SIPRI Research Policy Paper
February 2024

ESCALATION RISKS AT THE SPACE–NUCLEAR NEXUS

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SUMMARY

● **Space systems are essential for nuclear and non-nuclear missions for China, Russia and the United States, with the space domain central in their national security strategies. Amid the strategic competition and rivalry between the three states, their threat perceptions exhibit unprecedented levels of worst-case scenario thinking, signalling a preparedness to respond with force in case of attacks or incidents involving space systems. Escalation risks in outer space, even possibly extending to the use of nuclear weapons, thus appear to be growing, especially as the deterrent role of such weapons is expanding to account for more capabilities with strategic effect.**

While different variables will impact escalation dynamics at the intersection of outer space, nuclear weapons and related systems (the 'space–nuclear nexus'), some factors clearly contribute to the risk of escalation. These include strategic ambiguity and unclear red lines on what actions could result in potential nuclear retaliation. These fuzzy red lines are further blurred by the many uncertainties in space operations, such as congestion of orbits, considerations of potential civilian harm, the role of commercial actors in space, and the integration of artificial intelligence into space systems. Additional space–nuclear-related risk reduction measures are therefore vital. This paper proposes measures at the multilateral, bilateral and unilateral levels for China, Russia and the USA to consider.

I. Introduction

Escalation risks, particularly the risk of potential nuclear weapon use, are growing amid worsening state relations, a crumbling global arms control and disarmament architecture, and ongoing regional conflicts.[1] The deteriorating global geopolitical context, meanwhile, is exacerbated by developments in outer space that have made that domain more complex and weaponized. Yet the ways in which trends in space interact with escalation dynamics remain little understood. This limited understanding is striking given the strategic significance of outer space, including the role space systems play in nuclear deterrence practices.[2]

This paper aims to identify escalation risks at the intersection of outer space, nuclear weapons and related systems (the 'space–nuclear nexus'). It focuses on China, Russia and the United States, the key actors in contemporary strategic competition and rivalry. Russia and the USA possess the largest nuclear weapon stockpiles in the world by orders of magnitude, while China is reportedly increasing its arsenal through an extensive modernization programme.[3] The three states all rely on space systems and have integrated them into some of their nuclear deterrence practices, including in missile early warning; command, control and communications; intelligence, surveillance and reconnaissance (ISR); and navigation. However, the degree of integration varies among the three states, which means that the strategic significance of a certain type of space system can differ depending on the state. Each of the three also possesses counterspace capabilities that can hold space systems under threat by disruption, damage or destruction.

Confrontation involving China, Russia and the USA in outer space is highly concerning given the potential for escalation to use of nuclear weapons. Conflicts in the space domain may include (but are not limited to) the following scenarios: (*a*) conflict in which strategically valued space systems are targets of attack or perceived imminent threat; (*b*) conflict in which space systems are used (or perceived to be imminently used) offensively, including in an enabling manner for conventional attack; (*c*) conflict in which activities or

[1] See e.g. Wan, W., *Nuclear Escalation Strategies and Perceptions: The United States, the Russian Federation, and China* (United Nations Institute for Disarmament Research, UNIDIR: Geneva, 2021); Kühn, U., *Preventing Escalation in the Baltics: A NATO Playbook* (Carnegie Endowment for International Peace: Washington, DC, 2018); and Hersman, R., 'Wormhole escalation in the new nuclear age', *Texas National Security Review*, vol. 3 (autumn 2020).

[2] See e.g. Raju, N. and Erästö, E., 'The role of space systems in nuclear deterrence', SIPRI Background Paper, Sep. 2023.

[3] See Kristensen, H. M. and Korda, M., 'World nuclear forces', *SIPRI Yearbook 2023: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2023).

* The authors would like to thank the Ministry of Foreign Affairs of the Netherlands, which generously provided funding for this project.

confrontation in space carries across other domains, for instance, an anti-satellite test triggering a conventional response; and (*d*) conflict in which parties to an existing terrestrial conflict expand the battlefield to conduct attacks against space systems.

Yet whether these scenarios might trigger nuclear escalation is a function of a number of variables. These involve, among other things, the strategic significance of the particular space system, the nature of the attack (including whether by kinetic or non-kinetic capabilities), the ability to attribute the attack, and the larger context in which these scenarios may unfold. This paper will explore these risk drivers and consider escalation dynamics at the space–nuclear nexus. Section II analyses threat perceptions of the three states surrounding their nuclear weapons and strategically significant space systems, based on national doctrines, policies and rhetoric. The section focuses on the expressed nuclear escalation threshold of those states as it pertains to these systems. Section III builds on those assessments and considers specific activities at the space–nuclear nexus that could be construed as crossing red lines and driving potential nuclear retaliation. The section also identifies other variables that can contribute to escalation dynamics, including strategic ambiguities and uncertainties unique to space operations, integration of artificial intelligence (AI) in space systems and possible misperceptions regarding the role of commercial actors in the space domain. Section IV suggests a series of space–nuclear-related risk reduction measures. The paper ends in section V with some concluding thoughts.

II. Threat perceptions

Threat perceptions are subjectively determined by a range of factors that can include received signals and assumptions about adversarial intentions, aggregate and relative power or capabilities, and broader geopolitical or environmental factors.[4] The USA has explicitly named China and Russia as key threats to national security, and vice versa, with specific references in their nuclear, space and security policies. This section examines, in turn, the threat perceptions of the USA, Russia and China derived from their respective doctrines, force structures, policy, and rhetoric in national and multilateral forums, in relation to their space systems and in the context of nuclear thresholds. Analysis of these threat perceptions points to potential pathways for nuclear escalation, both inadvertent and deliberate.

The United States

The nuclear threshold and space threats

The 2022 US Nuclear Posture Review, published alongside the 2022 National Defense Strategy, states that nuclear weapon use would be considered 'in extreme circumstances to defend the vital interests of the United States or its Allies and partners'.[5] In addition, it notes that 'a near-simultaneous conflict

[4] For an overview of theories see e.g. Gross Stein, J., 'Threat perception in international relations', eds L. Huddy, D. O. Sears and J. S. Levy, *The Oxford Handbook of Political Psychology* (Oxford University Press: Oxford, Dec. 2013).

[5] US Department of Defense (DOD), *2022 National Defense Strategy of the United States of America* (DOD: Washington, DC, Oct. 2022), 2022 Nuclear Posture Review, p. 9.

with two nuclear-armed states would constitute an extreme circumstance'; this directly follows text on the 'major and growing nuclear threat' posed by China and Russia, with the 2022 National Defense Strategy also referring to those two states in observing the 'challenge of deterring two major powers'.[6] Echoing language from its 2018 predecessor, the 2022 Nuclear Posture Review observes that the deterrent role of nuclear weapons extends beyond nuclear attack to 'a narrow range of other high consequence, strategic-level attacks'.[7] The document also affirms that nuclear weapons may have a role in deterring 'attacks that have strategic effect against the United States or its Allies and partners' as well as 'all forms of strategic attack'.[8] What constitutes an attack that is strategic or strategic-level in nature, or would have strategic effects or high consequences, is not elaborated upon, but the 2018 version linked 'significant non-nuclear strategic attacks' to attacks on US, allied or partner civilian populations or infrastructure, attacks on US or allied nuclear forces, or command and control or warning and attack assessment capabilities.[9]

Notably, the October 2023 report of the Congressional Commission on Strategic Posture recommends that the USA prepares for potential joint aggression from China and Russia by 'fully and urgently executing' nuclear modernization and future expansion, potentially further broadening the role of nuclear weapons in doctrine.[10] While not official US policy, this bipartisan congressional report also mentions that 'future potential conflict with China or Russia would likely involve new kinetic and non-kinetic attacks on the US homeland and assets in space and cyber domains—further underscoring the importance of deterring and defeating such attacks'.[11] Such thinking on the strategic value of space, and its importance in the context of nuclear doctrine, is evident across US policy documents. The 2022 National Defense Strategy, for example, lists counterspace weapons as one among other technologies 'complicating escalation dynamics and creating new challenges for strategic stability'.[12] Elsewhere, space technologies are highlighted for their potential ability to change kinetic conflict and for their threat to 'day-to-day US supply chain and logistics operations'.[13]

The USA specifies that it does not view conflict or confrontation in space as inevitable, but consistently reiterates its right to act in self-defence in its national doctrines and policies.[14] A key takeaway regarding the framing of space security policies over the past two decades, including in the 2011 National Security Space Strategy, the 2020 Spacepower Doctrine for

[6] 2022 Nuclear Posture Review, p. 12, and *2022 National Defense Strategy*, pp. 4–5 (note 5).

[7] 2022 Nuclear Posture Review (note 5), p. 8.

[8] 2022 Nuclear Posture Review (note 5), pp. 7–9.

[9] US Department of Defense (DOD), *Nuclear Posture Review 2018* (DOD: Washington, DC, Feb. 2018), p. 21.

[10] Congressional Commission on the Strategic Posture of the United States, *America's Strategic Posture: Final Report of the Congressional Commission on the Strategic Posture of the United States* (Institute for Defense Analyses, IDA: Alexandria, VA, 2023), p. 47.

[11] Congressional Commission on the Strategic Posture of the United States (note 10), p. 90.

[12] *2022 National Defense Strategy* (note 5), p. 6.

[13] *2022 National Defense Strategy* (note 5), p. 6.

[14] US Department of Defense (DOD) and Office of the Director of National Intelligence (ODNI), *2011 US National Security Space Strategy* (DOD and ODNI: Washington, DC, 2011); US Air Force, *Air Force Doctrine Publication 3-14: Counterspace Operations* (Curtis E. LeMay Center for Doctrine Development and Education, Air University: Maxwell Air Force Base, AL, 27 Aug. 2018); and US Space Command, 'Never a day without space: Commander's strategic vision', Jan. 2021.

Space Forces, the 2021 Space Priorities Framework and the 2022 US Department of Defense (DOD) Space Policy Directive, is the emphasis on preventing, deterring or defeating aggression in the domain.[15] US national policies also incorporate the term 'space superiority', defined in the 2002 Joint Publication 3-14 on doctrine for space operations (updated subsequently), as 'the degree of dominance in space of one force over another that permits the conduct of operations by the former … at a given time and place without prohibitive interference by the opposing force.[16] The use of the term began under the administration of President Barack Obama and has continued under the administrations of Donald J. Trump and Joe Biden. US officials may be re-evaluating the term, with reports that the 2023 classified update to Joint Publication 3-14 on space operations focuses on 'suppression of enemy space capabilities' (similar to the US Air Force 'suppression of enemy air defenses' concept).[17]

Over the past decade the USA has declared that space is a 'warfighting domain', including in its 2020 Defense Space Strategy.[18] Such framing reflects a shift in US thinking towards enhanced readiness or preparation for conflict, or at least confrontation, in the space domain.

In recent years the USA has also undertaken some organizational restructuring—notably with the establishment of the US Space Force in 2019—and reassessed the missions of both the US Space Command and the new Space Force. The Space Force was created to organize, train and equip forces to 'provide freedom of operation for the United States in, from, and to space; conduct space operations; and protect the interests of the United States in space'.[19] In 2023 the Space Force activated a dedicated unit to 'target adversary satellites'.[20] The US Space Command is a separate organizational branch dedicated to employing joint forces with other branches of the US military. In the 2023 classified update to Joint Publication 3-14 on space operations, it reportedly defined its area of responsibility as starting at 100 kilometres above sea level and extending to 'ex-geosynchronous' orbit—that is, beyond geostationary orbit which is at an altitude of about 36 000 km.[21]

This level of readiness by the USA to 'respond to hostile actions' against its space systems is also reflected in the concept of 'active space defense', which it defines as 'direct actions' to mitigate the effectiveness of threats, using a mix of weapon systems.[22] The USA's perception that the threats from China and

[15] *2011 US National Security Space Strategy* (note 14); US Space Force, *Space Capstone Publication: Spacepower: Doctrine for Space Forces* (US Space Force: Washington, DC, June 2020), White House, *United States Space Priorities Framework* (White House: Washington, DC, Dec. 2021); and US Department of Defense (DOD), 'DOD Directive 3100.10: Space Policy', 30 Aug. 2022.

[16] US Joint Chiefs of Staff, *Joint Publication 3-14: Joint Doctrine for Space Operations* (US Joint Chiefs of Staff: 9 Aug. 2002).

[17] Hitchens, T., 'New Joint Force space doctrine clarifies Space Command's "offensive", "defensive" ops', Breaking Defense, 27 Oct. 2023.

[18] US Department of Defense (DOD), *Defense Space Strategy Summary* (DOD: Washington, DC, June 2020).

[19] United States Code, Title 10, section 9081. See also US Department of the Air Force, Comprehensive Strategy for the US Space Force, Report to Congressional Committees, Aug. 2023.

[20] US Space Command, 'Frequently asked questions', [n.d.]; and Tingley, B., 'US Space Force creates 1st unit dedicated to targeting adversary satellites', Space.com, 16 Aug. 2023.

[21] Hitchens (note 17).

[22] *Defense Space Strategy Summary* (note 18).

Russia are immediate and serious, and the emphasis placed on its 'response', indicate that the USA is preparing itself to act within a short time frame.

Actors and capabilities

China and Russia are explicitly identified as key threats to US space security in US governmental reports and institutional objectives, alongside accusations that they are responsible for turning space into a 'warfighting domain'.[23] In the 2022 National Defense Strategy the USA ascribes those two states with malintent, with space capabilities, among others, integrated specifically to 'support coercive strategies and enable military campaigns intended to present the Joint Force with operational dilemmas'.[24] The USA views their space operations as part of a range of grey zone activities (i.e. hostile acts that seek to fall below perceived thresholds for armed conflict) aimed at providing them with opportunities to make 'adverse changes in the status quo'.[25] The 2022 US Defense Intelligence Agency report highlights other Chinese and Russian capabilities, including the ability to conduct kinetic strikes, both from the ground and in space through anti-satellite (ASAT) weapons, and interference by means of cyberattacks and electronic warfare.[26] The US DOD has also expressed concerns regarding the development of directed energy weapons by both states.[27]

There appears to be particular concern in the USA regarding China, which has considerably expanded its space capabilities as compared with Russia. For instance, the October 2023 report of the Congressional Commission on Strategic Posture specifically states that China could threaten US nuclear command, control and communications (NC3), and supporting critical national infrastructure, through its counterspace capabilities, including sophisticated cyber and electronic warfare capabilities.[28] This aligns with concerns expressed by the US DOD that China may attack or disrupt US early-warning satellites in a 'regional military conflict', presumably related to Taiwan.[29] US concerns about China are evident also in speeches to national audiences. For instance, in 2023 the Secretary of the US Air Force, Frank Kendall, stated that China considers space a warfighting domain, disregards strategic stability and continues to show a lack of transparency in its military space doctrine.[30] The US DOD also claims that China tested a 'fractional orbital launch of an ICBM [intercontinental ballistic missile] with a hypersonic glide vehicle' based on a 2021 test that 'likely demonstrated [China's] technical ability to field' a fractional orbital bombardment system (FOBS)—a

[23] See e.g. US Defense Intelligence Agency (DIA), *2022 Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion* (DIA: Washington, DC, 2022); and *Defense Space Strategy Summary* (note 18).

[24] *2022 National Defense Strategy* (note 5), p. 4.

[25] *2022 National Defense Strategy* (note 5), p. 6.

[26] *2022 Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion* (note 23), pp. 17, 28.

[27] US Department of Defense (DOD), Space Policy Review and Strategy on Protection of Satellites, Sep. 2023, p. 3; and US DOD, *Military and Security Developments Involving the People's Republic of China 2023*, Annual Report to Congress (DOD: Washington, DC, 19 Oct. 2023), pp. 102–103.

[28] Congressional Commission on the Strategic Posture of the United States (note 10), p. 92.

[29] *Military and Security Developments Involving the People's Republic of China 2023* (note 27), p. 98.

[30] Pope, C., 'Kendall explains why success in space requires "transformational change"', US Space Force, 19 Apr. 2023.

nuclear-capable delivery system designed to bypass early-warning radars.[31] However, Chinese officials maintain that the test was of a reusable spacecraft only and not of a FOBS.[32] The limited information about the test led experts to strongly caution against alarmist responses.[33] Some also emphasized that the strategic balance would not be altered even if China had a FOBS capability.[34] In addition, current US early-warning systems would provide coverage of incoming missiles. Nevertheless, the test has intensified US concerns about Chinese capabilities.

The USA has expanded development of its own counterspace capabilities—both kinetic and non-kinetic—in the past 15 years.[35] It has also expressed interest in developing space-based missile defence in different degrees. This began in the 1980s when the administration of President Ronald Reagan considered introducing space-based interceptors under the Strategic Defense Initiative (SDI), with the objective of intercepting potential incoming ballistic missiles.[36] Subsequent US administrations contemplated initiatives for space-based missile defence in various forms. This did not materialize amid the limits on missile defence (including space-based missile defence)—such as those under the 1972 Treaty on the Limitation of Anti-Ballistic Missile Systems (ABM Treaty)—agreed between the USA and the Soviet Union during arms control talks.[37] However, the USA withdrew from the ABM Treaty in 2002 and later conducted small-scale studies about the feasibility of space-based missile defence.[38] More recently, in the 2019 Missile Defense Review, the Trump administration mentioned the advantages of space-based sensors and interceptors, and directed the US DOD to identify technologies, schedules, costs and personnel for 'a possible space-based defensive layer that achieves an early operational capability for boost-phase defense'.[39] Yet the 2022 Missile Defense Review makes no mention of space-based missile defence, and the USA has to date only pursued space-based sensors rather than take any action towards space-basing of interceptors. Indeed, some US experts have strongly criticized space-based missile defence, questioning its overall technical feasibility and military advantages.[40] Still, the interest expressed under the Trump administration has not been explicitly rolled

[31] *Military and Security Developments Involving the People's Republic of China 2023* (note 27), pp. 103, 111.

[32] 'The first flight of China's suborbital reuse carrier flight demonstration verification project was a complete success', Xinhua, 16 July 2021 (in Chinese); and 'China denies report of hypersonic missile test, says tested space vehicle', Reuters, 18 Oct. 2021. FOBS were originally designed by the Soviet Union to attack targets by partially entering orbit and then deorbiting to attack from the south, thus avoiding the USA's northward-facing early-warning radars. See e.g. Siddiqi, A. A., 'The Soviet FOBS: A short technical history', *Quest the History of Spaceflight Quarterly*, vol. 7, no. 4 (spring 2000), p. 22.

[33] See e.g. Center for Strategic and International Studies (CSIS), *Space Threat Assessment 2022* (CSIS: Washington, DC, Apr. 2022), p. 23; Bowen, B. and Hunter, C., 'Chinese fractional orbital bombardment', Asia-Pacific Leadership Network Policy Brief no. 78, 2021; and West, J., 'The Sputnik moment re-examined', *Ploughshares Monitor*, vol. 42, no. 4 (winter 2021).

[34] Bowen and Hunter (note 33), p. 7.

[35] Weeden, B. and Samson, V. (eds), *Global Counterspace Capabilities: An Open Source Assessment 2023* (Secure World Foundation: Broomfield, CO, Apr. 2023).

[36] Bateman, A., 'The enduring impact of Reagan's Strategic Defense Initiative', *Arms Control Today* (Sep. 2023).

[37] Bateman (note 36). See also Treaty on the Limitation of Anti-Ballistic Missile Systems, opened for signature 26 May 1972, entered into force 3 Oct. 1972, not in force from 13 June 2002.

[38] Wolf, J., 'US to study possible space-based missile defense', Reuters, 17 Oct. 2008.

[39] US Department of Defense (DOD), *2019 Missile Defense Review* (DOD: Washington, DC, 2019).

[40] See e.g. Union of Concerned Scientists, 'Space-based missile defense', 30 Aug. 2018.

back. This silence, coupled with the USA's withdrawal from the ABM Treaty, has amplified Chinese and Russian allegations that the USA retains the option of space-based missile defence (see below).

Tests of either missile defence technology or direct-ascent anti-satellite (DA-ASAT) weapons can fuel fears surrounding the other, as missile defence systems can be repurposed to target satellites.[41] Each of the three states has previously tested DA-ASAT weapons, further heightening tense relations and sparking discussion on stability and sustainability in the space domain. In 2022 the USA made a national pledge that it would refrain from conducting DA-ASAT tests.[42] Notably, in its announcement the USA only mentioned China and Russia having conducted these tests and did not acknowledge India's test in 2019 or its own test in 2008. National pledges were subsequently made by many other states, culminating in a USA-led resolution adopted by the United Nations General Assembly, with 155 states voting in favour.[43] Notably, however, China, India and Russia were not among them. At the same time, the USA continues to seek to reduce incentives for attack by focusing on the 'resilience' of its own space systems. Its 2022 National Defense Strategy equates 'resilience' to increasing redundancy and introducing space systems in lower orbits, suggesting that the USA aims to reduce the number of high-value targets while distributing functions across orbits.[44]

Russia

The nuclear threshold and space threats

Russia's 2020 basic principles on nuclear deterrence document specifies four conditions under which it may use nuclear weapons, including in response to an attack of 'critical governmental or military sites … disruption of which would undermine nuclear forces response actions'.[45] Space systems relevant for Russia's nuclear deterrence could fall under this category. Russia may thus respond with a nuclear attack if it believes that its critical infrastructure (particularly certain space systems) is threatened. It also cites potential nuclear use if there exists 'arrival of reliable data on a launch of ballistic missiles attacking' Russia or its allies, reinforcing the importance of protecting data transmitted from its space-based early-warning systems.

Russia's space security priorities are reflected in its national doctrines. Russia's military doctrine, most recently revised in 2014, defines several key terms. It defines 'military risk' as 'a situation in the interstate or intrastate relations characterized by the totality of factors which can lead to a military threat under certain conditions'.[46] Russia then defines 'military threat' as 'a situation in the interstate or intrastate relations characterized by a real possibility of an outbreak of a military conflict between opposing sides and by a high degree of readiness' of a state or separatist organizations to resort to

[41] Grego, L., 'Outer space and crisis risk', eds C. Steer and M. Hersch, *War and Peace in Outer Space: Law, Policy and Ethics* (Oxford University Press: Oxford, 2020), p. 275.

[42] White House, 'Remarks by Vice President Harris on the ongoing work to establish norms in space', 18 Apr. 2022.

[43] UN General Assembly Resolution 77/41, 7 Dec. 2022.

[44] *2022 National Defense Strategy* (note 5), p. 8.

[45] Russian Ministry of Foreign Affairs, 'Basic principles of state policy of the Russian Federation on nuclear deterrence', Approved by Russian Presidential Executive Order no. 355, 2 June 2020, para. 19.

[46] Russian Military Doctrine, no. Pr.-2976, 25 Dec. 2014, para. 8(b).

armed violence.[47] There appears to be a distinction of time and scale between military risks and military threats. Military risks may evolve over time, while military threats are imminent and urgent and are situations in which Russian armed forces are ready to take action.

As military risks, Russia lists the establishment and deployment of strategic missile defence systems and 'implementation of the global strike concept, intention to place weapons in outer space, as well as deployment of strategic non-nuclear systems of high-precision weapons'—an explicit reference to US efforts to extend the range of its precision-strike conventional weapons, including through hypersonic technology.[48] The doctrine also reflects Russian concerns regarding US strategic missile defences and Russian allegations that the USA is pursuing space-based missile defence. Moreover, Russia names certain risks that could evolve into military threats that would demand neutralization by nuclear deterrence.[49] These include 'development and deployment of missile defence assets and strike systems in outer space'.[50] Further up the scale, Russia outlines as 'military threats', among others, 'disruption of the functioning of its strategic nuclear forces, missile warning systems, systems of outer space monitoring'.[51] This appears consistent with the content of its 2020 Basic Principles document. Russia reiterated its priorities in discussions at the 2022 UN open-ended working group (OEWG) on reducing space threats through norms, rules and principles of responsible behaviours.[52] From Russia's national doctrine and policy, it is clear that targeting space systems for early warning and monitoring feature high among its threat perceptions, as this may impair its ability to detect an incoming nuclear first strike. This is notably separate from Russia's concerns regarding US interest in space-based missile defence, which relates to possible undermining of Russia's second-strike capability.

Russian posture has evolved from its previous military doctrine published in 2010. The 2014 version mentions that Russia will 'resist attempts by some states or group of states to achieve military superiority through the deployment of strategic missile defence systems, the placement of weapons in outer space or the deployment of strategic non-nuclear high-precision weapon systems'; this phrasing is notable given the US emphasis on 'space superiority' that emerged during the Obama administration.[53] Russia also states that it aims to deter conflict, and strengthen its potential for 'monitoring objects and events' in 'near Earth outer space' as well as international cooperation in this regard.[54] This reference to 'near Earth outer space' possibly alludes to the role of early warning or ISR systems, reinforced in 2019 when Russia

[47] Russian Military Doctrine (note 46), para. 8(c).

[48] Russian Military Doctrine (note 46), para. 12(d). For further detail on US efforts to develop a global strike capability see Erästö, T., *New Technologies and Nuclear Disarmament* (SIPRI: Stockholm, May 2021), p. 11.

[49] 'Basic principles of state policy of the Russian Federation on nuclear deterrence' (note 45), para. 12.

[50] 'Basic principles of state policy of the Russian Federation on nuclear deterrence' (note 45), para. 12.

[51] Russian Military Doctrine (note 46), para. 14(b).

[52] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 'Space risks and threats', Submitted by Russia, A/AC.294/2022/WP.19, 20 Sep. 2022.

[53] Russian Military Doctrine (note 46), para. 21(l).

[54] Russian Military Doctrine (note 46), para. 21(o).

and China announced their intent to collaborate on space issues and early warning.[55]

Russia's doctrine mentions the 'permanent readiness' of its armed forces for potential military conflicts and includes among their key tasks the 'aerospace defence of critical infrastructure' and increasing their 'readiness to counter air and space attacks' during peacetime.[56] Russia was the first state to establish a national space force. This began with a separate branch for the military in 1992, which was then merged with the Russian Strategic Missile Forces in 1997, integrating early-warning, space surveillance and missile defence units.[57] These reorganizations may have been conducted to improve structure and resource management, rather than for a specific mission.[58] In 2001 the Russian Space Forces were re-established separately 'due to the negative results of integration and increasing role of space assets' in Russian security.[59] In 2011 Russia established the Aerospace Defence Forces, with a mandate to defend Russian territory from adversaries' 'joint air and space-based strike weapons'.[60] In 2015 the Aerospace Defence Forces merged with the Russian Air Force to become the 'Aerospace Forces'.[61] The mandate of the Aerospace Forces includes 'monitoring space objects and identification of potential threats, prevention of attacks'.[62] In a 2015 media report, a former Russian official implied that this reorganization drew lessons learned from past interventions by the North Atlantic Treaty Organization (NATO), and sought to provide Russia with a 'prompt response to any attack coming from air or space with a streamlined and unified command'.[63] The official also suggested that the Aerospace Forces were introduced partly as a response to the US Prompt Global Strike programme (now known as 'Conventional Prompt Strike') undertaken by the USA since the 2000s to extend the range of its conventional precision-strike weapons.[64] Given the speed and corresponding strategic effect of these weapons, Russia's concerns about them probably contributed to its development of ISR systems in space.

Actors and capabilities

In its most recent foreign policy concept, published in 2023, Russia explicitly names the USA as a threat multiple times and criticizes the USA for expressly labelling China and Russia as its competitors or adversaries.[65] It accuses the USA of being responsible for 'complicating the normalization of relations between Russia and European states' and underscoring 'US

[55] Raju and Erästö (note 2), pp. 6–7.
[56] Russian Military Doctrine (note 46), paras 19, 32(f).
[57] Russian Ministry of Defence, 'Aerospace Defence Forces', [n.d.].
[58] See e.g. Podvig, P., 'Russia and military uses of space', Russianforces.org, 1 July 2004.
[59] Russian Presidential Library, 'A new arm of the service, space forces, created under the decree of the RF president', 24 Mar. 2001; and President of Russia, ['On ensuring the construction and development of the armed forces of the Russian Federation, improving their structure'], Decree no. 337c of the Russian President, 24 Mar. 2001 (in Russian).
[60] Russian Ministry of Defence (note 57).
[61] Russian Ministry of Defence, 'Aerospace Defence Forces', archived web page, [n.d.].
[62] Russian Ministry of Defence (note 61).
[63] Bodner, M., 'Russian military merges Air Force and Space Command', Moscow Times, 3 Aug. 2015.
[64] Bodner (note 63); and Erästö (note 48), p. 11.
[65] Russian Ministry of Foreign Affairs, 'The concept of the foreign policy of the Russian Federation', Approved by Russian Presidential Decree no. 229, 31 Mar. 2023.

global domination'.[66] NATO too is named as a priority, in line with its status as a 'military risk' in Russian military doctrine.[67] Russia specifically alleges that the USA and its 'satellites' (i.e. US allies) used the war in Ukraine 'as a pretext to aggravate [its] longstanding anti-Russian policy and unleashed a new type of hybrid war'.[68] The concept states that US actions in Ukraine are 'aimed at weakening Russia in every possible way' and emphasizes Russia's right to 'existence and freedom of development using all means available'.[69] However, it also states that Russia is 'ready for dialogue and cooperation', 'maintaining strategic parity', 'peaceful coexistence', and establishing 'a balance of interests' with the USA, in the light of both being nuclear weapon states and their 'special responsibility for strategic stability'.[70]

As demonstrated in its statements in UN forums, Russia's threat perceptions in the space context appear to be primarily triggered by US missile defences and its fears that the USA will invest in space-based and space-to-earth strike weapons.[71] While there is no evidence that space-based missile defence and space-to-earth strike weapons are being pursued by the USA, Russia has increasingly vocalized related concerns in the years following the USA's withdrawal from the ABM Treaty. This is evident in its joint initiative with China in the Conference on Disarmament—first submitted in 2008, then revised and re-submitted in 2014—to negotiate a draft treaty on the prevention of placement of weapons in outer space and the threat or use of force (hereafter referred to using the abbreviation PPWT).[72] In response, the USA argued that the definition of 'weapon in space' contained in the draft addressed only Russian and Chinese concerns about space-based weapons, and excluded ground-based DA-ASAT weapons (which China, Russia and the USA are known to possess) and directed energy weapons.[73] However, China and Russia stated that DA-ASAT weapons were covered by the draft PPWT clause prohibiting use of force against space objects, reflecting the treaty's focus on regulating DA-ASAT weapons by restricting their use, rather than their development or deployment.[74]

[66] 'The concept of the foreign policy of the Russian Federation' (note 65).

[67] 'The concept of the foreign policy of the Russian Federation' (note 65); and Russian Military Doctrine (note 46).

[68] 'The concept of the foreign policy of the Russian Federation' (note 65).

[69] 'The concept of the foreign policy of the Russian Federation' (note 65).

[70] 'The concept of the foreign policy of the Russian Federation' (note 65).

[71] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, Document regarding possible elements of the final report, Submitted by Russia, A/AC.294/2023/WP.19, 26 July 2023.

[72] Conference on Disarmament, Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects, Submitted by China and Russia, CD/1985, 12 June 2014.

[73] Conference on Disarmament, Letter from the Permanent Representative of the USA addressed to the Secretary-General of the Conference transmitting comments on the draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or use of Force against Outer Space Objects (PPWT) as contained in document CD/1839 of 29 Feb. 2008, CD/1847, 26 Aug. 2008.

[74] Conference on Disarmament, Letter from the Permanent Representative of China and the Permanent Representative of Russia addressed to the Secretary-General of the Conference transmitting answers to the principal questions and comments on the draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT) introduced by Russia and China and issued as document CD/1839 dated 29 Feb. 2008, CD/1872, 18 Aug. 2009, p. 4.

Russia has also raised its concerns about stealth spaceplanes, referring to the US X-37B spacecraft on multiple occasions as a 'weapon'.[75] While details about the X-37B and its mission remain classified, the US Space Force refers to it as an uncrewed reusable spaceplane conducting technology experiments.[76]

Russia has additionally expressed concerns regarding cyberattacks on its space systems, and the head of the Russian space agency, Roscosmos, stated in 2022 that 'offlining the satellites of any country' could be construed as 'a cause for war'.[77] This proclamation came in response to a claim from a hacktivist group that it had stolen data from the agency and that Russia 'no longer had control over spy satellites'.[78] However, Russia denied any such cyberattack occurred and experts cautioned that there was no evidence that the group gained control over any of Russia's operational space systems.[79] The claim emerged after the Viasat cyberattack that occurred at the onset of Russia's full-scale invasion of Ukraine in February 2022. The attack affected not only Ukrainian military end-users but also civilian users across Europe, and was attributed to Russia by the USA, the United Kingdom and several other states, although Russia did not publicly accept responsibility.[80]

In addition to describing threats from the USA and NATO, Russia has articulated concerns regarding non-state actors, claiming that USA-based companies are aiding the Ukrainian military. These companies include Maxar Technologies and Planet Labs, which have provided satellite imagery, and SpaceX, which has provided its Starlink system for communication.[81] Russia raised this issue several times during discussions at the UN OEWG on reducing space threats, notably warning that 'quasi-civilian infrastructure may become a legitimate target for retaliation'.[82] Russia also recommended introducing a prohibition against using civilian systems for purposes 'other than their declared peaceful designation'.[83]

China

The nuclear threshold and space threats

China's perceptions of threats to its space systems are not elaborated in detail in its national policies and statements, at least when compared with those of the USA or Russia. Both China's 2016 and 2021 white papers on space do mention that China aims to be an 'all-round space power' and that

[75] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 10th meeting, 1st session, 13 May 2022, UN Web TV, 01:59–02:00.

[76] See e.g. US Space Force, 'United States Space Force launches seventh X-37B mission', 29 Dec. 2023; and US Space Force, 'X-37B orbital test vehicle concludes sixth successful mission', 12 Nov. 2022.

[77] 'Russia space agency head says satellite hacking would justify war—report', Reuters, 2 Mar. 2022.

[78] 'Russia space agency head says satellite hacking would justify war—report' (note 77).

[79] Saalman, L., Su, F. and Dovgal, L. S., 'Cyber crossover and its escalatory risks for Europe', SIPRI Insights on Peace and Security no. 2023/09, Sep. 2023, p. 6.

[80] Raju, N. and Saalman, L., 'The space–cyber nexus', *SIPRI Yearbook 2023: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2023) pp. 489–90.

[81] Raju and Saalman (note 80), p. 498; and Erwin, S., 'Commercial spy satellites put Russia's Ukraine invasion in the public eye', SpaceNews, 27 Feb. 2022.

[82] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 2nd session, Statement by the Head of the Russian Delegation K. V. Vorontsov at the second session of the Open-Ended Working Group established pursuant to UNGA resolution 76/231, 12 Sep. 2022.

[83] United Nations, A/AC.294/2023/WP.19 (note 71).

it opposes the weaponization of space.[84] While the papers focus mostly on China's space programme for civilian uses, they also refer to the development of capabilities including in-orbit inspections and life extension of space systems.[85] In-orbit inspections and repair and maintenance of space systems require precise rendezvous and proximity operations (RPOs), which could be used for offensive purposes, such as attacking other space systems.[86]

China's laws reiterate commitments to prevent nuclear threats and attacks and, separately, to ensure peaceful exploration and use of space.[87] China further states that it shall 'take necessary measures to protect its activities, assets and other interests' in critical security domains including space.[88] In space security forums, China states that the risk of conflict and confrontation in space is rising, and reiterates that it opposes weaponization and an arms race in space.[89] China warns that 'no country should cross the red line of conflict' in space, suggesting it has such a line.[90] It also frequently states that 'a space war cannot be won and must never be fought'.[91] This wording is significant as it repeats the framing of the joint statement on nuclear war delivered by the leaders of the USA and Soviet Union in 1985, which heralded key US–Soviet arms control agreements. The wording was also used in the joint statement of the leaders of the five nuclear weapon states on preventing nuclear war and avoiding arms races in January 2022.[92]

China's consistent reiteration of its 'no-first-use' nuclear policy 'at any time and under any circumstances' does, from a doctrinal perspective, close off the possibility that it would consider using nuclear weapons in the context of the space domain, for instance, if key space systems are attacked or under threat.[93] Nonetheless, China's 2019 white paper on national defence does recognize outer space as a 'critical domain in international strategic competition'.[94] Furthermore, China's thinking on nuclear deterrence is potentially evolving due to its shift towards 'proactive defence' for multidomain deterrence and alleged entanglement between its nuclear and non-nuclear assets, including space systems.[95] Experts point to Chinese writings where the term 'proactive defence' appears in relation to space and cyberspace, referring to the state being prepared to use offensive measures on early warning of an impending attack, including pre-emptive action.[96] In recent years, China has also

[84] Chinese State Council Information Office, 'China's space program: A 2021 perspective', White paper, Jan. 2022; and Chinese State Council Information Office, 'China's space activities in 2016', White paper, 27 Dec. 2016.

[85] 'China's space program: A 2021 perspective', and 'China's space activities in 2016' (note 84).

[86] Raju and Erästö (note 2), p. 14.

[87] Chinese National Security Law, Order no. 29 of the Chinese President, 1 July 2015, Articles 31–32.

[88] Chinese Law on National Defence, Order no. 67 of the Chinese President, 1 Jan. 2021, Article 30.

[89] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, Submitted by China, A/AC.294/2022/WP.9, 13 May 2022.

[90] United Nations, A/AC.294/2022/WP.9 (note 89).

[91] United Nations, A/AC.294/2022/WP.9 (note 89).

[92] Joint statement of the leaders of the five nuclear weapon states on preventing nuclear war and avoiding arms races, 3 Jan. 2022.

[93] Chinese State Council Information Office (SCIO), *China's National Defense in the New Era*, White paper (SCIO: Beijing, 2019.

[94] *China's National Defense in the New Era* (note 93).

[95] Saalman, L., 'Navigating Chinese–Russian nuclear and space convergence and divergence', EU Non-proliferation and Disarmament Consortium, *Non-proliferation and Disarmament Paper* no. 78 (May 2022), p. 8.

[96] Saalman, L., 'Multidomain deterrence and strategic stability in China', SIPRI Insights on Peace and Security no. 2022/2, Jan. 2022, p. 4.

acknowledged the need to address space systems in the context of reducing nuclear risks, expressing particular concerns about the development and deployment of anti-ballistic missile (ABM) systems, while calling for dialogue in the Conference on Disarmament on preventing the threat or use of force against space objects and on a legally binding instrument on space arms control.[97]

China reorganized its armed forces in 2015 to establish the People's Liberation Army (PLA) Strategic Support Force (SSF).[98] The SSF oversees operations in different domains, including nuclear, space and cyberwarfare. This reorganization demonstrates China's evolving thinking regarding warfare across domains. Some suggest that the reorganization was sparked by scholarly discussions that it was not only technological capabilities but also the structure and organization of the PLA that hindered China's modernization efforts.[99] In 2015 China issued a Military Strategy in which it states that 'the first signs of weaponization of outer space' had appeared.[100] It is possible that China is referring to uncoordinated RPOs conducted by the USA during this period (see below), and the DA-ASAT test by the USA in 2008 that followed China's own test in 2007.

Actors and capabilities

China explicitly names the USA as a threat in its statements and policies. In multilateral discussions China criticizes the USA for declaring space to be a warfighting domain and for its framing of 'dominance' in space. China refers to the USA's 'irresponsible policies, doctrines and strategies as the greatest threat to outer space security'.[101] China argues that the dedicated US Space Force and Space Command as well as NATO's declaration of space as an operational domain exacerbate the trend of an arms race in outer space and increase the risk of turning space into a 'warfighting domain'.[102] China's 2019 white paper on national defence similarly notes US development of capabilities, NATO expansion and the increasing number of NATO military exercises as key concerns.[103] Moreover, China's calls for dialogue to stop overseas deployments of space-related systems—including of missile and ABM systems—and new strategically destabilizing weapon systems reflect its concerns about the activities of the USA and its allies (both in NATO and in Asia) in these areas.[104] China also names and criticizes the UK, both for establishing the UK Space Command and for using terminology such as 'competition, adversaries and threat'.[105] In addition, China has expressed

[97] Preparatory Committee for the 2026 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, 'Nuclear risk reduction', Working paper submitted by China, NPT/CONF.2026/PC.I/WP.30, 2 Aug. 2023, pp. 2–3.

[98] 'New combat support branch to play vital role', People's Daily, 23 Jan. 2016.

[99] Costello, J. and McReynolds, J., *China's Strategic Support Force: A Force for a New Era*, China Strategic Perspectives no. 13, Center for the Study of Chinese Military Affairs, Institute for National Strategic Studies (National Defense University Press: Oct. 2018).

[100] Chinese State Council Information Office, China's Military Strategy, May 2015.

[101] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 3rd session, Working paper submitted by China, A/AC.294/2023/WP.2, 19 Jan. 2023.

[102] United Nations, A/AC.294/2022/WP.9 (note 89).

[103] *China's National Defense in the New Era* (note 93).

[104] Preparatory Committee for the 2026 Review Conference, NPT/CONF.2026/PC.I/WP.30 (note 97), pp. 2–3.

[105] United Nations, A/AC.294/2022/WP.9 (note 89).

concern that data for space situational awareness—which can be used not only to track space objects but also to enable targeting—would be 'monopolized' by the USA.[106]

The Chinese–Russian joint statement delivered by President Xi Jinping and President Vladimir Putin in 2022 shares insight into the convergences and shared goals of the two states, in particular with reference to their perceived threats from the USA. The statement openly mentions the USA and explicitly names NATO, the US Indo-Pacific Strategy and AUKUS (the trilateral security partnership between Australia, the UK and the USA) as concerns, and criticizes the US withdrawal from arms control agreements including the 1987 Treaty on the Elimination of Intermediate-Range and Shorter-Range Missiles (INF Treaty).[107] The statement refers to US development of precision-guided weapons and deployment of missile defence in different regions.[108] While the statement does not mention space-based missile defence or space-to-earth weapons specifically, it more generally underscores the Chinese–Russian draft PPWT and the need to prevent weaponization and an arms race in space.[109]

Similar to Russia, China appears concerned with the USA's development and possession of specific counterspace capabilities: China has pointed to references to space-based missile defence in the US 2019 Missile Defense Review and the USA's investment in missile defence systems overall.[110] China has also raised concerns about the USA's X-37B spacecraft and its potential offensive uses and about the RPOs conducted by the USA.[111] Perhaps linked to these threat perceptions, both the 2015 Military Strategy and the 2019 white paper on national defence mention enhancing Chinese capabilities, including for early warning, air strike, and air and missile defence.[112] The white paper further states that China will safeguard its security interests 'in outer space, electromagnetic space and cyberspace', possibly exhibiting threat perceptions about electronic warfare and cyberattacks, including on strategically relevant space systems.[113]

Similar to Russia, China has expressed concern regarding the role of commercial entities in armed conflict, reminding states during discussions at the UN OEWG on reducing space threats of their binding legal obligation to exercise authorization and ongoing supervision over the actions of their non-governmental entities.[114] Given the timing of the OEWG sessions (2022–23), this could refer to the role commercial entities are playing in the war in Ukraine. As noted above, USA-based entities such as SpaceX are known to be providing services to assist the Ukrainian military.[115]

[106] United Nations, A/AC.294/2023/WP.2 (note 101).

[107] Joint statement of the Russian Federation and the People's Republic of China on the international relations entering a new era and the global sustainable development, 4 Feb. 2022. See also Treaty on the Elimination of Intermediate-Range and Shorter-Range Missiles (INF Treaty), opened for signature 8 Dec. 1987, entered into force 1 June 1998, not in force from 2 Aug. 2019.

[108] Joint statement of the Russian Federation and the People's Republic of China (note 107).

[109] Joint statement of the Russian Federation and the People's Republic of China (note 107).

[110] United Nations, A/AC.294/2022/WP.9 (note 89).

[111] United Nations, A/AC.294/2022/WP.9 (note 89).

[112] China's Military Strategy (note 100); and *China's National Defense in the New Era* (note 93).

[113] *China's National Defense in the New Era* (note 93).

[114] United Nations, A/AC.294/2023/WP.2 (note 101).

[115] Raju and Saalman (note 80), p. 498; and Erwin (note 81).

III. Risk drivers

China, Russia, the USA and other states have placed great value on the space domain, in part because of the centrality of specific systems in their nuclear deterrent practices. As exhibited in national doctrines, policies and statements, the consequent potential for those systems to be targeted shapes possible escalation pathways, including nuclear escalation. Some hypothetical scenarios come to mind such as the deliberate targeting of early-warning satellites (also used to enable conventional weapons) in a regional confrontation or inadvertent escalation surrounding an uncoordinated close approach of one state's space system near a rival's early-warning satellite. Such scenarios are being discussed increasingly in the expert community due to the growing entanglement of nuclear and non-nuclear capabilities and the multifunctional nature of some space systems.[116]

At the same time, the strategic significance of certain space systems suggests common understandings exist that attacks or even perceived threats to such systems could form direct pathways to nuclear escalation. Attacks on early-warning systems would likely be interpreted as a precursor to a nuclear first strike, with the targeted state potentially responding under the impression that it was in a 'use it or lose it' situation—leading to devastating consequences. Given this high scope for escalation, it may appear that states would be significantly deterred from deliberately targeting these systems or engaging in risky behaviours in their vicinity. This might suggest that escalation risks at the space–nuclear nexus are minimal, with red lines delineated and general principles of nuclear deterrence (focused on preservation of a second-strike retaliatory capability) holding. Space–nuclear-related escalation, in this view, seems unlikely because of the stakes involved, as understood by all.

Yet, as this section argues, the space domain adds significant complexities to escalation dynamics. Building upon the analysis of the threat perceptions of China, Russia and the USA outlined above, this section identifies potential drivers of escalation risk at the space–nuclear nexus. These relate to the extension of strategic ambiguity beyond the limits of the uncertainty characteristic of nuclear deterrence (described by Schelling as 'the threat that leaves something to chance'), as well as some uncertainties linked to potential military operations in space.[117] Ultimately, these have destabilizing effects, with escalation, including to nuclear weapon use, remaining a distinct possibility. Indeed, escalation dynamics can change rapidly depending on a number of variables explored below.

Strategic ambiguity and the blurriness of red lines

As mentioned, attacks on systems for early warning and strategic communication (i.e. NC3 systems) have clear escalatory effects given the direct role that these systems play in nuclear deterrence. Threat perceptions of the three states suggest that there are 'red lines' with regard to these systems. In the case of the USA and Russia, attacks on these systems, and even interference

[116] See e.g. Acton, J. M. et al., *Entanglement: Chinese and Russian Perspectives on Non-nuclear Weapons and Nuclear Risks* (Carnegie Endowment for International Peace: Washington, DC, 2017).

[117] Schelling, T. C., *The Strategy of Conflict* (Harvard University Press: Cambridge, MA, 1960).

with their operations, constitute clear doctrinal grounds for consideration of nuclear weapon use. The USA has, moreover, observed that 'states could view interference with certain space objects, such as those designed to support treaty compliance monitoring; command, control, and communications of nuclear forces; or missile strike warning, as a precursor to other, more escalatory activities'.[118] The USA may view these systems in the same category of criticality; in addition, it appears to view different space activities as more or less escalatory. In the same vein, Russia cites as high priority not only systems that ensure 'functioning of its strategic nuclear forces' but also 'missile warning systems' and 'systems of outer space monitoring'.[119] Furthermore, it has listed as critical infrastructure its entire space and rocket/missile industry.[120] In addition, the classification of particular systems and attacks thereon under 'military threats' implies that Russia is prepared to respond to such interference, possibly opening pathways for nuclear retaliatory responses. In comparison, Chinese priorities for high-value space systems are difficult to ascertain from its (relatively) opaque space doctrine. Whether the red lines regarding NC3 systems hinted at by Russia and the USA also apply to China is thus less clear. While it has a no-first-use policy, China would likely respond harshly to attacks on its NC3 systems, given consistently expressed concerns about the specific threat to its deterrent forces posed by US missile defence.

Beyond those systems immediately related to strategic functions, there are indications that the USA also accords high value to other space systems, for instance those linked to operation of critical national infrastructure. The USA has listed 16 different sectors that constitute critical infrastructure.[121] In its 2020 National Space Policy, the USA appears to place high importance on these, specifying that purposeful interference or attack on these systems will 'allow for a deliberate response at a time, place, manner, and domain of its choosing'.[122]

Deliberate targeting of such strategically significant systems may therefore seem unthinkable at first glance because each of the three states is aware of the high potential for nuclear escalation. Yet, in practice, these red lines can be anything but, as their identification, articulation and indeed enforcement largely depend on prevailing circumstances and the leadership of the states concerned. Exacerbating this ambiguity are differences between China, Russia and the USA in the value of their space systems and the range of counterspace capabilities at their disposal. It is not presently clear from these states' national positions *what* each state wishes to deter and *how*. This is evident in the deliberately broad manner in which these states outline the strategically significant systems that may be targeted ('certain' space objects), the nature of a hypothetical attack ('disruption of functioning' of such systems) and the potential response considered. Red lines in this strategic context are purposefully blurry, but this can also lead to confusion. Moreover,

[118] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 'Proposals of the United States of America regarding responsible state behavior for outer space activities', Submitted by the United States, A/AC.294/2023/WP.5, 26 Jan. 2023.

[119] Russian Military Doctrine (note 46), para. 14(b).

[120] Russian Federal Law no. 187 'On the security of critical information infrastructure of the Russian Federation', 26 July 2018, Article 2(8) (in Russian).

[121] US Cybersecurity and Infrastructure Security Agency, 'Critical Infrastructure Sectors', [n.d.].

[122] White House, *National Space Policy of the United States of America* (White House: Washington, DC, 9 Dec. 2020).

whether a state exercises restraint depends on the target and capabilities involved. For instance, while in 2023 Russia retaliated conventionally to Ukrainian strikes—enabled by space systems—on bases hosting Russian strategic assets, there is no guarantee future comparable incidents will not elicit another type of response, as Ukraine notably is not a nuclear-armed or allied state.[123] In addition, entanglement of systems for nuclear and conventional purposes further blurs red lines; a state may consider attacking a satellite to gain a conventional advantage despite that asset's NC3 functions, which could spark inadvertent escalation, including nuclear use.[124]

The fuzziness of red lines, and the accompanying potential for crossing them, is especially palpable given evolving thinking on cross- and multi-domain deterrence. While China's nuclear doctrine publicly remains unchanged, there are indications that it is implementing a 'multidomain approach' that may, in turn, have implications for attacks involving the space and cyberspace domains.[125] The USA has clarified that it could respond with nuclear weapons if its space systems are under attack. The trend towards using electronic warfare and cyberwarfare in conflicts further contributes to blurring of red lines. While US conduct suggests that it views electronic interference and cyberattacks as grey zone activities that do not amount to use of force, this could change as some have noted a shift in Russia's thinking in its approach to such activities, most likely involving its strategic considerations about what types of satellite could be permissible targets in specific circumstances.[126] Russian posturing in UN forums that it views quasi-civilian infrastructure as a possible legitimate target further blurs red lines. In this way, strategic ambiguity and unclear red lines create scope for escalation. Related to this, strategic ambiguity could bleed into uncertainties characteristic in space operations, creating additional escalation pathways discussed below.

Risks arising from uncertainties in space operations

The purposeful strategic ambiguity between China, Russia and the USA is also complicated by factors linked to the manner of potential confrontation in the space domain. No state has ever conducted a kinetic strike (using DA-ASAT or co-orbital ASAT weapons) against another state's space system and this would be construed as a clear use of force under international law. Given the varying effects of counterspace capabilities on space systems, however, the nature of an actual response—and accompanying potential for escalation—is likely to depend on a combination of the effect of the use of the capability, the value (real or perceived) of the target and the broader strategic context.[127] Therefore, the use of a counterspace capability may not necessarily result in escalation, let alone to nuclear use; after all, electronic and

[123] Baklitskiy, A., *Strategic Stability in Outer Space after Russia's Invasion of Ukraine*, CNA Occasional Paper (Center for Naval Analyses, CNA: Arlington, VA, Oct. 2023), pp. 15–16.

[124] Zhao, T., 'Managing the impact of missile defense on US–China strategic stability', in T. Zhao and D. Stefanovich, *Missile Defence and the Strategic Relationship between the US, China and Russia* (American Academy of Arts and Science: Cambridge, MA, 2023), pp. 27–28.

[125] Saalman (note 96). See also analysis of China's Strategic Support Force integrating multiple forms of warfare. E.g. Costello and McReynolds (note 99).

[126] Baklitskiy (note 123), pp. 15–16.

[127] See e.g. Raju and Erästö (note 2), p. 21.

cyberattacks have long been used to interfere with space systems and, while escalatory, are considered essential to modern warfare by China, Russia and the USA. Nevertheless, the political acceptability of the use of certain counterspace capabilities on their own is as of yet unknown; consequently, how states choose to respond to such attacks is unknown as well. Accordingly, ambiguities specific to space operations could further contribute to escalation risks, identified below.

Varying acceptability of counterspace activities

Kinetic operations targeting another state's space system would be unprecedented. It could also be argued that even just the testing of kinetic counterspace capabilities, particularly DA-ASAT weapons, would be perceived as escalatory. After China's DA-ASAT test in 2007 and the USA's test in 2008 there was a lull in destructive (debris-creating) DA-ASAT tests for several years until India's test in 2019 and then Russia's in 2021.[128] The USA pledged in 2022 not to conduct destructive DA-ASAT missile tests, but further testing by any state would likely be seen as inflammatory depending on the circumstances in which it is conducted, as it may suggest the testing state's willingness to use these capabilities. Some have argued that perceived threats to NC3 systems could drive escalatory responses, including in the form of attacks on counterspace capabilities, possibly the DA-ASAT weapons or missile defence systems themselves or even an adversary's assets.[129] In this context, the spread of precision-strike weapons—particularly hypersonic weapons—could upend the risk calculus as they could create uncertainty about second-strike capabilities.[130] That all of China, Russia and the USA are seeking to expand space-based ISR partly in response to the perceived threat of precision-strike weapons suggests an increased valuation of space systems for ISR and the escalatory potential linked to attacks on them.

Considerations regarding risk of civilian harm

Another factor that could impact space–nuclear escalation is that offensive space military operations (whether attacks or disruptions) may become more frequent. Attacks on space systems can significantly affect civilian lives by interrupting essential civilian services, as demonstrated by the Viasat cyberattack in February 2022.[131] Yet while such attacks can have substantial indirect impacts on civilians, they do not result in direct physical injury or loss of human lives, which has led to some suggestions that states may be more willing to attack space systems in a crisis.[132] Still, indirect impacts and consequences of attacks on space systems can be severe, possibly even resulting in casualties and loss of human lives.[133] For example, jamming global

[128] Raju and Erästö (note 2), p. 14.

[129] Acton, J. M., 'Escalation through entanglement: How the vulnerability of command-and-control systems raises the risks of an inadvertent nuclear war', *International Security*, vol. 43, no. 1 (summer 2018), p. 55.

[130] Erästö (note 48).

[131] Raju and Saalman (note 80), pp. 489–90.

[132] See e.g. Flanagan, S. J. et al., *A Framework of Deterrence in Space Operations* (RAND Corporation: Santa Monica, CA, 2023).

[133] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 'Preliminary recommendations on possible norms, rules and principles of responsible behaviours relating to threats by states to space systems', A/AC.294/2023/WP.7, Submitted by the International Committee of the Red Cross, 27 Jan. 2023, p. 2.

navigation satellite system (GNSS) signals that are used to guide civilian air traffic could fatally misdirect flights, and disrupting communications upon which humanitarian workers rely could deny civilians timely relief in emergency situations. There is a lack of clarity about how states factor risks of civilian harm stemming from attacks on space systems into their deterrence considerations. This could have varied effects on escalation. For instance, it may be difficult for a state to justify a conventional response to an attack on a space system; that state may therefore engage in more provocative action in space instead under the assumption that retaliatory action would be unlikely. However, that may not necessarily be the case if the action were to have significant impacts on civilians. In this manner, lack of consensus on risks to civilians and limited clarity on how states view potential 'human costs' of military space operations in their deterrence considerations contribute to scope for escalation.

Congestion in orbits

Another complicating factor relates to congestion in orbits across low earth orbit (LEO), medium earth orbit (MEO), geostationary orbit (GEO) and highly elliptical orbit (HEO).[134] LEO is a particular concern as 'megaconstellations' are increasingly being launched with hundreds, even thousands, of satellite launches under way.[135] LEO also contains a significant amount of space debris, such as abandoned spacecraft and debris from past ASAT weapon tests, that can pose collision risks. While none of the three states has early-warning or strategic communications space systems in LEO, the orbit is still useful for ISR, including potentially for detecting threats from hypersonic weapons, and for non-nuclear military communications.[136] GEO, which is often used for high-value systems serving deterrence functions, namely NC3 systems, does not experience the same scale of congestion, but is still exposed to space debris, especially because the physical characteristics of GEO mean that debris remains in the orbit for longer periods of time. Additionally, some uncoordinated and non-consensual RPOs have occurred in GEO between Chinese, Russian and US space systems.[137] This suggests scope for escalation resulting from collisions, interference and miscalculations regardless of whether a particular incident was caused by congestion or was a hostile act.

Technical malfunctions and attribution challenges

It is not untypical for satellites to experience technical issues in orbit. However, misperceptions, particularly worst-case scenario thinking among rival states, could result in situations where technical malfunctions are misinterpreted as a hostile act by an adversary. Similarly, there is also the chance for interference by electronic or cyber means to be incorrectly attributed. This is magnified by the fact that counterspace capabilities have become so advanced and widely distributed across actors, including non-governmental entities. In the past, when fewer actors had such capabilities, satellite failures were usually ascribed to natural causes such as radiation exposure, but

[134] For further detail on types of orbit see Raju and Erästö (note 2), p. 4.
[135] LeoLabs, 'What's up in LEO? Insights and analysis from 2022', 18 Jan. 2022.
[136] See e.g. Raju and Erästö (note 2).
[137] Weeden and Samson (note 35).

experts caution that currently, even during peacetime, malicious intent could be assumed.[138] This is an indication of the larger issues regarding non-kinetic attacks on space systems, particularly cyberattacks. Experts observe that there is a prevailing culture of reluctance to disclose information about or even acknowledge cyberattacks in the space sector due to concerns about reputational damage and a preference for information to remain classified.[139] Others also note that it is difficult to determine the source of an attack and, even if possible, it is challenging to attribute the incident to a specific entity and determine whether the perpetrator is a governmental or non-governmental entity.[140] These issues highlight that there is no common baseline for assessment and attribution of cyberattacks, which in turn contributes to potential for inadvertent escalation that could even stem from technical malfunction.

Another form of technical malfunction may more directly drive nuclear escalation: early-warning systems can provide false alarms, as in the case of the Soviet-era Oko system that incorrectly assessed the reflection of the sun on the satellite as an incoming nuclear attack.[141] This particular system had reportedly been criticized for its technical capability and accuracy. Fortunately, the responsible officer on duty, Stanislav Petrov, chose to await further corroborating evidence (which never came), at which point he proceeded to report the alert as a false alarm.[142] Questions about the accuracy of some early-warning systems persist, suggesting the potential for false alarms or technical malfunctions.[143]

Unclear governance of commercial entities

Some experts have argued that intentionally intertwining military services with commercial space systems could not only be highly escalatory but also amount to violations of international humanitarian law in certain circumstances.[144] China and Russia have each highlighted their concerns regarding participation of commercial entities in military space operations in their statements at multilateral forums. Commercial entities can provide critical services, including jam-resistant and secure communication satellites, which can be perceived as having force multiplier effects by rivals. The involvement of commercial entities in military operations, and even conflict, thus represents an additional risk variable. The public-facing nature of those entities and some individuals involved with them could further undermine deterrence signalling. For instance, a publicized Twitter (known as X since July 2023) exchange on 26 February 2022 that preceded SpaceX's provision of Starlink terminals to Ukraine suggested to the world that a single individual—

[138] Grego (note 41), p. 277.

[139] Samson, V., 'The cyber counterspace threat: Coming out of the shadows', Centre for International Governance Innovation (CIGI), Cybersecurity and Outer Space Essay, 29 Jan. 2023.

[140] Cesari, L., 'Commercial space operators on the digital battlefield', Centre for International Governance Innovation (CIGI), Cybersecurity and Outer Space Essay, 29 Jan. 2023.

[141] Saalman, L., Dovgal, L. S. and Su, F., 'Mapping cyber-related missile and satellite incidents and confidence-building measures', SIPRI Insights on Peace and Security no. 2023/10, Nov. 2023, p. 3.

[142] Saalman, Dovgal and Su (note 141); and Wan, W. (ed.), *Nuclear Risk Reduction: Closing Pathways to Use* (United Nations Institute for Disarmament Research, UNIDIR: Geneva 2020), p. 27.

[143] Podvig, P., 'Did Russian early-warning radars see North Korean missiles?', Russian Strategic Nuclear Forces, 5 July 2006.

[144] See e.g. Koplow, D., 'Reverse distinction: A US violation of the law of armed conflict in space', *Harvard National Security Journal*, vol. 13 (2022).

SpaceX founder and chief executive officer Elon Musk—spontaneously took the decision to intervene and provide assistance to a party to a conflict, even though this was not the case.[145] In reality, there had been weeks of prior negotiation where the USA had worked with SpaceX to transport terminals to Ukraine under a public–private partnership at SpaceX's own cost.[146] It was only later in 2023 that the US DOD officially contracted SpaceX for the provision of satellite services to Ukraine.[147] In another statement, SpaceX President Gwynne Shotwell claimed that the company had taken actions to prevent Ukraine from using Starlink in offensive drone operations.[148] These statements indicate the potentially complicating effects of the conduct of commercial entities on escalation dynamics in space.

These dynamics are not limited to only SpaceX or, indeed, the USA. The USA responded to Chinese and Russian allegations about commercial entities at the UN OEWG in January 2023, arguing that Russia had also purchased satellite imagery from Chinese commercial firms for use in armed conflict.[149] In line with the USA's allegations, reports suggest that Chinese companies provided satellite imagery to the Russia-affiliated Wagner Group to assist with combat in Ukraine as well as in the Central African Republic, Libya, Mali and Sudan.[150] Ultimately, states do not share a common understanding on the permissibility of such commercial actors in armed conflict, in particular, how their involvement may affect the status of neutral states.[151] In the absence of consensus on the permissible roles of commercial entities, and clear governance of them under the international framework, the increasing engagement of their services in conflicts could be a driver of escalation.

The role of artificial intelligence

It is difficult to estimate the extent to which China, Russia and the USA have already integrated artificial intelligence (AI) into their space systems.[152] Nevertheless, AI can clearly influence the efficacy of various space applications, including collision avoidance mechanisms between spacecraft, monitoring the health of space systems and processing data from ISR. Interest in and prioritization of AI—which has been expressed by all three states—affects threat perceptions, particularly regarding second-strike capabilities, and contributes to escalation dynamics in multiple ways.

[145] Elon Musk (@elonmusk), Twitter, 26 Feb. 2022, <https://x.com/elonmusk/status/1497701484003213317?s=20>.

[146] USAID, 'USAID safeguards internet access in Ukraine through public–private–partnership with SpaceX', Press release, 5 Apr. 2022; and Foust, J., 'SpaceX worked for weeks to begin Starlink service in Ukraine', SpaceNews, 8 Mar. 2022.

[147] Stone, M. and Roulette, J., 'SpaceX's Starlink wins Pentagon contract for satellite services to Ukraine', Reuters, 3 June 2023.

[148] Roulette, J., 'SpaceX curbed Ukraine's use of Starlink internet for drones—company president', Reuters, 9 Feb. 2023.

[149] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 3rd meeting, 3rd session, 31 Jan. 2023, UN Web TV, 02:53–02:54.

[150] Jones, A., 'US sanctions Chinese satellite firm for allegedly supplying SAR imagery to Russia's Wagner Group', SpaceNews, 27 Jan. 2023; and AFP, 'Chinese firm sold satellites for intelligence to Russia's Wagner—Contract', Moscow Times, 5 Oct. 2023.

[151] Wang, G., 'The complex neutrality of commercial space actors in armed conflict', ICRC Blog, 16 Nov. 2023.

[152] Boulanin, V. et al., *Artificial Intelligence, Strategic Stability and Nuclear Risk* (SIPRI: Stockholm, June 2020).

For instance, AI could considerably shorten time frames to obtain and process data from ISR, while also potentially improving the accuracy of such data; however, because AI enables shorter time frames, leaders may have even less time to make decisions and respond to the information. This in turn could result in heightening urgency and pressure to act. Information may be assumed accurate, without corroboration. In addition, advances in autonomy and machine learning, which are changing the design and deployment of cyberwarfare and electronic warfare tools, may not only bolster defences of space systems but also drive more grey zone activities that can have a cumulative escalatory effect.[153] AI could, moreover, be used as a force multiplier, destabilizing conflicts by putting strategic assets at risk, including from smaller actors and non-governmental entities such as hacktivist groups.

There are many notable historical examples of technologies becoming critical force multipliers in conflicts. During the 1990–91 Gulf War, for example, the USA monitored Iraqi army movements during sandstorms through ISR satellites, then used global positioning system-guided munitions to conduct attacks. In 2007 Israel used electronic warfare to disable Syrian air defence and enhance the efficacy of its conventional strikes. More recently, reports suggest that Russia used electronic warfare and cyberattacks against Starlink satellites in the war in Ukraine.[154]

Greater reliance on AI could also create new vulnerabilities that drive escalation. Machine learning algorithms, for instance, are only as accurate as the quality of their training data, which can reflect the bias of programmers, resulting in unforeseen consequences and poor performance.[155] In this context, threat perceptions at the space–nuclear nexus outlined in section II of this paper could directly contribute to self-fulfilling prophecies. Indeed, while AI-enabled technologies may outperform humans in some tasks, AI lacks what humans understand as 'basic common sense', which is essential in decision making.[156]

The variables presented in this section reflect potential drivers of escalation risk at the space–nuclear nexus between China, Russia and the USA. Strategic ambiguities inherent in nuclear doctrines and deterrence practices are exacerbated by questions surrounding their applicability to space systems, especially NC3 systems. Meanwhile, developments in space activities add further uncertainties to the equation. These drivers point to the resounding need to adopt risk reduction measures to minimize scope for escalation, whether inadvertent or deliberate. This topic is examined in the following section.

IV. Risk reduction

Reducing risk at the space–nuclear nexus entails both preventing incidents and mitigating their consequences. For China, Russia and the USA, ensuring outer space remains a peaceful domain in the long term—and closing pathways to escalation including to potential nuclear use—will ultimately require

[153] Boulanin et al. (note 152), p. 28.
[154] Malik, T., 'Elon Musk says SpaceX focusing on cyber defense after Starlink signals jammed near Ukraine conflict areas', Space, 5 Mar. 2022.
[155] Boulanin et al. (note 152), p. 12.
[156] Boulanin et al. (note 152), p. 12.

that the three states take steps to reconcile their disparate threat perceptions. This includes addressing their developments in capabilities by advancing arms control measures where feasible, curtailing certain behaviours, clarifying legal and normative frameworks and, overall, seeking to reorient their competitive and, at times, conflicting approaches to the space domain. Bilateral strategic stability dialogues could provide the opportunity for these discussions. For example, an exchange of views on the military utility of various counterspace capabilities, particularly the lose–lose scenarios of actual use of kinetic capabilities that generate debris (since each of these three states are so heavily dependent on outer space), could help to establish a common understanding on what conditions could be prescribed surrounding their actual use. This issue could possibly fall under the auspices of the Russia–USA Working Group on Capabilities and Actions with Strategic Effects established in 2021.[157] However, the Russia–USA bilateral strategic stability dialogue process was suspended by President Biden in February 2022 following the full-scale Russian invasion of Ukraine. The China–USA process, meanwhile, has not progressed much beyond an initial November 2021 meeting and a November 2023 discussion on arms control issues.

The three states could also seek to incorporate the space–nuclear nexus in the P5 process, which involves the five nuclear weapon states recognized by the 1968 Treaty on the Non-Proliferation of Nuclear Weapons (NPT).[158] In recent years the P5 process has resumed expert-level meetings and emphasized doctrinal exchange and strategic risk reduction.

Arms control at a standstill

The currently suspended 2010 Russian–US Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START) will expire in 2026 and with it the last limit on the size and composition of the nuclear stockpiles of Russia and the USA.[159] The pause in their bilateral strategic stability dialogue has halted negotiations towards a potential follow-on agreement. Given the signals from China and Russia, US missile defence—which has driven their threat perceptions and counterspace developments—will have to be an integral component of any future talks.[160] This is of added importance since missile defence systems can be repurposed as ASAT weapons. While noting the significant domestic sensitivities surrounding missile defence, some experts have suggested that the USA could assess its entire missile defence architecture and determine which systems could be scaled back or even capped; this would not necessarily affect existing US capabilities, but instead could limit further expansion.[161] Another possible measure could be a fixed-term moratorium on US space-based missile defence over an immediate period of 5–10 years, rather than a

[157] US Department of State, 'Joint statement on the outcomes of the US–Russia Strategic Stability Dialogue in Geneva on September 30', 30 Sep. 2021.

[158] Treaty on the Non-Proliferation of Nuclear Weapons (Non-Proliferation Treaty, NPT), opened for signature 1 July 1968, entered into force 5 Mar. 1970.

[159] Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START, Prague Treaty), opened for signature 8 Apr. 2010, entered into force 5 Feb. 2011.

[160] Korda, M. and Erästö, T., 'Time to factor missile defence into nuclear arms control talks', SIPRI Topical Backgrounder, 30 Sep. 2021.

[161] Korda and Erästö (note 160).

permanent ban, as this may help to assuage the concerns repeatedly raised by China and Russia. Yet while the USA has offered to negotiate a follow-on to New START with Russia and open arms control dialogue with China, experts have observed—in the context of the PPWT discussion—that the USA will not accept a blanket prohibition on capabilities that simultaneously bans missile defence systems.[162] For the USA to discuss missile defence limits in future talks, China and Russia would likely have to consider involving capabilities critical to them that are of key concern to the USA, namely Russia's non-strategic nuclear weapons and China's growing ICBM arsenal. Although little progress seems likely in the short term, dialogue on arms control should remain a priority for all sides.

Given the strategic context, a parallel pragmatic way forward would be to prioritize some of the risk drivers identified in the previous section. This could include adopting measures to reduce ambiguities (particularly strategic ambiguities), elaborate red lines where possible and address uncertainties influencing current space operations. Many of these could draw on existing proposals for transparency and confidence-building measures raised in space security forums. An important first step would be for states to discuss suitable forums for adopting risk reduction measures and the configurations of states involved at the space–nuclear nexus, given consequent impacts on implementation. The remainder of this section presents proposals at multilateral, bilateral and unilateral levels.

Multilateral steps

Designate NC3 systems as off-limits

While states may be hesitant to reduce strategic ambiguity, balancing that with a degree of transparency could be stabilizing, as through an agreement or commitment not to attack or disrupt NC3 systems. Full verification of such an arrangement would admittedly be difficult, as a regularized exchange of 'sites' akin to the India–Pakistan non-attack agreement on nuclear installations and facilities is unlikely to work effectively for NC3 systems. Nevertheless, some form of verification—for instance involving a limited number of sites and drawing on existing ISR capabilities—could be modelled after New START procedures. Furthermore, the commitment itself would help to ease tensions surrounding these specific systems. On this, the USA has indicated at the UN OEWG that it could be open to regulatory measures for specific space systems, particularly those that play a direct role in nuclear deterrence practices.[163]

Identify specific space systems as critical infrastructure

States could additionally commit not to attack or disrupt space systems used for critical infrastructure. As recommended by the International Committee of the Red Cross (ICRC), this would entail states committing not to target space systems that constitute critical infrastructure for civilians and those

[162] Byers, M. and Boley, A., 'Space security', M. Byers and A. Boley (eds), *Who Owns Outer Space: International Law, Astrophysics, and the Sustainable Development of Space* (Cambridge University Press: Cambridge, 2023).

[163] United Nations, A/AC.294/2023/WP.5 (note 118).

protected under international law.[164] This would help to establish a baseline of understanding about the strategic value of space systems, reducing the likelihood of nuclear escalation. A useful step could be for states to exchange information on how and which space systems are relevant for critical infrastructure. This could frame discussions of potential 'human costs' of targeting space systems. For instance, an agreed designation of transportation as a critical infrastructure sector could lessen the likelihood of disruption of the GNSS signals that guide civilian air traffic control. GNSS disruption is an increasingly common tactic and in 2023 was reportedly attributed to Israeli and Russian forces in their respective wars in Gaza and Ukraine.[165] Such designations could help to minimize possible civilian impacts, which could significantly affect the calculus for response and potential escalation.

Extend the ban on DA-ASAT missile tests

States could prohibit the use of space systems in an offensive manner through commitments restricting specific behaviours, in particular DA-ASAT missile tests. While China voted against the USA-led 2022 General Assembly resolution to prohibit these, it claimed to do so because the proposal did not mention 'the development, production, deployment, or use of such weapons' or 'activities that could threaten or disrupt the normal operation of satellites'.[166] China and Russia have argued that their proposed PPWT is more comprehensive.[167] While there exists broader disagreement in space arms control, there is potential for further engagement on the DA-ASAT test ban, including possibly extending its scope. Some experts have recommended a legally binding treaty on destructive DA-ASAT tests.[168] Since the USA has criticized the Chinese–Russian PPWT for excluding DA-ASAT weapons and has been opposed to a binding treaty for space arms control, the USA could articulate alternative means to limit DA-ASAT weapons beyond tests. Some analysts propose that the USA could engage China to discuss technical measures and possible variations of the DA-ASAT ban, with the objective of enhancing mutual confidence in the initiative.[169]

Procedures for rendezvous and proximity operations: Commitments, information exchange and space traffic management

States could commit to refrain from uncoordinated or non-consensual RPOs. In the event of such an RPO, states could commit to information exchange (i.e. two-way communication among concerned parties). This measure would be especially useful were it to involve NC3 systems. There is presently no consensus on the appropriate distance to be maintained between space systems of different states, which has led some analysts to argue that specific distances could be introduced for NC3 systems in GEO

[164] United Nations, A/AC.294/2023/WP.7 (note 133).

[165] Gebrekidan, S., 'Electronic warfare confounds civilian pilots, far from any battlefield', *New York Times*, 21 Nov. 2023.

[166] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 1st session, Statement by China, May 2022.

[167] United Nations, Statement by China (note 166).

[168] Samson, V. and Weeden, B., 'A window of opportunity for space security?', Stimson Center, 30 Oct. 2023.

[169] Zhao (note 124), p. 23.

and HEO.[170] This is similar to the concept of 'safety zones' proposed by the USA in its 2020 Artemis Accords—a series of non-binding principles for collaboration in space exploration with the USA that had been adopted by 34 other signatories as of mid February 2024.[171] However, others argue that safety zones may create tension by introducing a 'sphere of influence' by a state over a particular area in orbit, possibly amounting to a claim of national appropriation.[172]

One incontrovertible risk reduction measure would be for states to commit to refrain from uncoordinated and non-consensual RPOs and to elaborate procedures for steps to take should these occur. Related to this measure, ongoing multilateral discussions on space traffic management could help to minimize the risk of inadvertent escalation linked to accidental collisions, including from space debris and congested orbits.

Operationalize existing measures under international space law

There are several ongoing and upcoming multilateral discussions on space security, including a UN group of governmental experts (GGE) on prevention of an arms race in outer space (PAROS), a UN OEWG to continue work on reducing space threats and a separate four-year OEWG on PAROS. They present opportunities to clarify technical and legal limits to military space operations, operationalize existing risk reduction measures in the space treaties to prevent escalation, and more directly adopt measures regarding space systems integrated in nuclear deterrence practices. In addition, exploring the legal concept of 'due regard' in Article IX of the 1967 Outer Space Treaty, as proposed by the Philippines at the UN OEWG on reducing space threats, may allow the creation of a consultation mechanism on space security issues.[173] This is especially pertinent given growing incidents and scope for escalation at the space–nuclear nexus.

Clarify the role of commercial entities in military space operations

Given the inflammatory statements made by Russia on targeting commercial satellites that assist Ukraine and the overall lack of clarity about a state's neutral status when commercial entities are engaged in ongoing armed conflicts, it is essential that states convene to clarify these legalities. Specifically, this will require China, Russia and the USA to exchange views on permissible roles of commercial entities in military space operations under applicable international law, including international space law and international humanitarian law. Identifying existing legal gaps is an essential first step to introduce new governance measures for such entities.

[170] Acton, J. M., MacDonald, T. D. and Vaddi, P., *Reimagining Nuclear Arms Control: A Comprehensive Approach* (Carnegie Endowment for International Peace: Washington, DC, Oct. 2021) p. 63.

[171] US National Aeronautics and Space Administration (NASA), Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes, Adopted 13 Oct. 2020.

[172] Wang, G., 'NASA's Artemis Accords: The path to a united space law or a divided one?', Space Review, 24 Aug. 2020.

[173] United Nations, General Assembly, Open-ended Working Group on Reducing Space Threats, 'The duty of "due regard" as a foundational principle of responsible behavior in space', Submitted by the Philippines, A/AC.294/2022/WP.12, 11 May 2022. See also Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty), opened for signature 27 Jan. 1967, entered into force 10 Oct. 1967.

Explore principles regarding AI in space systems

The increased attention on AI and states' commonly expressed desires to address the issue provide a potential entry point for engagement and mutual exploration of concerns, especially since China, Russia and the USA agree on the idea that it is unacceptable to entirely automate nuclear decision making.[174] This agreed general principle could allow further discussion of the acceptable and unacceptable integration of AI in strategically relevant space systems, particularly early-warning and NC3 systems. It could also be an opportunity for states to consider the role of AI in other strategically relevant space systems such as ISR. This exchange of views may shed light on the space systems that each state considers as essential to deterrence, further reducing strategic ambiguity in favour of more stability in space.

Bilateral steps

Extend nuclear risk reduction centres, geographically and in scope

Russia and the USA have national nuclear risk reduction centres (NRRCs) that stem from the cold war and are used for information exchange in accordance with obligations in their arms control treaties. These centres could be further leveraged to facilitate dialogue on nuclear doctrines, force postures and measures to prevent unauthorized or unintended nuclear use.[175] Other members of the P5, including China, could also establish their own versions of the NRRCs.[176] Such centres could be especially useful for future Russia–USA and China–USA agreements in the space context. In principle, China has expressed support for dialogue on outer space governance with several states, including Russia and the USA, as well as relevant international organizations.[177] The data-centric nature of NRRCs could provide an appropriate venue for information exchange on systems in the space domain.

Establish new hotlines or use existing ones for space

States could establish dedicated communication links to deconflict and clarify incidents in space. Establishing space hotlines in the China–USA and Russia–USA contexts appears politically feasible—akin to the Russia–USA deconfliction lines operated during the Syrian civil war and the war in Ukraine—although such hotlines should be designed with clear objectives, mandates and personnel in mind. Space hotlines would enable instant exchange and ensure that the appropriate entity is contacted, for instance, in the case of an uncoordinated RPO or suspected interference with space systems through non-kinetic means. For more regularized engagement, given the presence of space forces in Russia and the USA and space personnel in China's PLA SSF, having space-dedicated military-to-military communications could be another option. China has described military-to-military relationships with the USA as 'generally stable', suggesting scope for formal-

[174] Saltini, A., *AI and Nuclear Command, Control and Communications: P5 Perspectives* (European Leadership Network: London, 2023), pp. 20–21.

[175] Gottemoeller, R. and Zhukov, D., 'Nuclear risk reduction centers: Stable channels in unstable times', Stanley Center for Peace and Security, Analysis and New Insights, Oct. 2023, p. 7.

[176] Gottemoeller and Zhukov (note 175).

[177] 'China's space program: A 2021 perspective' (note 84).

ization.[178] Direct hotlines at the level of heads of state already exist in both China–USA and Russia–USA relationships.[179] States should ensure these remain active.

Technical capacity-building

There may be scope to consider capacity-building on exchange of technical skillsets between the USA and China even in contemporary geopolitical circumstances. Although the US Congress passed legislation in 2011 that necessitates explicit governmental approval for bilateral cooperation on space issues (the so-called Wolf Amendment), the law has not inhibited cooperation completely.[180] For instance, the US National Aeronautics and Space Administration (NASA) provided monitoring and observational support for China's Chang'e-4 lunar landing in 2019.[181] Such scientific cooperation could help to rebuild trust and confidence. While topics at the space–nuclear nexus would be far more sensitive, some experts suggest that, in the longer-run, there may be scope for cooperation on technical dimensions of early warning.[182] Widespread cooperation on technical issues of safety and security of nuclear materials and stockpiles provides precedent for such cooperation. Similarly, technical exchanges on aspects of AI may be feasible, given that China and the USA have stated their openness to bilateral dialogue on AI issues.[183]

Unilateral steps

Reaffirm commitments under existing international frameworks

The three states could individually reaffirm their existing commitments, whether political or legal, to international frameworks. This would include the space treaties discussed throughout this paper, as well as the 2002 Hague Code of Conduct against Ballistic Missile Proliferation (HCOC). The HCOC is a transparency and confidence-building instrument concerning the spread of ballistic missiles.[184] Among its provisions, the HCOC outlines voluntary pre-launch notification procedures for ballistic missiles and space launch vehicles. China is not among the subscribing states to the HCOC. China could therefore consider avenues for issuing pre-launch notifications to lessen the scope for misinterpretation, for instance, when conducting military

[178] *China's National Defense in the New Era* (note 93).

[179] Miller, S. E., 'Nuclear hotlines: Origins, evolutions, applications', Stanley Center for Peace and Security, Analysis and New Insights, Oct. 2020.

[180] Young, M., 'Bad idea: Wolf Amendment limiting China in space', Defense360, Center for Strategic and International Studies, 4 Dec. 2019; and Secure World Foundation, '10 years of the Wolf Amendment: Assessing effects and outcomes', Webinar transcript, 9 Dec. 2021.

[181] 'NASA's lunar orbiter has its third, overhead look on China's Chang'e-4 probe', Xinhua, 16 Feb. 2021.

[182] Rogers, J., Korda, M. and Kristensen, H., 'Nuclear Notebook: The long view—strategic arms control after the New START Treaty', Bulletin of the Atomic Scientists, 9 Nov. 2022.

[183] Chinese Ministry of Foreign Affairs, 'President Xi Jinping meets with US President Joe Biden', 16 Nov. 2023; and White House 'Readout of President Joe Biden's meeting with President Xi Jinping of the People's Republic of China', 15 Nov. 2023.

[184] Hague Code of Conduct against Ballistic Missile Proliferation (HCOC), 'Description of HCOC', [n.d.].

exercises.[185] Notably, the three states would also benefit from further elaborating their nuclear doctrines, with a view to reassuring rivals that they are maintaining a high nuclear threshold and taking appropriate measures to reduce nuclear risk, especially in the light of expressed concerns about modernization programmes. Moreover, the three states could follow up on the P5 leaders' January 2022 commitment to 'continue seeking . . . diplomatic approaches to avoid military confrontations', using the joint statement as a basis to connect the space and nuclear conversations.[186]

Publish national space policies, strategies and doctrines and disclose military space expenditure

The USA is the most transparent of the three states in terms of publishing space doctrines, policies and strategies; Russia and particularly China could engage further in unilateral information sharing on military space doctrine. Moreover, all three states could share additional information on military space expenditure, which was listed as a recommendation—along with exchanging information on national policies, doctrines and strategies—in a consensus-based 2013 report compiled by the UN GGE on transparency and confidence-building measures in outer space activities.[187] Although there has been limited engagement on this front, sharing relevant information could also have substantial benefits from a domestic perspective. Disclosing such data could prevent wasteful expenditure and unnecessary acquisitions, help to ensure adequate resource allocation that aligns with national priorities, and facilitate improved intragovernmental coordination.

Improve registration practices

China, Russia and the USA are parties to the 1974 Convention on Registration of Objects Launched into Outer Space, which requires states parties to maintain a national registry of space objects and provide information on such objects to the UN.[188] The aim is to enable clear identification of state jurisdiction and control of space objects, and disclosure of information about their orbital parameters and basic functions. However, compliance with the treaty provisions is not uniform and notifications are not always registered in a time-sensitive manner.

In the context of escalation risk, China, Russia and the USA could help to reduce strategic ambiguities and uncertainties related to space operations by ensuring timely registration and by providing additional information about the function and purpose of space systems beyond the bare minimum required by the convention. Notably, the ICRC has called for registration as a means of designating systems that should not be attacked, with the objective of minimizing potential civilian harm.[189]

[185] Wan (note 1), p. 29.

[186] Joint statement of the leaders of the five nuclear weapon states (note 92).

[187] United Nations, General Assembly, Report of the group of governmental experts on transparency and confidence-building measures in outer space activities, A /68/189, 29 July 2013.

[188] 1974 Convention on Registration of Objects Launched into Outer Space, opened for signature 14 Jan. 1975, entered into force 15 Sep. 1976.

[189] United Nations, A/AC.294/2023/WP.7 (note 133).

Strengthen safety, sustainability and resilience

Strengthening safety and sustainability measures for space systems could help to contribute towards overall stability in the space domain, including by means of political commitments on space debris mitigation.[190] A related theme is the 'resilience' of space systems. The USA previously adopted resilience measures that considered cost-effective space system protection; cross-domain solutions; hosting of payloads on a mix of platforms in various orbits; distributed international and commercial partner capabilities; and developing and maturing responsive space capabilities.[191] However, in more recent years, the USA has interpreted 'resilience' to mean disaggregating functions of space systems for nuclear and non-nuclear missions among more systems in lower orbits.[192] China and Russia have not publicly opined on what resilience would mean for their space systems. The three states could take active steps towards resilience based on their priorities, such as hardening space systems against attack by improving cybersecurity and jamming-resistant features, and upgrading early-warning systems, each of which could reduce the risk of technical malfunction and inadvertent escalation. These are, in turn, linked with safety and sustainability since they contribute to stability in the domain. Of course, these measures could simultaneously be interpreted by rivals as strengthening deterrence, given their varying reliance on space for nuclear deterrence. Therefore, the three states should clearly articulate in national policies any steps they are taking towards resilience.

V. Conclusions

China, Russia and the USA all view space as essential for their national security, utilizing space for both nuclear and non-nuclear functions. Given their strategic competition and potential to be drawn into confrontation through regional conflicts, there is high scope for escalation including potential nuclear weapon use, stemming from or extending to the space domain. An analysis of the threat perceptions of China, Russia and the USA exhibits an unprecedented level of worst-case scenario thinking and preparedness to respond with force in case of incidents involving their strategically relevant space systems. Potential drivers of escalation risk are centred on strategic ambiguity and unclear red lines that become more blurred due to uncertainties in the space domain. This paper proposes a series of pragmatic risk reduction measures at the space–nuclear nexus for the three states to consider, at different levels.

Considerations of cross- and multidomain interactions increasingly feature in the security strategies of some states, including China, Russia and the USA. As the deterrent role of nuclear weapons expands to account for a greater number of capabilities with strategic effect, a wider spectrum of potential escalation pathways emerges, including to nuclear use. This paper has highlighted risks at the space–nuclear nexus between those three states;

[190] Erickson, S. and Ortega, A. A., *To Space Security and Beyond: Exploring Space Security, Safety, and Sustainability Governance and Implementation Efforts*, Space Dossier no. 9 (United Nations Institute for Disarmament Research, UNIDIR: Geneva, 2023), pp. 34–35.

[191] *2011 US National Security Space Strategy* (note 14).

[192] Wilson, R. S., 'Space Force budget brief: New priorities and long-term developments toward a new architecture', Center for Space Policy and Strategy, Issue Brief, June 2023.

yet, even through this specific lens, developments in cyber and electronic warfare and AI could directly and indirectly intensify risk scenarios with grave consequences for all. Multilateral governance must adapt accordingly. However, conversations in existing UN processes, among like-minded states and even parts of a single government apparatus, tend too often to be separated among capabilities and domains, with little consideration on how developments in one can impact the others. Purposeful exchange could allow a more holistic view of individual issues as well as their intersection, as delegates of UN space and cyber processes have attested.[193] Such bridge-building efforts encounter numerous obstacles, notably vast differences in the fundamental nature of capabilities and concerns, the maturities of the conversations and the composition of expertise and stakeholder groups. The space–nuclear nexus is no exception. But, as this paper argues, the potential for escalation at that nexus necessitates moving forward together, as a means to more comprehensive risk assessment and, in turn, effective risk reduction.

[193] Raju and Saalman (note 80), pp. 487–88.

SIPRI RESEARCH POLICY PAPER

ESCALATION RISKS AT THE SPACE–NUCLEAR NEXUS

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