraine: UK intel," *The Hill*, October 20, 2023, https://thehill.com/policy/defense/4267375-russian-helicopters-lost-to-us-atacms-missiles-ukraine/.

62 Stefan Korshak, "Kremlin Claims It Shot Down ATACMS, Other Sources Say the US Weapons Took Out Russian Anti-Missile Systems," *Kyiv Post*, October 27, 2023, https://www.kyivpost.com/post/23353.

63 "Russian air defense forces practice intercepting ATACMS missiles, says general," TASS, November 2, 2023, https://tass.com/defense/1700647.

China

This section details the history of China's development of missile defenses and its ongoing programs. Given the relatively recent nature of China's missile defense capabilities, this section assesses China's possible motivations for developing strategic BMD rather than attempting to describe its doctrine. Special attention is also paid to the overlap of China's BMD development and its ASAT program.

History

Despite only recently beginning to deploy missile defenses, China's interest in the technology dates back to the 1960s. In 1964, Mao Zedong ordered the commencement of Project 640, an effort to develop the technology necessary for a BMD system, including research into kinetic kill vehicles, high-powered lasers, as well as early warning and tracking radars.[64] This research may have been prompted by observation of US and Soviet missile defense developments, as well as a fear that the United States might consider a preemptive attack to eliminate China's nascent nuclear deterrent.[65] Early Chinese nuclear planners were preoccupied with the survivability of their forces and the credibility of their retaliatory capabilities, a theme that would persist into the twenty-first century.[66] As will be discussed later, missile defense may be one possible solution to this survivability problem. Project 640 was hampered by technological challenges and the upheaval of the Cultural Revolution and ultimately ended without deploying any operational systems.[67] However, the project laid the groundwork for future Chinese missile defense and ASAT capabilities.

The announcement of the SDI by then US president Ronald Reagan in 1983 prompted renewed Chinese research into missile defense, and particularly space-based technology, under Project 863 launched by then Chinese president Deng Xiaoping.[68] From this point onward, Chinese research of missile defense technology occurred in parallel with its development of counterspace capabilities designed to neutralize possible US space-based defenses resulting from the SDI. In the 1990s and early 2000s, China repeatedly voiced opposition to US national missile defense development.[69] China was also outspokenly critical of US-led theater missile defense projects in East Asia, such as the sale of the Patriot system to Taiwan in 1997, participation of Japan in the Aegis BMD program in 2003, and the deployment of the Terminal High-Altitude Area Defense (THAAD) system to South Korea in 2016, which China viewed as undermining its strategic deterrent and, potentially, its coercive leverage over Taiwan.[70] However, in the mid-1990s, the Central Military Commission initiated a ten-year program to develop an indigenous missile defense capability, including interceptors and early warning satellites.[71] This development may have been spurred by Chinese observation of the 1991 Gulf War and the vulnerability of Iraq to a coordinated US air and missile strike campaign.[72] At this time, China was heavily reliant on Russia for advanced radars and air defense capabilities and purchased the S-300PMU in 1991 as well as the S-300F naval variant in 2002, which would form the basis of its own domestic production.[73]

In 2001, China introduced the HQ-9 SAM system, which is derived from the S-300 and forms the basis for a family of Chinese air and missile defense systems, including those with some limited capability against SRBMs and MRBMs.[74]

64 Brad Roberts, *China and Ballistic Missile Defense: 1955 to 2002 and Beyond*, Institute for Defense Analyses, 2003, https://nuke.fas.org/guide/china/doctrine/bmd.pdf.

65 William Burr and Jeffrey T. Richelson, "Whether to 'Strangle the Baby in the Cradle:' The United States and the Chinese Nuclear Program, 1960-64," *International Security* 25, no. 3 (Winter 2000/01), https://doi.org/10.1162/016228800560525.

66 Wu Riqiang, "No stability without limits on missile defense," *Bulletin of the Atomic Scientists*, September 24, 2014, https://thebulletin.org/roundtable_entry/no-stability-without-limits-on-missile-defense/.

67 Roberts, *China and Ballistic Missile Defense*.

68 Qiang Zhi and Margaret M. Pearson, "China's Hybrid Adaptive Bureaucracy: The Case of the 863 Program for Science and Technology," *Governance: An International Journal of Policy, Administration, and Institutions* 30, no. 3 (2017): 407–424, https://doi.org/10.1111/gove.12245.

69 Roberts, *China and Ballistic Missile Defense*, 24–26.

70 Roberts, *China and Ballistic Missile Defense*, 20; Marc R. DeVore, "Off the Radar? China, THAAD and Northeast Asia's Alliances," *Global Asia* 12, no. 3 (September 2017), https://www.globalasia.org/v12no3/feature/off-the-radar-china-thaad-and-northeast-asias-alliances_marc-r-devore.

71 Mark A. Stokes, "Chinese Ballistic Missile Forces in an Age of Global Missile Defense," Strategic Studies Institute, US Army War College, 2002, https://www.jstor.org/stable/pdf/resrep11959.8.pdf.

72 Roberts, *China and Ballistic Missile Defense*, 22.

73 "Hongqi-9 (HQ-9)," Claremont Institute, May 6, 2006, https://web.archive.org/web/20060506100233/http:/missilethreat.com/systems/hq-9_china.html#note4.

74 "HQ-9/-15 and RF-9 (HHQ-9 and S-300) (China), Defensive weapons," *Jane's Strategic Weapons Systems*, January 7, 2010, accessed August 2023, https://web.archive.org/web/20120503102455/http://articles.janes.com/articles/Janes-Strategic-Weapon-Systems/HQ-915-and-RF-9-HHQ-9-and-S-300-China.html.

A DF-21 MRBM on display at the Beijing Military Museum. Source: Max Smith

During the 2000s, China continued its development of ASAT weapons, including conducting a destructive direct-ascent test in 2007 at an altitude of 863 km with an interceptor designated SC-19 by US intelligence and believed to be based on its DF-21 MRBM.[75] Since then, China has continued to expand its ASAT capabilities and, in 2010, claimed to test a midcourse BMD interceptor, as will be further detailed below. China has also gained greater technology independence from Russia over the last decade; however, it has continued to take advantage of Russian technical experience and purchase Russian-designed systems. In 2014, China purchased the S-400, which began delivery in 2018.[76] China also announced its cooperation with Moscow on developing its space-based early warning system which, as will be discussed later, has been at least partially successful.[77]

Rationale for developing ballistic missile defenses

Compared to sources on Russian missile defense, there is less public information on Chinese doctrine regarding missile defense; however, it is possible to draw some conclusions from the available evidence. China has strong in-

75 Brian Weeden, “Chinese Anti-Satellite Test Fact Sheet,” Secure World Foundation, updated November 23, 2010, https://swfound.org/media/9550/chinese_asat_fact_sheet_updated_2012.pdf.

76 Franz-Stefan Gady, “China Makes Progress in Induction of Second S-400 Air Defense System Regiment,” *Diplomat*, May 27, 2019, https://thediplomat.com/2019/05/china-makes-progress-in-induction-of-second-s-400-air-defense-system-regiment/.

77 Dmitry Stefanovich, “Russia to Help China Develop an Early Warning System,” *Diplomat*, October 25, 2019, https://thediplomat.com/2019/10/russia-to-help-china-develop-an-early-warning-system/.

centives to develop nonstrategic air and missile defenses to help defend its airspace from hostile attack and allow it to project power into the Pacific. However, China's interest in strategic ballistic missile defense and its associated technologies likely stems from several related objectives. The list below relies heavily on research conducted by Bruce W. MacDonald and Charles D. Ferguson in 2015, for which they interviewed Chinese experts and officials regarding various rationales for developing BMD.[78]

The most likely drivers of China's BMD development include:

- Enhancing the progress of, and providing international legitimacy for, its ASAT weapons program.
- Providing limited defenses of key objects such as political leadership, command and control, and nuclear forces against preemptive attack by the United States and possibly Russia.
- Providing a more robust defense against Indian intermediate-range and ICBM class missiles.
- Gaining further understanding of the nature and vulnerabilities of US BMD technology and operations.
- Demonstrating international technological achievement and competitiveness.

Over the past decades, China has demonstrated a commitment to the development of ASAT systems, including kinetic interceptors, as a key part of its strategy for prevailing in a possible conflict with the United States.[79] The technology for kinetic ASAT weapons overlaps significantly with strategic BMD, as both capabilities involve intercepting high-speed objects at various altitudes outside the Earth's atmosphere.[80] Strategic BMD development may be a natural offshoot of China's efforts to enhance its ASAT capability or an effort to gain additional utility from its research investments. However, Chinese and Russian destructive ASAT testing has drawn international condemnation and provided the United States an avenue to push for limitations and bans on such systems.[81] Therefore, BMD may serve as a useful cover for tests of systems privately envisioned as having a primarily ASAT role. For example, in 2014, China conducted what it claimed was a missile interception test; however, the US Department of State later assessed that it was intended as a test of an ASAT weapon.[82] One result of China's incentive to misrepresent is that it is difficult to categorize claimed Chinese BMD tests or determine whether systems in development are primarily intended for BMD or ASAT roles.

China may also be interested in strategic BMD as one solution to long-standing concerns about its resilience to a first strike by the United States or Russia and the growing sophistication of India's nuclear arsenal. While a defense against the United States or Russia would only be very limited for the foreseeable future, China may view it as beneficial for complicating a possible strike on Beijing or its ICBM silos.[83] Noted expert on Chinese nuclear forces Tong Zhao has suggested that one explanation for the relatively dense arrangement of China's newly constructed ICBM silos could be to facilitate a possible area defense for those weapons.[84] Other possible targets to be defended might include military command and control locations during an ongoing conflict or critical infrastructure, such as the Three Gorges Dam.[85]

Another driver of Chinese interest in strategic BMD could be the increasing range and capability of Indian ballistic

78 Bruce W. MacDonald and Charles D. Ferguson, *Understanding the Dragon Shield: Likelihood and Implications of Chinese Strategic Ballistic Missile Defense*, Federation of American Scientists, September 30, 2015, 43, https://uploads.fas.org/2015/09/DragonShieldreport_FINAL.pdf.

79 Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China: 2023, Annual Report to Congress,* US Department of Defense, 2023, 98–99, https://media.defense.gov/2023/Oct/19/2003323409/-1/-1/1/2023-MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA.PDF.

80 Ashton B. Carter, "The Relationship of ASAT and BMD Systems." *Daedalus* 114, no. 2 (Spring 1985): 171–189, http://www.jstor.org/stable/20024984.

81 Heather Foye and Gabriela Rosa Hernández, "UN First Committee Calls for ASAT Test Ban," Arms Control Association, December 2022, https://www.armscontrol.org/act/2022-12/news/un-first-committee-calls-asat-test-ban.

82 Frank A. Rose, "Ballistic Missile Defense and Strategic Stability in East Asia," remarks, Federation of American Scientists, Washington, DC, February 20, 2015, https://2009-2017.state.gov/t/avc/rls/2015/237746.htm.

83 MacDonald and Ferguson, *Understanding the Dragon Shield*, 23–25.

84 Tong Zhao, "Managing the Impact of Missile Defense on U.S.-China Strategic Stability," in Tong Zhao and Dmitry Stefanovich, *Missile Defense and the Strategic Relationship among the United States, Russia, and China* (Cambridge, MA: American Academy of Arts and Sciences, 2023), 11.

85 Wan Yung-Kui, "Can the Chinese Armed Forces Successfully Protect the Three-Gorges Dam?" *Hong Kong Tangai*, no. 31, October 15, 1993, 72–80, cited in Roberts, *China and Ballistic Missile Defense*.

missiles.[86] In 2014, India deployed a small number of Agni-III IRBMs capable of striking the majority of China and is developing an improved Agni-IV IRBM with even greater range.[87] India also recently successfully tested its developmental Agni-V ICBM with multiple independently targetable reentry vehicles.[88] Given increased tensions with India, it would be hard to believe that Chinese decisionmakers are not concerned about the potential for India to hold any Chinese target at risk with a new generation of ballistic missiles. However, India will likely deploy a far smaller number of delivery vehicles with nuclear warheads compared to the United States or Russia, making a more comprehensive Chinese BMD shield a potentially attractive goal.

China may wish to develop strategic BMD as part of a broader technology development strategy beyond the immediate benefits of a BMD capability. Given its outspoken concern over US missile defense capabilities on strategic stability and interest in defeating them, China may hope to gain a greater understanding of how BMD operations are conducted and the limitations of the technology through its own research and development.[89] Chinese experts have argued that, as long-range strike missiles become increasingly sophisticated and proliferated, it is necessary for China to be competitive in all areas of advanced air and missile defense technology.[90] As such, achieving an ICBM midcourse intercept capability would be a strong signal of Chinese military technology parity with the United States.

Finally, Chinese development of the necessary sensor architecture for BMD could complement its interest in the capability to adopt a launch-on-warning (LOW) nuclear posture.[91] The ability to detect and accurately characterize an incoming missile attack is a necessary prerequisite of both a LOW posture and a strategic BMD capability. As noted below, China is actively expanding its number of ground-based large, phased-array radars and has recently launched satellites for missile detection. In MacDonald and Ferguson's study, they noted that "a Chinese move to deploy early warning satellites would be a significant indicator of greater interest in BMD deployment."[92] If China does choose to deploy strategic BMD, it will be notable which People's Liberation Army (PLA) branch is responsible for its operation. The most likely candidates are the PLA Strategic Support Force, which is responsible for counterspace ca-

An Agni-V ICBM successfully launched from a mobile launcher on Dr. Abdul Kalam Island, 2018. Source: India's Ministry of Defense

86 MacDonald and Ferguson, *Understanding the Dragon Shield*, 24.

87 Hans M. Kristensen and Matt Korda, "Indian nuclear weapons, 2022," *Bulletin of the Atomic Scientists* 78, no. 4 (2022): 224–236, https://doi.org/10.1080/00963402.2022.2087385.

88 Abdul Moiz Khan, "India's Agni-V Test: Implications for Regional Strategic Stability," *Diplomat*, March 18, 2024, https://thediplomat.com/2024/03/indias-agni-v-test-implications-for-regional-strategic-stability/.

89 MacDonald and Ferguson, *Understanding the Dragon Shield*, 23.

90 陈翔 [Chen Xiang], 董立勇 [Dong Liyong], and 于宁宇 [Yu Ningyu], "美军导弹防 御拦截武器发展趋势分析" [Analysis of the development trend of U.S. military missile defense interceptor weapons], 军事文摘 [*Miliary Digest*], no. 23 (2020): 44–47. Cited in Zhao, "Managing the Impact."

91 Office of the Secretary of Defense, *Military and Security Developments*, 112.

92 MacDonald and Ferguson, *Understanding the Dragon Shield*, 4.

pabilities, or the PLA Air Force, which operates China's ground-based air defense.[93]

Current capabilities & future development

Since 2010, China has been actively developing a ground-based midcourse interceptor, with the first tests occurring in 2010, 2013, and 2014. While these early tests may have been primarily oriented around ASAT capabilities, China's latest interceptor, designated the Dong Neng-3 (DN-3), has undergone recent successful BMD tests in 2018, 2021, and 2023.[94] The DN-3 is a hit-to-kill interceptor that has been used to intercept a target DF-21 MRBM and has been compared to the US Standard Missile-3.[95] It has yet to be tested against an ICBM-class target, but the US Department of Defense assesses that the DN-3 will "form the upper-layer of a multi-tiered missile defense."[96] The DN-3 may be a variant of earlier Chinese ASAT weapons, iterations of which have been occasionally referred to as DN-1 and DN-2.[97] China has also tested the HQ-19, a kinetic interceptor derived from the HQ-9, which has the capability to intercept ballistic missiles with a range of 3,000 km in their midcourse and terminal flight stage and has been called "roughly analogous to the US [THAAD] system."[98] The HQ-19 has not yet publicly been deployed and is presumed not to have the capability to defeat an ICBM-class target; however, it could possibly be adapted to do so in the future.[99] Notably, China has also expressed interest in purchasing the S-500 system from Russia, which would likely be complementary to the HQ-19.[100] Furthermore, the People's Liberation Army Navy (PLAN) is reportedly planning to develop the HQ-26, a mid-course interceptor designed to defend against IRBMs, which will eventually be installed on its Type 055 destroyers.[101]

These systems are complemented by China's arsenal of SAMs, primarily designed to defeat aircraft and cruise missiles but with residual SRBM defense capability. China has deployed the HQ-9 to contested islands in the South China Sea and has developed a naval variant, which is integrated into a number of PLAN surface ships.[102] Finally, China also fields a number of Russian SAM systems with capabilities to defend against SRBMs, including the S-300 PMU-2 and the S-400.[103]

China's lack of early warning sensors represents the largest gap in its missile defense architecture.[104] To fill this gap, China is undertaking several initiatives. As noted previously, Russia has signaled that it may aid China in developing satellites for ballistic missile launch detection. This partnership seems to have been successful as the US Department of Defense assesses that "As of 2022, [China] likely has at least three early warning satellites in orbit."[105] China is also building additional ground-based large phased-array radars to provide coverage of Japan, Russia, and the Korean Peninsula, as well as for space observation.[106] Finally, the PLAN plans to develop a new naval radar system to be in-

93 Office of the Secretary of Defense, *Military and Security Developments*.

94 "China says conducted mid-course missile interception test," AP, April 15, 2023, https://apnews.com/article/china-interceptor-missile-test-defense-c77ae53a43f5e74bc48c4be45e46af80.

95 Ankit Panda, "Revealed: The Details of China's Latest Hit-To-Kill Interceptor Test," *Diplomat*, February 21, 2018, https://thediplomat.com/2018/02/revealed-the-details-of-chinas-latest-hit-to-kill-interceptor-test/.

96 Office of the Secretary of Defense, *Military and Security Developments*.

97 Jennifer DiMascio, "China May Have Operational ASAT Program, Reports Say," *Aviation Week*, March 31, 2020, https://aviationweek.com/shows-events/space-symposium/china-may-have-operational-asat-program-reports-say.

98 Phillip C. Saunders, "Testimony before the U.S.-China Economic and Security Review Commission Hearing on China's Nuclear Forces," June 10, 2021, https://www.uscc.gov/sites/default/files/2021-06/Phillip_Saunders_Testimony.pdf.

99 Hans M. Kristensen, Matt Korda, and Eliana Johns, "Chinese nuclear weapons, 2023," *Bulletin of the Atomic Scientists* 79, no. 2 (2023): 108–133, https://doi.org/10.1080/00963402.2023.2178713.

100 "India, China may be first buyers of Russia's latest S-500 air defense system," TASS, November 2, 2021, https://tass.com/defense/1356905.

101 Thomas Corbett and Peter W. Singer, "China's Big New Warship Is Missing an Important New Weapon," *Defense One*, January 23, 2023, https://www.defenseone.com/ideas/2023/01/chinas-big-new-warship-missing-important-new-weapon/382082/.

102 Jenevieve Molenda, "Chinese HQ-9 SAMs No Longer Visible on Woody Island," Missile Threat, Missile Defense Project, Center for Strategic and International Studies, updated June 15, 2018, https://missilethreat.csis.org/chinese-hq-9-sams-no-longer-visible-on-woody-island/.

103 Gady, "China Makes Progress."

104 Justin Bronk, *Modern Russian and Chinese Integrated Air Defence Systems: The Nature of the Threat, Growth Trajectory and Western Options*, Royal United Services Institute, 2020, https://static.rusi.org/20191118_iads_bronk_web_final.pdf.

105 Office of the Secretary of Defense, *Military and Security Developments*.

106 Mike Yeo, "New Chinese radar looks toward Japan, satellite image shows," *Defense News*, April 18, 2022, https://www.defensenews.com/global/asia-pacific/2022/04/18/new-chinese-radar-looks-towards-japan-satellite-image-shows/.

A HQ-9 SAM system, the basis of the Chinese air and missile defense systems, displayed at China's 60th anniversary parade in 2009.
Source: Jian Kang

tegrated into its surface combatants that could support a sea-based BMD capability.[107]

China is moving quickly to develop various types of missile defense technology including strategic BMD. The defining feature of its BMD development, however, is its overlap with ASAT testing, an area which likely is a greater priority than missile defense.[108] One of the key enablers of China's progress is its ability to rely on Russian technology and expertise both in developing its interceptors and sensor architecture. While China has made large strides in exoatmospheric interception with hit-to-kill technology, it still has to develop a robust sensing and data processing system as well as trained personnel to create a true capability.

Implications and conclusion

Comparison with US capabilities

The United States' BMD capabilities remain more advanced than those of Russia or China. While both Russia and China are developing the capabilities for midcourse interception of ICBMs, only the United States deploys both the interceptors and sensors to achieve a degree of BMD coverage over its entire territory in the form of the Ground-Based Midcourse Defense (GMD) system. Furthermore, only the United States maintains a sea-based midcourse defense and missile tracking capability through the Aegis BMD system. Both Russia and China, however, are actively pursuing parity. China's midcourse interception capability

107 Stephen Chen, "China is building the most powerful warship radar on record: scientists," *South China Morning Post*, June 7, 2023, https://www.scmp.com/news/china/science/article/3223091/china-building-most-powerful-warship-radar-record-scientists.

108 MacDonald and Ferguson, *Understanding the Dragon Shield*, 23.

A Russian 50P6 missile launcher of the S-350 which was created to replace the S-300PS variant of the S-300 missile defense system.
Source: Wikimedia user Zumlik

is being actively tested and Russia has development plans for a similar system. Both countries also aim to match the US THAAD system with the Russian S-500 system and Chinese HQ-19 designed for high-altitude terminal defense. The United States, Russia, and China are also all carrying out programs to update their early warning and tracking capabilities. The United States is embarking on an ambitious plan to modernize its space-based tracking for a wide variety of threats, such as hypersonic glide vehicles.[109] Russia is also recapitalizing its space-based early warning satellites and ground-based radars but faces serious resource and sanction constraints. China is moving quickly to improve its early warning system but is still far from a comprehensive architecture.

The United States, unlike Russia and China, does not deploy significant ground-based defenses on its homeland territory, aside from the GMD system. Other than a THAAD deployment on Guam and cruise missile defense of the national capital area, the United States typically does not deploy terminal defenses near domestic military facilities or critical infrastructure.[110] In contrast, both Russia and China deploy a larger number and wider variety of ground-based area air and missile defense systems than the United

109 Masao Dahlgren and Tom Karako, *Getting on Track: Space and Airborne Sensors for Hypersonic Missile Defense*, *Center for Strategic and International Studies*, 2023, https://www.csis.org/analysis/getting-track-space-and-airborne-sensors-hypersonic-missile-defense.

110 Trevor Wild, "THAAD Battery in Guam Successfully Completes Table VIII Evaluation," US Army, March 21, 2024, https://www.army.mil/article/274693/thaad_battery_in_guam_successfully_completes_table_viii_evaluation.

States. Russia has deployed the S-400 and S-300 systems at military facilities, including those in Kaliningrad, Belarus, Crimea, and the Arctic Circle. China deploys several varieties of air and missile defense systems around Beijing and near military facilities, including basing the HQ-9 at its contested border with India and on artificial islands in the South China Sea.[111]

Strategic and operational use cases

Ground-based air defenses remain central to Russian and Chinese military thought. Unlike the United States, Russia and China have historically relied on SAMs for homeland defense. Russia and China have clear incentives to develop advanced nonstrategic air and missile defenses systems such as the S-400 and HQ-9. These systems are primarily aimed at denying the United States and its allies and partners the ability to operate aircraft or launch cruise missiles near Russian or Chinese territory.[112] As the United States begins to develop longer-range conventional ballistic missiles over the next decade, such as the Precision Strike Missile, the ability of Russian and Chinese systems to defeat these threats will become increasingly operationally relevant. Furthermore, Russia and China likely view US conventional precision-strike capabilities as having strategic deterrence implications. The United States has previously signaled that it would consider responding to limited nuclear escalation with a massed conventional precision-strike campaign.[113] Russia and China may fear that, under various scenarios, US conventional munitions could be used to target their political and military leadership, command-and-control systems, and/or nuclear forces.[114] Therefore, systems that might be referred to as nonstrategic or tactical could have strategic significance.

Russia and China share many motivations for developing strategic BMD systems but emphasize different applications in their approach. Russia's A-135 system defense of Moscow likely has the primary goals of providing a degree of protection for political and military leadership in case of nuclear attack and also complicating US targeting of the Moscow region. However, if the system's planned modernization is completed, it could also provide a degree of defense for several Russian ICBM bases in the region. Furthermore, systems like Peresvet and the S-500 can serve as protection for mobile ICBMs. These capabilities coincide with the overarching program of nuclear modernization which Russia has undertaken to increase the survivability and effectiveness of its nuclear deterrent. China may also see a role for strategic BMD in defending its strategic forces and political leadership. China's pursuit of the capability is intertwined with its development of sophisticated ASAT capabilities. China may frequently label tests of ASATs as BMD efforts. Russia's PL-19 Nudol system has also been referred to as both an ASAT and BMD system. In fact, most exoatmospheric missile defense systems are at least theoretically usable as ASAT weapons, although the reverse is not always true. This dual functionality likely makes these systems a more attractive investment for Russia and China.

The most troubling possible use case of missile defenses for Russia and China is to provide a backstop to nuclear aggression against the United States or its allies and partners. While this option is not discussed in Russian or Chinese doctrine, in a conflict, either country might consider using nuclear weapons in a limited manner to coerce war termination and rely on missile defenses to deny a proportionately limited US response. In this case, Russia or China would gamble that the United States would be unwilling to consider a response that would be guaranteed to overcome any missile defenses as doing so would require using a large enough number of weapons to risk provoking a strategic exchange.[115]

On a positive note, Russian and Chinese development of limited missile defenses could also produce stabilizing effects and create opportunities for arms control agreements. When developing plans for missile defense capabilities, the defender is forced to consider the lowest possible

111 Molenda, "Chinese HQ-9 SAMs."

112 Kofman et al., *Russian Military Strategy*.

113 Edward Helmore, "Petraeus: US would destroy Russia's troops if Putin uses nuclear weapons in Ukraine," *Guardian*, October 2, 2022, https://www.theguardian.com/world/2022/oct/02/us-russia-putin-ukraine-war-david-petraeus; Matthew Kroenig, "Memo to the President: How to deter Russian nuclear use in Ukraine—and respond if deterrence fails," Atlantic Council, October 2, 2022, https://www.atlanticcouncil.org/content-series/memo-to-the-president/memo-to-the-president-how-to-deter-russian-nuclear-use-in-ukraine-and-respond-if-deterrence-fails/.

114 Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China: 2022, Annual Report to Congress*, US Department of Defense, 2022, 158, https://media.defense.gov/2022/Nov/29/2003122279/-1/-1/1/2022-MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA.PDF.

115 Ottawa Sanders, Mark Massa, and Alyxandra Marine, *The Impact of the Evolving Sino-Russian Relationship on Chinese Military Modernization and the Implications for Deterrence in the Indo-Pacific*, Atlantic Council, (unpublished manuscript, 2022).

A mobile launch vehicle of Russia's new S-500 air defense system. Source: Russian Ministry of Defense

efficacy of their system while the attacker is forced to plan for the highest possible level in order to create a worst-case scenario assessment.[116] This means that the attacker may be deterred from conducting a limited strike, for fear it would fail, even while the defender might not be fully confident they could defeat it. This condition could contribute to strategic stability by disincentivizing either side to take provocative actions. This effect primarily applies to a limited system, as opposed to an effort to create a comprehensive defense, as the attacker still has recourse to an overwhelming strike to maintain its deterrent. To the extent that limited missile defenses can reassure Russian and Chinese leaders that they need not fear a decapitating first strike by the United States, they could support crisis stability and reduce the need for Russia and China to expand the size of their nuclear arsenals to ensure survivability. Furthermore, a more robust understanding of missile defense capabilities could moderate Russian and Chinese fears of US missile defense systems, such as their claim that US SM-3 missiles could intercept their ICBMs. Finally, a demonstrated Russian or Chinese strategic BMD could reopen avenues for arms control negotiations on missile defense or strategic forces more broadly. The United States has not been willing in the past to put its own missile defense capabilities on the negotiating table, but, as the United States would have an interest in limiting deployment by Russia or China, it might be possible for all three parties to reach a reciprocal agreement.

In conclusion, both Russia and China have far greater missile defense capabilities and ongoing development programs than are often acknowledged and are pursuing closer parity with the United States. BMD will likely become a feature of the strategic relationship between the three countries, which could have both positive and negative implications for US national security. Understanding Russian and Chinese reasons for developing this capability can yield insights into their broader defense priorities.

116 MacDonald and Ferguson, *Understanding the Dragon Shield*, 16–17.

Table 1: US, Russian, and Chinese Strategic Ballistic Missile Defense Systems

Country	System	Type/Capability	Number	Deployment/Development
United States	Ground-Based Midcourse Defense (GMD)	Midcourse national intercontinental ballistic missile (ICBM) defense	44 silo-based interceptors[117]	Deployed at bases in Alaska and California. Planned augmentation to 64 interceptors based on the Next Generation Interceptor (NGI)
United States	Next-Generation Interceptor (NGI)	Midcourse national ICBM defense	0	Development, slated to replace current GMD interceptors
United States	Aegis Ballistic Missile Defense	Naval midcourse defense against theater-range missiles; limited capability against ICBMs	49-53 US Navy ships, 8 Japanese ships, 2 Aegis Ashore sites[118]	Deployed on US and Japanese naval vessels as well as Aegis Ashore sites in Romania and Poland. The Poland site became operational as of December 2023.[119]
United States	Terminal High- Altitude Area Defense (THAAD)	Provides terminal area defense against medium- and intermediate-range ballistic missiles at both endo- and exoatmospheric ranges. Could be upgraded to have capability against ICBMs and hypersonic glide vehicles	42 launchers with 8 interceptors each and an AN/ TPY-2 radar[120]	Deployed in South Korea. Previous deployments in Guam, Hawaii, the United Arab Emirates, Israel, Romania, and Wake Island
Russia	A-135/53T6 Gazelle/PRS-1M	Provides terminal defense against ICBMs in the Moscow region. The 53T6 Gazelle interceptors with nuclear warheads will likely be replaced by the PRS-1M/53T6M interceptors, with conventional warheads.	68 silo-based interceptors supported by Don-2N radar	Deployed around Moscow
Russia	PL-19 Nudol	Anti-satellite (ASAT) weapon and possible midcourse interceptor meant to supplement Moscow ICBM defense	Unknown	In development, tested against a satellite in 2021
Russia	S-500	Provides terminal area defense against theater-range ballistic missiles and may have capability against maneuvering warheads and ICBMs	~1	First unit deployed to Moscow region, awaiting full production. Tested against an ICBM representative target in 2024
China	Dong Neng-3/ DN-2/SC-19	ASAT weapon and midcourse ballistic missile defense interceptor capable against ICBMs	Unknown	In development. Tested from Korla missile complex. ASAT capability possibly operational
China	HQ-26	A naval-based ballistic missile defense (BMD) interceptor currently under development	0	In development. Expected eventual deployment on Type 055 destroyers
China	HQ-19	Terminal defense against medium- and intermediate-range ballistic missiles, with possible capability against ICBMs and low-altitude satellites	>1	Possible initial operating capability. Not yet publicly deployed

117 "Current U.S. Missile Defense Programs at a Glance," Arms Control Association, accessed March 25, 2024, https://www.armscontrol.org/factsheets/usmissiledefense#gbmd.

118 Ronald O'Rourke, *Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress*, Congressional Research Service, updated February 6, 2024, https://crsreports.congress.gov/product/pdf/RL/RL33745/250.

119 Ido Vock, "US anti-missile base in Poland to start operations - Polish PM," BBC News, December 11, 2023, https://www.bbc.com/news/world-europe-67681947.

120 International Institute for Strategic Studies, *The Military Balance 2022* (London: Routledge, 2022), 51.

Table 2: US, Russian, and Chinese Nonstrategic Ballistic Missile Defense Systems

Country	System	Type/Capability	Number	Deployment/Development
United States	MIM-104 Patriot PAC-3	Long-range air defense system. Provides terminal defense against short- and medium-range ballistic missiles (SRBMs and MRBMs) as well as cruise missiles and aircraft	15 Battalions and ~480 launchers. Each can fit up to 12-16 PAC-3 interceptors and is directed by an AN/MPQ-65 radar.[121]	Multiple overseas deployments and operated by 17 nations
Russia	S-400	Long-range air defense system. Provides some terminal defense against MRBMs as well as cruise missiles and aircraft	21 regiments with ~450 launchers. In 2023, elements of several batteries were damaged or destroyed in Crimea.[122]	Widely deployed, including in Belarus, Crimea, and Kaliningrad. In combat use against Ukraine
Russia	S-300 VM/S-300 PMU-2	Long-range air defense system with capability against SRBMs. S-300 PMU-2 and VM variants have limited capability against MRBMs	~32 regiments plus variants deployed on naval vessels[123]	Widely deployed and in combat use against Ukraine
Russia	S-350	Medium-range air defense system primarily designed against air-breathing targets but is also reportedly effective against tactical ballistic missiles[124]	Unknown, ~6 as of 2022[125]	Initial production and deployment. One unit lost in Ukraine[126]
China	S-400	Long-range air defense system purchased from Russia. Provides terminal defense against MRBMs as well as cruise missiles and aircraft	32 launchers[127]	Reportedly deployed to China's border with India in 2021
China	HQ-9/HQ-22/S-300 PMU-2	Long-range air defense system with limited capability against SRBMs. HQ-9 and HQ-22 are domestically produced, while China purchased the S-300 PMU-2 variant from Russia	>500 launchers[128]	Deployed around Beijing and military facilities including ICBM bases. HQ-9 was previously deployed to Paracel Islands in the South China Sea.
China	HQ-16	Medium-range air defense system effective against tactical ballistic missiles	200 launchers[129]	Deployed with the People's Liberation Army Ground Force and Navy

121 International Institute for Strategic Studies, *The Military Balance*, 51; "Defense Systems > Patriot," Missile Threat, Missile Defense Project, Center for Strategic and International Studies, last updated August 23, 2023, https://missilethreat.csis.org/system/patriot/.

122 International Institute for Strategic Studies, *The Military Balance*, 192.

123 Ibid.; "Anti-aircraft Missile System S-300V / S-300VM Antey-2500," Missilery.info, accessed March 25, 2024, https://en.missilery.info/missile/c300v.

124 Dmitriy Litovkin, "'Витязи' воздушной обороны: Чем не могут похвастаться зарубежные разработчики системы ПВО" [The 'Vitiyazi' of Air Defense: What Foreign Air Defense System Developers Can't Boast], TASS Online, January 23, 2020, https://tass.ru/opinions/7588391.

125 International Institute for Strategic Studies, *The Military Balance*, 192.

126 "Russians Lost S-350 Vityaz SAM System Due to Mine Explosion," *Defense Express*, February 11, 2024, https://en.defence-ua.com/news/russians_lost_s_350_vityaz_sam_system_due_to_mine_explosion-9480.html.

127 International Institute for Strategic Studies, *The Military Balance*, 255-261.

128 Ibid.

129 Ibid.

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Acknowledgments

The Scowcroft Center for Strategy and Security's work on nuclear and strategic forces has been made possible by support from our partners, including Los Alamos National Laboratory, Northrop Grumman Corporation, the Norwegian Ministry of Defense, the Swedish Ministry for Foreign Affairs, the United States Department of Defense, the United States Department of Energy, the United States Department of State, as well as general support to the Scowcroft Center. The partners are not responsible for the content of this report, and the Scowcroft Center maintains a strict intellectual independence policy.

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