

**Title: NATO's space deterrence in the dual-use technology era**

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## **Abstract**

Outer space is a critical domain for collective security, encompassing surveillance, communications, and strategic deterrence. The increasing militarization of space by great powers has raised concerns about preserving outer space as an environment of long-term sustainability. China and Russia have expanded their space capabilities, including anti-satellite weapons, advanced satellites, and missile defense technologies, signaling a growing strategic footprint and challenging NATO's security. This evolving landscape necessitates a reassessment of NATO's approach to space security, balancing defensive readiness with arms control commitments and normative obligations. By analyzing NATO's policy in conjunction with Chinese and Russian space policies, this essay seeks to explore the outer space as a field of geopolitical tensions, as well as to research how NATO can enhance strategic deterrence without challenging outer space norms. This is essential for informing NATO's defense strategy and preventing space from becoming a contested domain.

**Keywords:** Outer Space, NATO Deterrence, Russia-China Space Cooperation, Dual-Use Space Technologies.

## **Introduction**

Outer space is vital to economic and public life on Earth. As new technologies emerge, the space domain becomes ever more complex. In the 2019 London Summit, the Atlantic Community formally recognized outer space as increasingly "crowded, contested, and competitive" (NATO, 2019).

The Sino-Russian technological-military partnership adds to concerns about space competition. Both states are deepening their cooperation to advance their civil-military interests in the space domain. They are investing heavily in dual-use space and counter-space technologies capable of denying access to space services as part of broader efforts to adapt to the demands of high-technology warfare and advance space dominance (NATO ACT, 2025). The upward trend in their relationship extends to dominance over civil space infrastructure (Pollpeter et al. 2023).

This reflects a fundamental shift from a conventional missile arms race toward a space-based contest aimed at denying and degrading an adversary's ability to support terrestrial operations. For NATO, such competition challenges the resilience of allied space constellations and the free use of space as a global commons.

Notwithstanding their ambitions, aging infrastructure, highly centralized management, and continued reliance on foreign advanced technology slow their push for space dominance. Both their civilian and military space programs are constrained by industrial bottlenecks and uneven capabilities. Their pursuit for technological independence and their industrial weaknesses drive a closer strategic cooperation with one another, as well as with authoritarian partners. Understanding the underlying systemic shortfalls provides a foundation upon which to inform NATO's deterrence policy.

### ***Racing Against its Past: The Militarization of Russia's Space Industry***

The Russian space industry struggles to match the rapid technological surge of the new space age. Systemic deficiencies have produced a declining launch cadence and a limited capacity to design next-generation satellites.

Over the past three decades, Russia's space sector experienced the overall downsizing of its industrial base (Mathieu, 2008; Vidal and Privalov, 2024). The reformist tide, undertook to sustain Soviet-era space infrastructures, prevent obsolescence and ensure the industry's economic survival, delaying modernization. After 2014, sanctions sharply restricted Russia's access to Western electronics and satellite-grade components, pushing the industry into deeper technological isolation (Aliberti and Lisitsyna, pp. 1–2).

Shortcomings in performance and profitability weakened the civilian space sector, creating an inward-looking ecosystem anchored to legacy platforms and unable to pivot quickly toward commercial innovation. Russia's space sector failed to balance profitability with commercialization of national prestige products (Vidal and Privalov, 2024, p. 2).

To reverse the domestic industry crisis and its limits in legacy space capabilities, the Kremlin redirected much of its spending toward military space applications under the Ministry of Defense and the Military Space Command (Aliberti and K. Lisitsyna, 2019, pp. 1-2).

The new face of the Russian space ecosystem became increasingly tied with achieving technological sovereignty and compensating for conventional asymmetries. The militarization of the space industry serves to secure asymmetric advantages and preserve dominance along the conventional escalation ladder by denying, degrading, and disrupting NATO's sensing and communications capabilities should deterrence fail (DIA, 2025, p. 14). To this end, Russian doctrine prioritizes advanced electronic warfare capabilities targeting adversary command, control, communications, computers, intelligence, surveillance, and reconnaissance networks (C4ISR), aiming to 'change the conditions of the operational environment' by degrading space-dependent capabilities and reducing the effectiveness of weapons systems (McDermott, 2017, p. 3).

Yet, critical dependencies on dual-use technologies revealed by sanctions have made it difficult for Moscow to modernize its military sector. Russia has no longer access to "to quality dual-use electronic components, microchips and microprocessors, advanced optical systems and space-grade components," all of which are critical to meeting high-quality requirements of hardware and advanced equipment (Bouleague, 2025, p. 13).

To overcome space isolation, Russia has strengthened its partnerships with China. As a leading proliferator of space technology, Russia expands its technical cooperation in space-applicable and dual-use technologies (DIA, 2025), replacing Western components with imports from alternative suppliers to ensure the technological resilience and modernization of its military space capabilities. To this end, Beijing has increased exports of critical high-tech dual-use products to Russia (NATO ACT, 2025).

According to the commander of the U.S. Space Command, the high-level exchanges between China, North Korea (DPRK) and Iran, as Russia seeks support in Ukraine, has complicated the space domain (Hadley, 2024). Moscow has dedicated much of its efforts to modernizing its Standard Launch Vehicles (SLVS). The growing authoritarian partnerships raise concerns of proliferating missile technology to

advance their ballistic missiles and nuclear programs. Their space programs can mask efforts to advance missile capabilities and nuclear programs, as much of the technology used for satellite launches overlaps with that of long-range missile vehicles. The propulsion technologies of SLVs used for satellite launches can be redesigned for missile development, including intercontinental ballistic missiles and anti-satellite (ASAT) platforms (DIA, 2025, p. 21; DIA, 2024, p. 27; Notte and Lamson, 2024, 5-31).

Russia's assistance to the Iranian space program may benefit Tehran hedging its technological expertise by developing its SLV program to shorten the path to long-range ballistic missiles, possibly with assistance on re-entry vehicle technology or acquiring ASAT missile systems and co-orbital satellites (DIA, 2022, p.31; Notte and Lamson, 2024, 5-31). Through cooperation on the dual-use Iranian Khayyam satellite, Moscow can significantly enhance Tehran's surveillance and targeting capabilities in the Middle East (Guardian, 2022). For the North Korea (DPRK), space and satellite development remains a top priority. During a visit to the Vostochny Cosmodrome, President Putin offered cooperation on DPRK's reconnaissance satellite program. Russia has proposed providing expertise in personnel training, SLV propulsion, and satellite development to support the DPRK's space ambitions (DIA, 2025, p. 21; Lampinen, 2023; Van Diepen, 2023).

### ***China's Space Industry: Progress and Military constrain***

China's space ambitions date to the 1970s and 1980s, when it made early, largely unsuccessful attempts to build an Early Warning System (EWS). Although progress has been made, China's EWS remains ill-suited for modern warfare. For a long time, U.S. export controls and amendments prohibiting cooperation of U.S. space agencies with China, prevented Beijing from acquiring foreign satellite technology. This led People's Republic China (PRC) to pursue indigenous innovation. Through its military-civil fusion (MCF) strategy, the People's Liberation Army (PLA) has integrated defense technology with civilian industry to advance military space capabilities (Kim, 2025, pp. 149- 157).

Despite initial growth, China's dependence on foreign technology and imported electronic components from Taiwan and Western markets undermines its ambition to achieve strategic dominance and high technological performance in space. The MCF policy has therefore left its civilian space industries vulnerable to trade sanctions and economic restrictions, constraining Beijing's ability to produce durable space components and maintain its satellites with regular updates and software support. Unlike the U.S. model, which benefits from private innovation and contribution of private space companies, China's centralized system is less profitable and innovative. As with Russia, the state-centric enterprise model and limited private participation had slowed satellite deployments and operational lifetime, leading to sustained coordination failures in military operations. Its ecosystem faces slow progress in developing reusable rockets, restricting China's ability to replenish lost military satellites and restore fast operational capability (IMR, 2025).

To address this, PRC begun decentralizing its space industry and promoting the commercialization of its sector. Developing reusable spacecraft has become a national security priority. Private-sector participation rose from 0% in 2014 to 45% within a decade, enabling reusable SLVs to launch by 2025 and the Hyperbola-3B spacecraft to debut in 2030 (U.S. DoD, 2024; Kim, 2025, p.157).

On the operational side, PLA's military strategic guidance prioritizes informationized and intelligentized warfare as strategic, tactical, and operational priorities. The first imperative is to control battlespace information by integrating C4ISR across joint operations, while AI and intelligent systems link units through automated networks to maintain wartime information dominance (Dahm, 2024, pp. 2, 8).

Although this doctrine forms the backbone of PRC's command-and-control capabilities, it faces practical limitations. Compared with the U.S. global network of satellite stations hosted by allied countries, China lacks global coverage and redundancy, as PLA remains limited to centralized ground stations. This setup exposes PLA's satellite command infrastructure to cyberattacks and physical strikes, weakening the survivability and coordination of its forces in modern environments. As part of its Modernization and Reform strategy, PRC is investing heavily in ground- and space-based C4ISR capabilities. Seeking closer defense and operational ties with Russia, it is building large phased-array radars to extend coverage from Japan and Russia to the Korean Peninsula and support space observations (U.S. DoD, 2024, p. 94; Global Security, 2020).

Yet, the limited number of space-based assets leaves its early-warning sensors incomplete (Mezey, 2024, p.14). Russian officials have expressed willingness to collaborate on a Ballistic-Attack Warning system by integrating Russian and Chinese infrastructure to enhance long-range detection and data coverage (U.S. DoD, 2024; Global Security, 2020). The integration of early-warning infrastructures would pose a serious threat to NATO. Since missile defense architectures rely on space and enable counter-space operations, dual-use interceptors—used for both ballistic missile interception and exoatmospheric ASAT missions—make missile defense modernization a driver of space militarization (Mezey, 2024).

Russia and China coordinate their MCF space and counter-space doctrines to achieve information dominance. Moscow is willing to deploy high-orbit assets and space-based weapons to secure both countries (NATO ACT, 2025, A-23). Under the 2021–2025 China-Russia Roadmap for Cooperation in Satellite Navigation, Russia's GLONASS and China's BeiDou Positioning, Navigation, and Timing (PNT) systems are being integrated to enable fully interoperable military capabilities and reduce reliance on the U.S. GPS system. This cooperation has strengthened Russia's war effort in Ukraine by improving battlefield communications and the effectiveness of missile and drone operations (Ibid, A-18).

To extend its operational reach, China spreads its BeiDou system overseas in Antarctic and across developing countries in Africa and South America through ground stations. BeiDou is tied to the Belt and Road Initiative, fusing development and national security strategies. Officially described as an environmental monitoring system, it aims to increase satellite coverage, resilience, and operational capability. China's network of ground space infrastructure can support telemetry, tracking, and command (TT&C) functions such as space situational awareness, ASAT coordination, and foreign intelligence collection (NATO ACT, 2025, A-22; U.S. DoD, 2024, pp.84–85; Roulette et al., 2025; Funaiolo et al., 2022).

### ***Implications for NATO***

Activities in space are not isolated from events occurring on Earth. The political reality is that any attack on space services would constitute an extension of terrestrial warfare, and thus credible space deterrence reflects the quality of external events on Earth.

Rising space congestion and intensifying competition on Earth have eroded the transparency and predictability once characteristic of the Cold War (Remus, 2010, p. 2). The emergence of dual-use systems blurs the civil-military line, making response thresholds ambiguous (Bowen, 2024, p. 87). Sino-Russian activities in orbit illustrate a pattern of destabilizing behavior in which the boundaries of deterrence remain unclear. NATO has yet to determine how the Atlantic Community should respond to disruptive actions in space as part of its broader deterrence planning.

Both China and Russia have repeatedly threatened Allied satellites and the freedom to operate in space. Destabilizing actions include anti-satellite tests that generated large debris clouds, putting other space assets and satellite infrastructure at risk (Saunders and Lutes, 2007; U.S. DoS, 2021; NASA, 2021). Non-kinetic hostile activities have also increased since Russia's invasion of Ukraine, with disruptions rising "both in frequency and size". These include deliberate GPS jamming during NATO exercises, cyberattacks on networks such as Viasat's KA-SAT broadband system causing spillover effects across Europe, and close satellite maneuvers that could physically disable communication and intelligence satellites. In 2024, Russia disrupted navigation signals in the Baltic Sea for 72 hours, affecting maritime and air traffic. The electronic attack interfered with over 1,200 commercial flights and caused approximately \$180 million in economic losses (Norwegian Government, 2020; Soli, 2024, p. 3; Daws, 2022; Daws, 2025; Grossfeld, 2025; Debug Lies, 2025). All these activities frame a grey area between routine satellite monitoring and disruptive interference.

### ***Expanding NATO's Space Deterrence***

NATO should prioritize narrowing the gap between space technological capabilities and the existing legal framework to achieve transparency and prevent Russia and China from reshaping the outer space regime to their advantage. In parallel, it should orient its deterrence around resilience, interoperability, and redundancy to sustain operational effectiveness (Bowen, 2024, p. 90).

In absence of defined response thresholds, NATO members can play a major role in the development of general principles to guide states in a space arms-control initiative and promote a new code of conduct. Failing that, states would have to take steps to defend themselves, risking an anti-satellite arms race.

Any deliberate use of kinetic ASAT weapons would be equally self-harming, generating hazardous zones that endanger the attacker's own military and commercial satellites as much as the target's. It would rather indicate a calculated trade-off, where the strategic gains of disabling an adversary's space systems outweigh the risks to its own space assets.

As this concerns the last stages of the escalation ladder, focusing on transparency helps avoid a self-defeating arms race and misperceptions. After all, an arms-race approach does little to resolve the deterrence problem posed by dual-use activities or to address the Sino-Russian cooperation. To avoid crisis instability and make escalatory steps less confronting, establishing a new code of conduct along with verification mechanisms is crucial.

### ***Narrowing the gap***

The first pillar of NATO deterrence should prioritize multilateral diplomacy. In the 2008 Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (PPWT), Russia and China jointly proposed an initiative to prevent an arms race in outer space. The treaty sought to cover both space- and Earth-based systems, but its definitions of space technologies were ambiguous. The draft neither explicitly defined systems designed as weapons nor included dual-use systems within the treaty's scope.

It did not clearly define dual-use space objects that are not intended as weapons but could be misused

or maneuvered aggressively, such as co-orbital satellites. Most importantly, it failed to provide for a ban on the testing or development of ASAT military technology and establish verification mechanisms to monitor compliance. The U.S. viewed the PPWT as an attempt to constrain its space-based missile interceptors. To this day, it opposes any binding legal prohibition, considering ASAT weapons a means of enhancing U.S. space security (Snyman, 2014, p. 511; Britt, 2024; Weeden and Samson, 2020).

An inclusive space arms control agreement could help prevent actions from being misinterpreted as attempts to gain military information dominance in crises and reduce the risks of unannounced proximity operations. The SALT I (1972) and SALT II (1979) treaties, along with the START (1991) and New START (2010) agreements, limited the growth of missile launchers and reduced their overall numbers (Freedman, 2023; U.S. DoS, n.d).

Drawing on Cold War verification mechanisms, a space arms control treaty could be modelled after these treaties. If properly adapted, the SALT treaties could pave the way for limiting the number of ASAT ground-based systems beyond a set number and reducing existing kinetic systems over time. Likewise, START and New START treaties could serve as the model of verification mechanisms to be pursued by space powers. Notifications of satellite launches and maneuvers, as well as data exchanges on dual-use interceptor numbers would increase transparency and reduce incentives. In addition, a space arms control treaty should develop a formal mechanism on the non-proliferation of dual-use SLV technologies that can be reconfigured to support missile and nuclear programs.

A Cold War-like diplomatic framework could improve strategic stability between space powers. Yet, it is unlikely that Russia and China would accept verification measures before they balance U.S. space dominance, or should ASAT technology proliferate to DPRK or Iran.

### ***Resiliency, interoperability, and redundancy***

The second pillar of NATO's deterrence should focus on resilience to dissuade a counter-space arms race. NATO can strengthen its capabilities and operational resilience through coordinated efforts with the EU, complementing diplomatic efforts, reducing reliance on the U.S., and avoiding fueling a renewed arms race under Trump Administration (Berge and Odgaard, 2023). Leveraging EU industrial initiatives can augment allied capabilities and increase redundancy and interoperability.

NATO has taken significant steps in the space domain by establishing the NATO Space Operations Centre in 2020 and including space hostilities within collective defence commitments. The Allied Persistent Surveillance from Space (APSS) program has enhanced space situational awareness by pooling and coordinating national and commercial space assets, providing a technological advantage through the use of commercial space solutions (NATO, 2025). The APSS program provides an exemplary solution upon which NATO can maintain its competitive edge and diversify the risk of adversarial capabilities.

Although the EU traditionally focuses on civilian space, it can complement NATO industrially, supporting technological and economic advantage over Russia and China, whose space programs face industrial decline, technological isolation, limited coverage and constrained capabilities. Relying on the capabilities of its member states, such cooperation would stimulate NATO's technological development and expand redundancy (Rendl, 2024). EU programs like Horizon Europe and SAFE provide a cooperative framework that could strengthen industrial development and defense by boosting research, innovation, and national space and satellite industries (European Commission, 2025a, 2025b).

Both Russia and China lag in innovation and technological quality, with space ecosystems that are less effective at supporting operational capabilities. China makes rapid advancements in the space industry favoring greater private-sector participation. Still, its space capabilities remain vulnerable due to centralized command structures and limited ability to restore operational functionality in space.

To address the military-civilian fusion approach and offset a potential Sino-Russian industrial development, NATO should focus on dispersing ground-based infrastructure with allies to increase coverage and interoperability, while investing in mega satellite-constellations. Investments in hard-to-kill small-satellite constellations, reusable rockets, and private-sector cooperation could enhance both the qualitative and quantitative aspects of NATO's deterrence. On one hand, rapid satellite replenishment reduces the effects of ASAT attacks by quickly sending new satellites into orbit. On the other hand, deploying a network of small satellites increases redundancy and makes targeting individual satellites far less effective. Although analysts argue that this is a costly solution compared to cheaper ASAT systems, U.S. and EU collectively benefit from the quantity and resilience of space-based services, even if these services are denied, degraded, or disrupted (Saunders and Lutes, 2007, p. 4; Richter, 2024, p. 28).

Over time, this cooperation could discourage a counter-space kinetic arms race. NATO member states are unlikely to reach a consensus on a definitive threshold in response to military-civil activities in space or non-kinetic provocations in the fear of escalation. Collective action at the diplomatic and techno-industrial levels, however, would better position NATO states to deter strategic instability and hard denial of services.

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