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# "Astropolitics" and weaponisation of space—Drawing past lessons to address space arms' escalation

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Once a distant dream, today space is not only achievable, but has become the most important domain for both civilian and military purposes. Modern society and its economy have come to vitally rely on space assets for running crucial services, from financial transactions, weather forecasting, telecommunications to navigation. Military operations are also heavily reliant on space to provide intelligence gathering, surveillance and communication capabilities. Once one of the few domains of international cooperation, space has become increasingly competitive, congested and contested. As we are navigating through an increasingly complex geopolitical environment, space is undergoing a similar process. Unlike during the Cold War, today Earth's low orbit is comprised of a higher number of national and private actors engaged in strategic competition with each other. While the use of space in support of military operations is not a novel concept, we are nonetheless witnessing an evolution of space emerging as the critical domain upon which national security and other sectors heavily depend. As it was the case with nuclear weapons during the Cold War, this is translating into a race for national space programs to acquire strategic advantage by developing space and counter-space systems. The objective of this paper is to draw a comparison between the militarization of space and the historical Cold War arms races, drawing lessons from that era and subsequent arms control frameworks. While accounting for space-unique challenges posed by a rapidly diversifying mix of state and private actors, the dual-use nature of modern space technologies, and the inherent difficulties in distinguishing between peaceful and hostile activities in orbit, as well as geopolitical considerations, this study highlights how measures from these past frameworks can be nonetheless emulated and implemented into currently available space diplomatic frameworks in order to mitigate risks, reduce misunderstandings, increase certainty, trust and accountability in space.

KEYWORDS

**militarization of space, cold war, counterspace, outer space treaty (OST), astropolitics, arms control and disarmament, geopolitical competition**

## 1 Introduction

Space-based activities have become essential to national economies in great part thanks to technological advancements in the fields of rocketry, sensors, data, and telecommunications. The direct and indirect effects of these breakthroughs have drastically contributed to the betterment of the world's economical, societal and military ecosystems, rendering them deeply dependent on the activities of an ever-growing number of orbiting satellite constellations; from navigation and climate observation, to data transfer, telemetry, and intelligence gathering, space economy has become crucial for everyday services and critical infrastructures such as agriculture, water and energy (OECD, 2023). The technological spill-over and its spread across nations accelerated by a spirit of international scientific cooperation, reduced satellite development and launch costs, have also permitted other States to access the space arena, both directly (by deploying their own assets) and indirectly (by sharing the benefits of accessible satellite data). Once a domain entirely under the duopoly of the United States and the Soviet Union during the Cold War, today there exist 77 national space agencies, 16 of which possessing launch capabilities (UNOOSA, 2025a) with varying degree of capacity (i.e., the ability to perform different space activities and steering space strategies into infrastructure and national policies) and autonomy (i.e., the ability to autonomously define a country's own space interests) (European Space Policy Institute, 2021). This has led to a proliferation of commercial and military space objects in orbit nearing 14.000 as of June 2025 (UNOOSA, 2025b) However, in the past two decades, the notion of space as an internationally recognized arena, guided by the principles on non-nuclearization and peaceful uses to the benefit of all mankind, is increasingly at odds with geopolitical considerations applied to outer space by major space faring States, by steering national military and civilian space policies and strategies toward seeking or maintaining strategic dominance (a trend accelerated by an ongoing shift in the global balance of power); a concept attributable to "Astropolitics." First identified by Everett Dolman, "Astropolitics" can be defined as "relationship between state power and outer space control for the purpose of extending the dominance of a single state over the whole of the earth," which can be achieved through the control of strategic areas in space, such as the Lagrange Points, by a single actor (Dolman, 2001). While Dolman's theory was developed with a unipolar international system in mind, dominated by US space hegemony, his theory's tenets nonetheless still hold true in an increasingly multipolar system of today, as leading spacefaring nations consider outer space as a domain for competition, whose monitoring, control, and defense guarantees crucial strategic advantage over adversaries. This has also led to the deployment of an increasingly expanded arsenal of counter-space assets (kinetic, directed energy, nuclear, electronic and cyber), sparking concerns over a risk of uncontrolled "space arms race." Military operations have come to rely heavily on space-based assets located in Low Earth Orbit (LEO) and Geosynchronous Orbit (GEO). Military satellites provide essential navigation, communication, intelligence and surveillance services for to maintain space domain awareness, detection, command and control, and early warning capabilities, allowing for timely and informed threat assessment and response. The unparalleled military advantage, provided by the extensive awareness of the location and type of adversarial strategic assets on Earth, is an incentive for States to invest to maintain and expand satellites capabilities (UK Parliament Defence Committee, 2022; Harrison et al., 2017), as well as to pursue the development of more sophisticated forms of counter-satellite systems capable of denying adversaries this advantage. Furthermore, in the past decade, the notion of space as a State-only domain has been challenged by the rise of private space actors, such as SpaceX, whose satellites and their capabilities are being more frequently leveraged and integrated into national defense networks, increasingly blurring the distinction between military and civilian uses (Erwin, 2024).

Against this background, while multilateral frameworks can, and should, coexist along with realist considerations, the current space legal framework and governance appear insufficient to keep up with an increasingly more complex and power-based international system, and toregulate the rapidly evolving landscape of the various military space activities, from satellite launches, to counter-space systems, as well as ambiguous space behavior (such as Rendezvous and Proximity Operations), unannounced maneuvers, which can interfere with their functions or orbiting path of other satellites (Jones, 2025; Chen and Singer, 2024; Secure World Foundation, 2025).

However, to aid in addressing the risk of space arms race, lessons can be drawn from the historical and geopolitical context in which the first space activities were carried out, as well as the instruments and measures the United States and Soviet Union devised to limit the proliferation of earth and space-based strategic weapons. In this sense, the Cold War nuclear and space competition can help guide todays' development of trust and confidence-building measures, arms control mechanisms in space, as well as navigating the complexities of geopolitics of outer space. By examining the evolution of strategic space competition, the vulnerabilities posed by new actors and dual-use systems, and the risks of inadvertent escalation and arms race in space, this study seeks to identify practical approaches to reduce misunderstanding, increase transparency, and build trust among spacefaring nations. The study will adopt a comparative approach, drawing from international legal and policy documents, and academic literature to analyze the evolution of space militarization and arms control, assessing the relevance of past arms control treaties, measures and mechanisms, while taking into account the inherent features characterizing the space domain, and the currently evolving and uncertain geopolitical power structure. The first section will provide a historical overview of space activities during the Cold War, followed by an overview of the main international legal frameworks, strategic arms treaties discussions, followed by an examination of current developments in the New Space Age, including the rise of private actors, dual-use technologies, and counter-space systems. Drawing lessons from Cold War arms control binding and non-binding approaches, and highlighting the parallelism between the spread of nuclear weapons and the risk of uncontrolled fallout vis-à-vis a much more uncontrollable cascade of space debris, the study evaluates their relevance and applicability to mitigate today's challenge of space weaponization, proposing an approach to address the current standstill.

## 2 The evolution of space military activities

Since the beginning of the first Space Era during the Cold War, space and military domains have always been inextricably interlinked for two main reasons. Firstly, early space efforts by the US and Soviet Union can be traced back to the 1950s during the development of the first nuclear ballistic missiles programs. The Soviet *R7 Semyorka* ICBM and the US *Redstone* SRBM were the first operational ballistic missiles, which contributed in great part to forming the technological basis necessary for the development of the first launch vectors capable of escaping the Earth's atmosphere, bringing the first ever satellites, Sputnik (1957) and Explorer (1958), into space (National Air Space Museum, 2023). Secondly, in the context of the nuclear arms race and the inception of the first nuclear doctrines, the US and USSR quickly realized the inherent strategic value that space-based reconnaissance, intelligence gathering and, later, early warning systems could provide through unimpeded monitoring and observing of the adversary's nuclear capabilities, as well as serving as a reliable verification mechanism of compliance to arms controls treaties.

On these basis, subsequent development of satellites and space technology in general (such as sensors, optics and later counter-space weapons) was directly related to military power, particularly through developments of ballistic capabilities. From 1957 to 1990, military satellites from both the US and the USSR accounted for 70% of total launches (Harrison et al., 2017), the majority of which was intended to gather intelligence and support nuclear command and control decision-making processes (Pawlikowski et al., 2012). The first US space-based reconnaissance programs, *Corona* and *Midas*, proved particularly successful in gathering high quality photographic pictures on Soviet's military installations and nuclear assets. Launched in August 1960 under the NASA civilian designation *Discoverer-14* to keep it secret from the Soviets, the first *Corona* satellite mission returned invaluable intelligence to the US. It was so successful that it changed the US threat perception of the Soviet ICBM capabilities, as the CIA had originally overestimated 140–200 missiles, while data returned from *Corona* revealed a much lower estimate (10–25 missiles) was more likely (Muszyński-Sulima, 2023). The direct successor of *Corona* was the *Midas* program. Operational as of 1963, *Midas* satellites were equipped with infrared optics in the place of cameras. Such infrared optics were designed with the intention to detect the heat signature from ICBM launches, making *Midas* the first ever early warning satellite constellation (Muszyński-Sulima, 2023). Consequently, since their inception, space activities were not intended to be used as a direct means of warfare. Instead, even as technology progressed in the fields of sensors, optics, and communication, they remained primary instruments for both superpowers to keep each other's nuclear and conventional arsenals tacitly under surveillance in a non-invasive way (Muszyński-Sulima, 2023). The resulting transparency of information of the other side's assets stemming from space surveillance systems allowed the US and USSR to freely monitor their true capabilities, movements, intentions and, later, also compliance to arms treaties. Through the reliable information provided by satellite programs such as *Midas* and *Corona*, the US was able to take informed decisions and assess its response accordingly and proportionately. This greatly diminished fears and uncertainty which contributed to establishing and maintaining stability and predictability in the international system, by reducing risks of misunderstandings, miscalculations, and lowering the incentives of nuclear first strike (Harrison et al., 2017; Pasco, 2025; Muszyński-Sulima, 2023).

Despite the extensive operational freedom that both US and USSR satellites enjoyed, since the very outset of the first space age signs of intention to counter these very systems emerged from both sides. Advancements in ballistic missile technology made possible to use missiles also as counter-space weapons to destroy orbiting satellites. As early as 1959, the US tested the first Air-Launched Ballistic Missile (ALBM), *Bold Orion,* from a B-47 Stratojet, successfully destroying an Explorer satellite, making it also the very first successful direct-ascent anti-satellite missile (DA-ASAT) (Spaceline, 2023). In 1962, US ASAT missile development continued with the successful testing of *Starfish Prime*, which involved the detonation of a 1.4 megatons nuclear warhead in the outer atmosphere over the Johnston Island. The exo-atmospheric nuclear explosion released a strong electromagnetic pulse (EMP) which affected communication systems and electricity infrastructure in Hawaii, as well as permanently disabling at least 7 orbiting satellites in the immediate aftermath, and damaging others in the following weeks (Stassinopoulos, 2015; Boatman, 2022). The damaging effects of nuclear fallout and EMPs caused by nuclear weapons atmospheric and exo-atmospheric tests provided the necessary negotiating conditions which eventually led to the signing of the Partial Test Ban Treaty in 1963 (US Department of State Diplomacy in Action, Archived Content, 2025a). While the US continued to pursue development of offensive direct-ascent vectors serving as both nuclear deterrence and ASAT in the 60s and 70s, such as Project 437, the Soviet Union approach was different; it placed greater emphasis on the development and deployment of strategic anti-ballistic missile defenses (ABM) and counter-space technology. From 1963 and until 1982, the USSR developedthe only operational dedicated ASAT weapons program which relied on *co-orbital* mechanism, where an attacking space object (a mine or another satellite) is placed in orbit and then maneuvered to intercept another satellite using the latter's orbit, detonating when the attacking object would be close enough to its target (Amenabar, 2022). In the early 1980s, developments in the field of missile guidance and targeting encouraged the US to develop a new generation of DA-ASAT missiles: the Air-Launched Miniature Vehicle (ALMV). Compared to Soviet *co-orbiting* systems, the ALMV was more flexible, as it could be launched at any time from an F-15, as opposed to the limited window of *co-orbiting* ASAT where the target can only be engaged when flying overhead (Grego, 2012). This program was short lived as it was disbanded in 1987 after one successful test in 1985 with the destruction of the Solwind satellite which generated more than 250 traceable space debris (Grego, 2012), which prompted the US Congress to temporarily ban ASAT tests (Grego, 2012). Exaggerated US concerns over an alleged Soviet "breakout" in the development of ballistic missile defense prompted the Reagan administration to launch the Strategic Defense Initiative in 1983, as an effort to eliminate the threat of nuclear weapons from ballistic missile attacks through the novel strategic defense technologies (The White House, 1984; Hoffman, 2010). Though it only remained on paper without any concrete project, the initiative conceptualized for the first time proposals including space-based kinetic and energy-based defense interceptors with inherent ASAT capabilities (Waller et al., 1986). The SDI program sparked criticism from the Soviet Union, which claimed it contravened Article V of the 1972 ABM Treaty (US Department of State Diplomacy in Action, Archived Content, 2025b). In response, the Soviet Union resumed its strategic defense missile research, while at the same time issuing a unilateral moratorium on ASAT weapons tests (UPI, 1983). While no additional satellite-kill test was conducted until the end of the Cold War, both the US and USSR continued their research in the field of ASAT. In the final years of the confrontation, and in an effort to develop ASAT systems that would create less space debris, both States research efforts went into the development of directed-energy solutions (such as microwave and lasers). In 1997, the US Navy ground based *Mid-Infrared Advanced Chemical Laser* (MIRACL) coupled with the *Sea Lite Beam Director* were tested in an attempt to use its 30-watt chemical laser against an orbiting satellite, which was allegedly temporarily dazzled from a distance of 500 km (Donnelly, 1997). While sources on the state of Soviet directed-energy technology of that time are scarce, no significant technological breakthrough was achieved. This prompted US Congress to reconsider the relevance of ASAT testing, and repeatedly banning the MIRACL tests against orbiting satellites in throughout the 90s (US Congress, 1997).

# 3 Addressing nuclear arms race and its effects on space: development of legal and technical frameworks for confidence building, nuclear risk mitigation and arms control

## 3.1 Bilateral and multilateral measures: technical cooperation as a tool to build confidence

Notwithstanding the military purpose and origin of early space activities, around the same time as the launch of Sputnik, it soon became evident that space, due to its unique characteristics, required to be treated differently than other environments on Earth. Hence, a nascent regulatory framework on nuclear test ban and the internationalization of special regions, including in space, began to form. The origin point of a legal framework for space activities stemmed, once again, from military activities on Earth. In fact, while technical developments in ballistic and satellite technology, as seen previously, continued throughout the early Cold War, around the same time the US and Soviet Union began to engage in bilateral technical talks over scientific matters (with inherent military applicability), which would later form the basis of discussion for nuclear arms talks, and in parallel, international agreements regulating specific environments, including space, from which it drew most of its operating principles.

Bilateral talks, were initially attempted by the US through the conclusion of a transparency agreement over reciprocal military installations with the Soviet Union through Open Skies in 1955. However such proposal was rejected by the latter out of fear that the Americans could use this information to "accumulate target information" (Hall, 1995). The catalyst for early negotiations on arms control came thanks to the efforts of the international scientific community in the early 1950s aimed at promoting scientific cooperation and share knowledge across different fields through a common forum. These efforts culminated into the launch of the International Geophysics Year (IGY) that lasted from 1957 to 1958. The scope of the program encompassed 11 sciences (including Antarctic and space research) and involved scientists from 67 different countries, whose countless contributions and activities (including Sputnik and Explorer 1) were collected in the World Data Center, established as a means to share the results with the rest of the world (Uri, 2022). Parallel to multilateral discussions on arms control, the Soviet Union had proposed, since 1954, a system to ensure rapid communication channels with the US to reduce the risk of miscalculation which could lead to an accidental nuclear attack. As a consequence of the political deadlock present at the UN Disarmament Commission, and following exchanges of correspondence between the two Heads of State, an initiative was launched in 1958 by Western powers to convene a Conference of Experts comprised of an independent panel of scientists from West and East to discuss technical detection means to monitor test bans as a form of safeguard against surprise attacks. Though it did not lead to any significant outcome, it was an important technical development that would later provide the establishment of "national technical means" as a form of verification for the LTBT and future disarmament treaties (Jacobson, 1966). The Program for General and Complete Disarmament in a Peaceful World endorsed by Kennedy in 1961 at the UN General Assembly was another step in that direction, as it contained concrete measures to reduce the risk of accidental nuclear war and surprise attack, such as the provision of early notification of major military maneuvers, observation posts at key locations, inspections, and the establishment of an independent Commission of Experts for studying the feasibility of means to reduce risks of accidental nuclear war or failure of communication (US State Department, 1961). However, the catalyst came in 1962 during the Cuban missile crisis, which underscored the dangers of miscommunication between the nuclear powers, and prompted the US to submit an agreement proposal at the Eighteen Nations Committee on Disarmament for establishing direct communications link. The "Memorandum of Understanding Between the United States of America and the Union of Soviet Socialist Republics Regarding the Establishment of a Direct Communications Link" (referred to as Hot Line Agreement), signed in 1963, provided for each country to set up a prompt and continuous communication delivery mechanism to its head of government in case of crisis, and it comprised of a full-time duplex wire telegraph circuit (Washington-London-Copenhagen-Stockholm-Helsinki-Moscow), a full-time duplex radiotelegraph circuit (Washington-Tangier-Moscow), and two terminal points with teletype equipment, with a radio circuit system as a backup (US Department of State Diplomacy in Action, Archived Content, 2025c). Due to its success, the Hot Line Agreement was subsequently adjourned multiple times to include satellite circuits links and facsimile transfer (US Department of State Diplomacy in Action, Archived Content, 2025d). Building on the success of direct communication lines, and as a consequence of the successful technical discussions in Geneva, the US and USSR later signed a separate agreement, the Nuclear Risk Reduction Centers, for the creation of a dedicated hot line aimed at specifically reducing risks of nuclear war via rapid exchange of facsimile-based notification as well as regular annual meetings (US Department of State Diplomacy in Action, Archived Content, 2025e).

Such bilateral hotlines, albeit useful in emergency scenarios, are nonetheless limited by their *ad hoc* uses and narrow scope, and cannot single-handedly replace broader soft law and hard law instruments to regulate space activities. Arguably, the transparency afforded by such hot lines, as well as the technical and scientific cooperation initiatives, such as the IGY, had both a positive effect in building confidence and mitigating risks of misunderstandings. The continued use to this day of bilateral channels (political and technical in nature), and the establishment of new ones with other States, as well as the proliferation of various multilateral, regional, and independent technical and political committees for arms control (such as the SCC for SALT I and II, and the Zangger Committee and IAEA for the Non-Proliferation Treaty) and for the conduct of outer space activities (such as Scientific and Technical Subcommittee within COPUOS), including the prevention of arms race therein through the *Ad Hoc* PAROS Committee under the Conference on Disarmament, underscore their crucial role in fostering collaboration and building trust through the development of technical standards and guidelines, common interpretation and implementation of legal texts, and knowledge sharing, turning misguiding threat perceptions at political level into tangible reality.

The results and effectiveness of such technical committees in regulating nuclear and space activities has varied over the years, as will be examined later. On one hand, they have provided an important forum for ongoing discussions for both high-level, as well as more in depth, technical discussions, with the aim to provide a common understanding across multiple State and non-State actors over the conduct of space activities; for example, through the publication of studies, joint memorandums, and UN reports. On the other hand, such soft law instruments suffer from a high fragmentation of their scope of work, State representation, and differing approaches, which led in some cases to their work stalling in recent years (e.g., the PAROS Committee). To overcome these shortcomings, a clear and comprehensive regulatory framework provided for by a set of international treaties is required. In this sense, the Antarctic and Outer Space treaties provided the necessary legal and operational principles for the peaceful use of internationally recognized environments, and their protection through the exclusion of nuclear tests.

## 3.2 The international regulatory framework: peaceful uses and nuclear risks as guiding principles for the establishment of international legal regimes in space

The momentum stemming IGY's cooperative nature with the aim to promote scientific discovery for peaceful purposes and to the benefit of mankind, coupled with the risks stemming from nuclear posturing, contributed to steer US and USSR political efforts toward an internationalization of arms control on one hand, and the establishment of a "special regime" for Antarctica the high seas and, later, outer space on the other, whose scientific value was deemed as priority over strategic and sovereignty considerations (Berkman, 2011). Signed in 1959 by 7 claimant and 5 non-claimant nations following a series of preparatory meetings, the Antarctic Treaty was a landmark achievement which provided the basis for future nuclear arms control through the creation of an internationalized and institutionalized management of a defined geographical area, with international scientific cooperation for peaceful purposes serving as the its guiding principle (The Antarctic Treaty, 1959). It was the first international agreement to prohibit the establishment of military bases, the conduct of any military activity, and testing any type of weapon, including nuclear (Article I and V), to establish an international regime through the prohibition of (new) territorial claims (Article IV). Another innovation, following the experience of Open Skies and the issue raised by Eisenhower that "disarmament agreements without adequate reciprocal inspection increase the dangers of war" (Rostow, 1983), was the inclusion of a provision allowing Contracting Parties to designate Observers tasked with carrying out inspections to monitor Treaty compliance in a transparent and reciprocal way (Article VII).

Throughout the 1950s and 1960s, several resolutions outlining the same principles contained in the Antarctic Treaty space had been endorsed at the General Assembly to be applied in outer space (see for example United Nations, 1958). This was also in line with the content of the letters exchanged between President Eisenhower and Chairman Bulganin in 1958, who outlined the need to limit uses of outer space to peaceful purposes (Jacobson, 1966). As a means to create a forum of discussion over the growing number of space activities, and to facilitate and promote international cooperation in the exploration and peaceful uses of outer space, in 1959 the UN established, following the launches of Sputnik and Explore 1, the Committee on the Peaceful Uses of Outer Space (COPUOS). In addition to fostering space cooperation, the Committee was initially tasked with "studying the nature of legal problems which may arise from the exploration of outer space" (United Nations, 1959). Legal efforts to accomplish the mandate were carried out at COPUOS Legal Subcommittee in five different sessions from 1959 to 1966. Though the Legal Subcommittee was initially focused on the discussions surrounding a space launches, rescue of astronauts and liability for damages caused by space vehicles, it also submitted in 1961 a resolution proposal on basic principles that should govern space exploration: specifically the free and equal nature of the exploration of outer space and other celestial bodies, the prohibition of national appropriation, and the applicability of the UN Charter and international law to outer space (United Nations, 1961). Such principles were later reiterated and adopted in Resolution 18/1962 of 1963 (United Nations, 1963), which can be regarded as evidence, complemented by prior resolutions, and based on the precedent of the Antarctic Treaty, of *opinio iuris* potentially forming customary international law concerning outer space (Arons and Dembling, 1967), though State practice is more difficult to prove (Pascuzzi, 2023). In 1965, and in light of a renewed sense of urgency, COPUOS was further "urged" to "incorporate into international agreement form the legal principles governing the activities of States in the exploration and uses of outer space" (United Nations, 1965), which was carried out during the 5$^{th}$ session of the Legal Subcommittee. The language and principles used to guide the drafting of the Outer Space Treaty (OST) was clearly inspired, and expanded upon, by both the Antarctic Treaty and the LTBT, as well as being extended not only to outer space but also to the Moon and other celestial bodies (Arons and Dembling, 1967). For example, the principle of the use of outer space for peaceful purposes, enshrined in Article I and IV of the OST, is directly related to Article I of the Antarctic Treaty; Article II of the OST prohibits national appropriation of space and celestial bodies similarly to Article IV of its counterpart; Article I of the LTBT, which prohibits nuclear explosions in outer space, can be considered as applicable by extension to Article IV of the OST, insofar extending the ban of nuclear weapons test to celestial bodies (Ibid). The international regime governing outer space exploration and activities is further stated in Article III, which provides that international law, including the UN Charter, is applicable to outer space, reinforcing the provision on free and equal exploration by all States as outlined in Article I. The importance of Article IV should be noted. It was defined by US President Lyndon Johnson as "the most important arms control development since the 1963 treaty on a limited test ban" (New York Times, 1966). The novelty provided by Article IV is in its first paragraph, which outlines the prohibition of the placement in orbit of any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, and the installation of such weapons on celestial bodies, stationing such weapons in outer space in any other manner (United Nations, 1966). The second paragraph reiterates the use of the Moon and other celestial bodies for peaceful purposes only. However, the prohibitions contained in this paragraph does not include outer space. While delegations raised this inconsistency during the 5th session, it was understood that the extension of peaceful uses only to outer space activities would have created issues for the US and the Soviet Union disarmament talks, as their satellites already in orbit were being used for military purposes (Arons and Dembling, 1967). Notwithstanding minor disagreement over the inclusion or exclusion of specific language, the works at the 5th session of the Legal Subcommittee proceeded without interruptions (Ibid). The OST was opened to signature in January 1967, and entered into force in October 1967. An additional four conventions, already preliminary discussed between the first and fourth session, complemented this legal framework, establishing and expanding upon the principles of providing assistant to astronauts (Rescue and Return Agreement, 1968), of State's liability for national space activities (Liability Convention 1972), of registering space objects (Registration Convention 1974), and of regulating activities and use of celestial bodies via international regime (Moon Agreement 1979).

## 3.3 The impact of space on the development of arms control treaties

Recognizing the detrimental nature and effects of radioactive fallout caused by nuclear explosions, around the same time as IGY, nuclear states began negotiating efforts to first limit, and eventually ban, nuclear weapons testing in the atmosphere, in outer space and in the seas. In 1955, initial negotiations over a nuclear test ban among the US, France, the UK, Canada and Soviet Union took place initially at the UN Disarmament Commission. The main points of contentions were the inclusion of test bans within a general nuclear disarmament agreement, and the question of onsite inspections as verification mechanism, perceived as necessary in particular by the US to monitor against secret testing (Jacobson, 1966). Despite a stark perception of mistrust between the Western powers and the Soviet Union, and the belief by the Soviet Union that an inspection system did not provide enough guarantees against a surprise attack (Office of the Historian, 1958), negotiating efforts nonetheless continued under the auspices of different multilateral fora, driven by international public resentment toward the detrimental effects of nuclear test's fallout (US Department of State Diplomacy in Action, Archived Content, 2025a). While the barrier on the first point was eventually overcome after a change of position by most parties, discussions over on-site inspection continued until 1962, when the matter was dropped entirely, as it was deemed that "national technical means" of detection were adequate to monitor all environments (Ibid). Such national technical means comprised of seismographers, acoustic and radar sensors, and notably satellite intelligence from *Corona* photographic images and *Vela* sensors to detect radiations. This made negotiations much smoother, and eventually the agreement was signed in August 1963. In the same vein as the Antarctic Treaty, the Limited Test Ban Treaty (LTBT) draws from the same principle of denuclearization of specific environments (with the exception of underground tests), including a clause prohibiting the explosion if radioactive debris spill-over outside its territorial boundaries. Unlike the former, the LTBT does not contemplate the establishment of a comprehensive ban across land, sea and underground, nor does it provide for an inspection mechanism. However, it established a new principle: a clear prohibition of nuclear detonations in space.

At the beginning of 1960s, US intelligence indicated a drastic increase in the number of Soviet ICBMs and the development ABM capabilities. To understand the full extent of the Soviet capabilities, and under domestic pressure, President Lyndon Johnson turned to the National Reconnaissance Office (NRO), in charge of the satellite intelligence programs, to obtain clearer data. Crucially, the increasingly higher quality and number satellite images included in NRO reports, particularly from *Corona* missions, likely played a pivotal role in providing the US national security apparatus the necessary confidence in the ability to detect Soviet strategic weapons, reassuring the higher levels that Soviet efforts in developing and deploying new systems were limited, and that additional efforts could easily be monitored and detected (Central Intelligence Agency, 1973). Under the Nixon administration, international pressure, US strategic considerations to stabilize nuclear forces vis-à-vis Soviet ramp up of ICBM silos, and the above legal framework all played a role in framing strategic arms limitations discussion for both offensive and defensive arms. Initially, the US negotiating position was to place limits on both types of strategic armaments under a single umbrella treaty, arguing that this would allow to effectively limit the overall Soviet build up. The Soviet Union counterproposal was to sign first a separate agreement on ABM, which would have allowed them to finalize the modernization of their ICBM program. The US accepted this proposal as, officials argued, strict limitations on ABM deployment and development would have eased the pressure on both sides from increasing their offensive capabilities (Garrity, 2014). Arguably the decoupling of discussions on offensive arms from defensive ones, and their continuous verifiability provided by satellites was pivotal in setting the stage for the first strategic armaments treaties in 1972, for the limitation of ICBMs, and the testing and deployment (including in space) of anti-ballistic missiles respectively (US Department of State Diplomacy in Action, Archived Content, 2025f). The need for verification mechanisms, omnipresent in US negotiating demands, was based on the assumption that it would be incoherent to enter into agreements "in which the Soviet Union could cheat in ways we could not detect" (Pfaltzgraff, 1979). During the negotiations on the ABM and SALT I provision of national technical means of verification (NTM), it was understood by both the US and USSR that military satellites would be included, and that they would also enjoy the protection stemming from the prohibition of interference 1963 (US Department of State Diplomacy in Action, Archived Content, 2025g; Harold and Coyle, 1971). Due to their effectiveness, the NTM provision was also included in all subsequent arms limitation treaties: SALT II (1979), the three START treaties (1991, 1993, 2010), INF (1987), and SORT (2002). Complementary to NTM, the Standing Consultative Commission (SCC) was envisaged in the ABM Treaty as a technical panel of experts mandated to monitor the implementation of SALT and successive arms control treaties and was additionally responsible for acting as forum of discussion to negotiating new amendments and resolve compliance issue through voluntary exchanges of documentation. Despite the fluctuating political environment, technical exchanges at SCC remained constant, and proved important to clarify ambiguity regarding interpretation matters (such as the meaning and location of "ABM test ranges") increase trust, and establish common measures for crisis management (Buchheim and Caldwell, 1986; Graybeal and Krepon, 1985; NTI, 2011).

# 4 The new space age: strategic, technological, and governance shifts

## 4.1 Multipolarity and renewed strategic competition

The end of the Cold war marked the transition of space activities to what is referred to as "the New Space Age": a period of proliferation of commercial space activities coupled with a new found use of military satellites (Cremins, 2014). Technological advancements and the growing commercialization of the space sector drastically reduced launch costs and improved reliance of vectors over the years. This created the necessary conditions for both a diversification of space actors and a proliferation of satellites in orbit. Notably, the past two decades saw a concurrent gradual shift in the geopolitical balance of power, the entry of a dozen new space faring States with varying degree of capabilities (notably China, India, Japan and the EU) in the space arena, and the resumption of new ASAT tests by several space faring nations, leading to space becoming more diverse, disruptive and disordered (Harrison et al., 2017).

China's first direct ascent ASAT test in 2007 using a DF-21 ballistic missile that intercepted an old satellite, and produced more than 3,000 debris, was a watermark event that rekindled the practice of anti-satellite weapons test, halted since the end of the Cold War. For the US, this event highlighted the crucial need to protect its space assets from debris and ASAT weapons not just from Russia, but also from new actors with the same capabilities like China (Hadley, 2023). In 2019, India conducted its own ASAT test, Mission Shakti, making it the third country to develop ASAT capable ballistic missiles (Tellis, 2019). Finally, after 20 years pause, Russia has reconfirmed its direct ascent ASAT capabilities by destroying a satellite in 2021 (United States Space Command, 2021). In the EU, France is the only State with some form ASAT capabilities in active development. Though it never conducted tests, and is committed not to perform them, the release of its first Space Defense Strategy in 2019 marked a shift in France's approach to outer space military activities with the inclusion of active satellite defense policy, through the development of ground based and co-orbiting counter space weapons using directed energy technology (Ministère de l'Europe et des Affaires étrangères, 2022; Secure World Foundation, 2025). Other countries (Israel, the UK, North Korea, South Korea, Japan, Iran, and Australia) have also been developing some form of destructive or non-destructive ASAT technology, or the capabilities to attain such (Secure World Foundation, 2025; Swope et al., 2025). Parallel to offensive systems, countries have also been developing their own space programs and launching hundreds of satellite constellations over the years, and have developed increasingly sophisticated systems as well as new operational capabilities (Pike, 2001).

Though presence in space and capabilities across States greatly vary (with the US currently in the lead), these developments, along with changing geopolitical dynamics, have raised concerns over a growing weaponization of space. While military uses of space had always existed in the form of reconnaissance satellites, which contributed to the nuclear balance and deterrence during the Cold War, today the increasingly active weaponization of space through the development and recent proliferation of testing of offensive counter-space systems, ground, and space based, by multiple actors increases the risk of escalation on Earth (Stojanovic, 2021). Arguably, this trend can lead to destabilizing effects on both space operations (Pascuzzi, 2023), andon the nuclear strategic balance (Stojanovic, 2021). As pointed out by Gottemoeller, while in the past strategic nuclear stability was insured by the deterrence offered by a second strike, today retaliatory nuclear forces, whose concealment and secrecy safeguard their effectiveness (particularly submarines and mobile launchers), are increasingly being challenged by emerging technologies, particularly analytical AI tools, improved and widespread satellite images and sensors, rendering them targetable. This would eventually lead to a "standstill conundrum" where States will increasingly have to account for their second strike capabilities to be vulnerable to attacks in various forms (Gottemoeller, 2021). As it was the case during the Cold War, this mutual vulnerability could be stabilizing in itself (Gottemoeller, 2021), however States would nonetheless attempt to find other means to address this gap by either developing new systems for defending their second-strike option (Gottemoeller, 2021), or targeting those that cause such vulnerability in the first place. This in turn would create the conditions, and need, for States to race to develop both offensive and defensive space capabilities to achieve strategic dominance. This is particularly true for the United States, which saw the establishment of a dedicated military branch for space as well as the development of an elaborate space warfighting doctrine and strategy over the past decade. The recent announcement by President Donald Trump of the "Golden Dome" project, a space-based missile defense network, is another exemplification of this strategic trend.

## 4.2 From monitoring and peaceful uses to warfighting domain

The way in which space has been utilized has undergone a significant shift in the New Space Age. From monitoring capabilities and treaty compliance, providing early missile warning, and generally being used for peaceful purposes, the scope and uses of space has been drastically expanded over the past two decades. The 1991 Operation Desert Storm is considered to be the first instance where military satellites were employed, in addition to their conventional role of monitoring strategic asset, as a decisive tool to support and enhance combined arms operations on Earth, particularly by providing navigation, command and control communications, weather forecasting, sensing and imaging capabilities (Grimley and Ulisse, 1999). Today, military activities in outer space can be summarized into 4 main categories: space support, force enhancement, control, and force. Space support refers to the ability to launch and maintain space systems in orbit. Force enhancement refers to all supporting activities to ground operations, planning and decision-making process (command and control, communication, intelligence, surveillance, reconnaissance, etc.). Control in space refers to one's ability to monitor and tracking all kinds of space activities, identify objects, their capabilities, behavior and potential threat (a concept known today as space domain awareness) (Di Mare, 2021), and prevent interference through mitigating actions. Finally, force refers to all offensive and defensive activities, including the use of weapons (Rabkin and Yoo, 2017).

As the importance of space grew, it is no wonder that most space faring nations developed dedicated space programs to leverage and steer space for scientific research, industrial and economic development to their benefit (D'Ambrogio, 2024; State Council PRC, 2022; NASA, 2020). At the same time, the increased traffic in space brought about new security challenges, notably cyber-attacks, improved electronic warfare, hostile maneuvers and the proliferation of space debris. Such challenges have led nations to extend their national security concerns to the space through its inclusion as a battlefield domain that needs to be controlled and defended (France Armed Forces Ministry, 2019; Department of Defense, 2020; Pollpeter et al., 2020; Presidenza del Consiglio dei Ministri, 2019; Government of Japan, 2024; NATO, 2022). Militaries from leading space-faring nations have undergone significant doctrinal reforms which have either expanded their scope of operations, or even created new branches tasked to defend national interest and activities in space as part of their competence. On this note, the US and China are the only two space-faring countries that have established a dedicated space force branch as part of their armed forces.

## 4.3 US space force and space warfighting doctrine

Established in 2019, the United States Space Force (USSF) is tasked with organizing, training, and equipping personnel in order to protect U.S. and allied interests in space and to provide space capabilities to the joint forces through the management of all matters related to space operations including satellite monitoring and coverage, tracking, early warning against missile threats, and command and control support to ground forces. In 2025, the USSF published its first comprehensive doctrine which defines the service's purpose, structure, operational scope, and how it employs space power to support the joint force. As stated in the Space Force Doctrine Document 1 (SFDD-1), the branch is expected to: protect and support US interests, provide freedom of operations in, from and to space, support and conduct space operations, and deter aggressions in, from and to space (United States Space Force, 2025a). To perform its duty, the USSF developed the concept *space superiority* (defined as "the degree of control that allows forces to operate at a time and place of their choosing without prohibitive interference from space or counter space threats, while also denying the same to an adversary") as its primary operational objective (United States Space Force, 2025a). To achieve this, two preconditions are required. The first is the ability and preparedness to conduct warfare in space (*space warfare*) aimed at either deterring, or denying attacks, compelling aggressive behaviors, undermining adversarial strategies, and providing space-based support to other domains. The second is the ability to maintain a credible nuclear deterrence posture and high intensity readiness (*competitive endurance*) by establishing full space domain awareness, deterring first strike, and conducting (responsible) counter-space operations while "maintaining the safety, security, stability, and long-term sustainability of space" (United States Space Force, 2025a). USSF area of operation starts "above the altitude where atmospheric effects on airborne objects become negligible," and it involves three orbital regimes: geocentric, cislunar, and heliocentric. In addition to the space domain, the USSF is expected to operate in the electromagnetic, cyber, air, land and maritime domains, as they are deemed essential to the conduct of space operations for differing reasons, such as for hosting critical infrastructures for space systems (air, land, maritime), sharing space-related data (cyber), or for enabling communication (electromagnetic) (United States Space Force, 2025a).

The SFFD-1 provides more granular details on the specific space activities by dividing the USSF functions into two distinct areas: *core functions*, and *enterprise functions*. The first function includes activities required to contest and control space (*space control*), those required to deliver space capabilities to the Joint Force such as communication, targeting, surveillance, navigation and missile warning (*global mission operations*), and finally those involving the movement and sustainment of equipment in, from and to space (*space access*) (United States Space Force, 2025a). Interestingly, SFFD-1 covers an extensive range of activities related to *space control*. In addition to more kinetic forms of warfare such as *orbital warfare* ("combat operations conducted through fires, movement, and maneuver"), the doctrine also includes defensive and offensive *electromagnetic warfare* and *cyberspace warfare* (Ibid). All these activities are carried out to "create effects in, from and to space" along a spectrum of three interdependent segments, all of which require protection in order to preserve space capabilities: orbital (space systems operating in space), terrestrial (systems operating on Earth), link (systems operating in the electromagnetic spectrum). Hence, compared to other US branches whose activities are exclusively dedicated to specific domains, USSF operational environments encompass all, with the addition of space and cyberspace.

Compared to other departments, a peculiarity of the USSF is its approach to command and control (C2). While in other physical domains the attribution and distribution of capabilities across joint operations areas follows a more linear logic, in space, due to its unique characteristics and rapidly changing environment, this becomes difficult, as some capabilities may support multiple simultaneous areas, while others may only support one or none. This could cause operational friction. At the same time, operations from, to and in space often transit across different joint operating areas, requiring a high degree of coordination between commands. The characteristics of space also affect how USSF performs missions. In fact, USSF views *mission command* as the leading principle for its C2 approach, which emphasizes the role of USSF subordinate personnel ("Guardians") to take the initiative based on mission parameters and commander's guidance, while at the same time adapt to new environments and identify new opportunities to exploit (United States Space Force, 2025a). Compared to other branches, USSF combat formations both provide support and space capabilities to other joint forces' combat commands, and can also be organized as Space Mission Task Forces: an aggregation of elements including a commander, and combat formations that conduct military space operations (United States Space Force, 2025a). To ease the collaboration and integration of space capabilities with joint forces, a unified combatant command (the United States Space Command) composed of forces from all service branches has been (re)established by the Department of Defense in 2019, whose joint combat components (supervised and led by a USSF Component Field Command) can either be attached to and coordinate with existing combat formations under other commands, or for executing military space operations taking place from the Karman line to the Moon (US Congress, 2025; United States Air Force, 2025).

Finally, SFFD-1 should also be read in conjunction with USSF Commercial Space Strategy. In a way similar, though comparably less extensive, to the Chinese approach of civil-military fusion the Commercial Space Strategy aims to directly integrate and embed space capabilities and assets from commercial actors into its missions; perhaps in an effort to emulate China's approach with a narrower, and more space-oriented, scope. Unlike other US branches, the strategy adopts a *commercial-first* approach, by treating private space infrastructure as part of the national space network, and explicitly links commercial integration to strategic deterrence in space (United States Space Force, 2024). This is done through three *Lines of Effort*: integration (by embedding commercial capabilities from the outset rather than as an add-on), innovation (by rapidly adopting emerging commercial technologies and services), and resilience (by building a diversified, redundant, and adaptive architecture using commercial and government assets) (United States Space Force, 2024).

## 4.4 China's space strategy and potential operational use: comparing approaches

While China officially adheres to the principle of peaceful uses of outer space and opposes its weaponization, as outlined in a previous defense white paper (The State Council Information Office of the People's Republic of China, 2015), the PLA has been developing its own space capabilities by leveraging dual-use technology and integrating civilian space systems into military space and counterspace roles; a concept known as civil-military fusion, and a key tenet of China's overarching national military strategy, which sets it apart from USSF doctrine. In fact, one of the main difference from the US is China's emphasis in embedding, and relying on, dual-use civilian space technologies, assets, infrastructures, and services into PLA space operations (Enayati, 2025). Both the US and China's doctrinal goals and means appear similar: the achievement of space control through the establishment of space domain awareness, defensive, and offensive counterspace capabilities across multiple areas (cyber, physical, and electromagnetic). Based on a comparison between Dr. Enayati analysis on China's space doctrine and of USSF SFFD-1 document, a distinction appears to lie in their approach. While SFFD-1 appears to favor a more defensive posture centered around maintaining and securing US space interests by creating a redundant and flexible space architecture, defending their assets, and deterring potential adversaries through offensive and defensive capabilities (leveraging its technological edge), and a credible threat of retaliation, the PLA's doctrinal approach appears to more proactive and offensive in nature, through the employment of coercive actions below the threshold of armed conflict (such as jamming, spoofing or otherwise active interference with other satellites) (Enayati, 2025; United States Space Force, 2024). In fact, as a consequence of the US lead in the area of space domain awareness, which Chinese strategists deem essential for achieving "information dominance" (Bath, 2021), China space operational approach may emphasize the use of asymmetric tactics, as well as pre-emptive or anticipatory actions (including DA-ASAT strikes) with the intent to degrade US space advantage over localized areas, such as in the South China Sea (Enayati, 2025; Bath, 2021).

A notable similarity with the US, is the establishment a dedicated space department by China. Established in 2024, the People's Liberation Army Aerospace Forces (PLAAF) also serves as an independent armed forces branch dedicated to the protection of China's space interests and activities and furthering China's space policy by performing similar operational duties to the USSF, and acting as a joint force structure supporting other branches with space capabilities, as well as performing space operations (Goswami, 2024). As it is a relatively novel branch compared to USSF, the PLAAF command structure, scope of activities, battle management, and level of inter-service cooperation and C2 is presumably less mature than USSF.

## 4.5 Other space forces

Despite not having established dedicated independent space branches, other countries have nonetheless built a defense operational framework for space activities within their existing structures. In 2015, Russia set up a dedicated space department under the Aerospace Forces branch (РИА Новости, 2015). Similarly, in 2020, France and Japan expanded the scope of their existing Air Force branches to include dedicated operational space units (Yamaguchi, 2020; Orban, 2020).

## 4.6 Rise of new counter-space capabilities

Ajey provided a comprehensive definition to the concept of "space weaponization," which posits the destruction of space targets through both space-to-ground weapons and ground-to-space weapons (Lele, 2013). As noted in the first section, already during the late Cold War period the US and Soviet Union, in parallel to developing new ABM systems (which have inherent ASAT capability), they had begun experimenting with other forms of counterspace such as the ground-based MIRACL directed energy laser. Technological developments in the fields of informatics, telemetry, sensors, and directed energy have opened the doors for the deployment and testing of new forms of counter-space, and counter-space capable, systems. The yearly report by the Center for Strategic and International Studies (CSIS) and Secure World Foundation (SWF) provide an excellent overview as to the various forms of counterspace weapons, their operational capabilities, potential for dual-use from the civil domain, and the current state and future trend of how the US, China, Russia, and other countries are implementing and developing such systems (Secure World Foundation, 2025; Swope et al., 2025).

On the basis of CSIS and SWF reports, contemporary counterspace capabilities can be classified into five main categories: DA-ASAT systems, co-orbital systems, electronic warfare (EW), directed energy weapons (DEW), and cyber operations (Secure World Foundation, 2025; Swope et al., 2025). In addition, Rendezvous and Proximity Operations (RPOs), initially designed with the civilian purpose of in-orbit servicing or debris removal, are increasingly being recognized for their potential offensive applications. While their employment location (in space or ground), level of destructiveness, and degree of sophistication vary, these systems all pose growing challenges to civilian and military space activities alike. DA-ASAT systems refer to ground-launched missiles capable of targeting and destroying satellites in orbit. Although no new tests were conducted in 2024, as confirmed by the CSIS report, as previously mentioned, China, Russia, the US, and India have all demonstrated or tested such capabilities in previous years, and retain them in their national arsenals. These systems remain strategically relevant due to their anti-ballistic missile capability. However, their impact with satellites carries significant consequence through long lasting, or even permanent, fields of debris that can hinder access, or potentially even deny, access to space and force orbiting objects to maneuver around them to avoid collision. Co-orbital systems, by contrast, involve space-based assets that are launched into orbit and then maneuver to approach and potentially interfere with other satellites. Such systems may physically damage, disable, or even capture their targets. Although none have been overtly employed in combat, Russia and China have shown increasing proficiency in this area. The SWF and CSIS reports document several maneuvers by Chinese satellites in GEO, including proximity operations and unusual fuel use, suggesting growing confidence of the technical feasibility of space maneuver warfare (Secure World Foundation, 2025; Swope et al., 2025).

Electronic warfare (EW) constitutes a non-destructive but highly disruptive form of counterspace, commonly taking the form of jamming or spoofing signals. This type of interference has been widely documented in and around contemporary conflict zones, especially in Ukraine and the Middle East, and is typically employed in a reversible, deniable manner. Because of its tactical flexibility and ambiguity, EW remains a preferred option for gray zone activities, making the attribution of responsibility of an attack challenging. Directed energy weapons (DEW) encompass systems such as high-powered lasers and microwave emitters capable of dazzling or permanently damaging satellite sensors. These technologies were first explored in the Cold War era (e.g., the MIRACL laser system) and remain a focus of research and development today. Although no confirmed uses of DEWs were recorded in 2024, multiple states, including the US, China and France, are advancing programs for ground, and potentially space-based, deployment in the coming years. Cyber operations are increasingly considered as central tools for counterspace activities. Such systems are capable of disrupting or seizing control of satellites, ground stations or data networks. Similarly to EW, cyberattacks are inherently difficult to attribute and can serve both espionage and sabotage purposes. The suspected Russian cyberattack against the DA-SAT network at the start of the Ukraine invasion is a concrete example of how space-linked infrastructure is now a target in cyber-enabled warfare. Finally, Rendezvous and Proximity Operations (RPOs), originally conceived for legitimate civilian missions such as satellite servicing or debris removal, have emerged as a significant concern due to their dual use potential. As noted in the CSIS assessment, both commercial and military satellites are now demonstrating capabilities for close approaches and docking, often without transparency or clear intent. The Chinese SJ and TJS satellite series have repeatedly performed complex maneuvers in GEO, raising alarms US military staff over their potential use in disabling or interfering with crucial assets under the pretense of maintenance operations.

Taken together, these developments underscore a broadening in the operational capabilities of military uses of outer space compared to the Cold War era. While Cold War counterspace activities were limited to a highly visible and easily detectable missile systems, today's counterspace environment has expanded to include a wide array of tools stemming from different technological architectures, and which often rely on civilian space systems. Assets from private space firms, notably SpaceX's Starlink satellites and Falcon 9 launchers, are incrementally being contracted by States for military operations, offering low cost, off-the-shelf, and ready-to-use technological solutions that can be adapted to military uses, as opposed to slowly developing them in-house (Sacchi, 2024). This creates an overlap of civilian and military activities which are difficult to track and assess, and whose limitation to single domain usage through binding norms without verification mechanism runs in contrast with State's perception of losing its strategic advantage (Ranjana, 2017). Combined with the lack of clear norms of behavior, dual-use activities enhance the risk of misperception of activities, which could lead to unintended escalation. The reliance of space systems on civilian infrastructure, such as satellite data centers and ground stations, internet relay stations and launch pads, makes them strategically sensitive targets, whose loss can lead one party to lose communication and connection to various satellite system, effectively disturbing, or even denying, crucial access to intelligence, navigation, early earning, launch and command, and control capabilities. This would likely erode nuclear strategic deterrence credibility, increasing the potential for retaliatory actions and escalation, impair military coordination capabilities, and critical civilian services such as finance, aviation, shipping, emergency response (Secure World Foundation, 2025; Swope et al., 2025).

## 4.7 Limitations of space frameworks today: ambiguity, lack of enforcement and new operational challenges

While the scope of space activities and number and type of actors has expanded over the last few decades, the current regulatory framework has notably lagged behind in the face of the new space age challenges. In addition to the rising risk of escalation stemming from the current geopolitical power shift, and increased weaponization of the space domain, the proliferation of space systems from a wide variety of actors has given rise to two additional challenges: space debris and space traffic. Despite their limited number, past and recent ASAT tests have created a considerable number of space debris. The European Space Agency (ESA) 2025 Space Environment Report tracked 39,246 objects, as well as estimating 54,000 objects greater than 10 cm, 1.2 million greater than 1 cm to 10 cm, and 140 million from greater than 1 mm to 1 cm (European Space Agency, 2025a). The considerable amount, variable size and velocity of such debris poses a significant risk for the safety of current and future space operations, fueling concerns over a possible chain reaction of collisions known as "Kessler syndrome" (Bartóki-Gönczy et al., 2024; European Space Agency, 2025a).

The sheer increase in orbital traffic, particularly in LEO, has outlined the urgency of space traffic management. With the proliferation of satellite constellations, such as those deployed by SpaceX, and emerging operators in China and Europe, avoiding collisions through constant awareness and maneuver operations have become a regular operational concern. In spite of the growing reliance on satellite-based services for military and civilian purposes, there is currently no binding international regime or centralized authority to coordinate space traffic. Instead, space traffic management (STM) relies on a variety of national-level space situational awareness (SSA) systems and voluntary data-sharing arrangements. While these efforts have improved tracking capacity, they remain fragmented, non-transparent, and politically sensitive, particularly when involving dual-use or military satellites. Efforts to enhance coordination and sustainability have largely taken the form of soft law initiatives under the auspices of the United Nations and other multilateral bodies. In 2019, COPUOS adopted a set of voluntary Guidelines for the Long-Term Sustainability of Outer Space Activities. These guidelines aim to promote best practices for debris mitigation, transparency, and operational conduct, and to further such discussion under the intergovernmental working group tasked with identifying and studying the challenges on space sustainability, over a 5-year period, by sharing best national practices, promoting international co-operations, and recommending implementing mitigating actions such as constant exchange of space data, and establishment of procedures for anti-collision mechanisms (UNOOSA, 2025c; United Nations Committee on the Peaceful Uses of Outer Space, 2025). However, such guidelines, and the legal framework on which they are based, suffer from ambiguous terminology, lack of enforcement, and significant disparities in implementation across national regulatory systems. Further, they are not legally binding, and their effect depends on the political will and technological capabilities of individual states, which vary widely (Pascuzzi, 2023).

There have been renewed diplomatic efforts to discuss arms control in outer space domain. The *ad hoc* Prevention of an Arms Race in Outer Space (PAROS) Committee, established in 1985 under the UN Conference on Disarmament, had the aim to extend the Outer Space Treaty's prohibition on the placement of nuclear weapons by also banning all types of weapons in outer space. Under the Committee, Russia and China introduced in 2008 a draft treaty proposal on the Prevention of the Placement of Weapons in Outer Space (PPWT). While the first draft attempted to define for the first time terms such as "outer space," "space weapon," "use of force," the US rejected this proposal arguing (ironically in a similar way as during the Cold War) that it would be impossible to develop a credible verification regime for an agreement which would ban both space-based and ground-based ASAT, and that terms such as "space weapon" were too vague. In contrast, the US have favored soft law instruments through transparency and confidence-building measures, arguing that binding legal instruments were premature without shared definitions and effective verification tools (Silverstein et al., 2020). This divide has led to mutually exclusive proposals. While Russia and China push for hard law instruments, like the PPWT, to address space arms escalation, Western states continue to promote voluntary guidelines under the UN First Committee and COPUOS. The result is a fragmented governance, with competing initiatives proceeding in parallel without convergence. Current efforts not only undermine collective trust but also reinforce the perception that the existing multilateral system is unable to respond effectively to the risks of militarization and strategic instability in outer space (Pascuzzi, 2023). In the absence of legally binding instruments, what is left is a range of soft law mechanisms to shape norms and expectations and to carry the weight left by this normative void. The Hague Code of Conduct Against Ballistic Missile Proliferation, while primarily focused on missile launches, is an example of voluntary transparency and confidence-building that some hoped would extend to the space domain. However, its effectiveness has been deemed doubtful due to the limited number of signatories, the exclusion of key States, and the fact that it did not prevent the proliferation of ballistic missiles (United Nations, 2003). The EU-led initiative from 2014 to establish an International Code of Conduct for Outer Space Activities (ICoC) attempted to replicate this model for outer space, promoting transparency, restraint, and notifications of maneuvers. However, as Beard rightly argues, the ICoC, just like the Hague Code before, remain ineffective instruments due to vague their language based on principles rather than binding norms, lack of institutional support for compliance verification, and absence of key actors such as Russia, China, and the U.S. Rather than fostering consensus, such soft law frameworks may risk further increasing legal uncertainty, overlapping with existing treaties, and creating the illusion of progress in an increasingly uncertain geopolitical environment (Beard, 2017). At the same time, and contrary to the author, in the absence of the necessary conditions for hard law instruments, it is difficult to see what else could be employed if not soft law measures. Despite the inherent limitations of soft law, technical-focused fora have gained some success in providing guidelines that could be applicable and replicated by all States and non-State actors. The European Space Agency's Zero Debris Charter, launched in 2024, aims to mobilize public and private stakeholders around a non-binding commitment to prevent the creation of new long lasting debris by 2030, while its Space Debris Mitigation Measures and Policy offer a practical framework for space mission technical requirements aimed at improving orbital clearance, avoiding collisions, guaranteeing safe object disposal and reentry (European Space Agency, 2023, 2025a,b). Similarly, the Artemis Accords, led by NASA with the inclusion of over 30 states, seek to provide a normative framework for lunar exploration and resource extraction (NASA, 2025). Other authors have also argued that, while hard law is difficult to achieve and lengthy to mature, soft law frameworks, such as ESA Zero Debris Approach, COPOUS guidelines, as well as other bilateral or multilateral mechanism like the Artemis Accords, can offer more immediate and transparent progress (albeit based on non-binding commitments) through either a replicable technical template or information exchange. However, as Steele and Michael observe, such environment of layered instruments reflect a shift toward "staged governance," which allows actors to develop operational rules outside and in parallel from formal treaty systems. While this approach may enhance flexibility, it risks bypassing dedicated space fora like COPUOS, and fragmenting the normative architecture of space law (Steele and Michael, 2022). Ultimately, while soft law plays an important role in shaping predictable behavior, common operational understanding and building consensus, it remains a poor substitute (though the only possible one for lack of alternatives) for binding international agreements, particularly in a domain as strategically sensitive and technically complex as outer space. Without robust verification mechanisms, clearly defined terminologies and obligations, and the involvement of all major space actors, soft law alone cannot address the systemic risks posed by debris proliferation, orbital congestion, and the increasing potential for miscalculation or conflict derived from counter space arms deployment and testing.

## 5 Learning from the past: what the cold war dynamics can teach us to address space weaponization

The evolution of the military (and later civilian) uses of outer space has always been inextricably linked to, and reflective of, geopolitical events and strategic arms developments occurring on Earth. The Cold War period reflects this dynamic when tensions stemming from nuclear arms race spilled over into space, which became a testing environment for the Soviet Union and the US arsenals just like on Earth. The destabilizing and long-lasting effects caused by the debris field created after the destruction of satellites by a nuclear explosion during early ASAT tests, such as *Starfish Prime*, prompted the two superpowers to limit such tests, and in parallel provided the necessary basis for discussions leading to the signing of international agreements on the use of special regions based on "peaceful use," "equal access," and "scientific cooperation" principles, as well as to negotiations on nuclear arms treaties. Continued discussions at technical level across bilateral (such as the Commission of Experts, the SCC) and multilateral (like UN CD and COPUOS) fora, while not decisive, contributed to providing evidence-based exchanges and overcoming political barriers. At the same time, the intelligence provided by satellite systems such as *Corona* and *Midas* was crucial for painting a clear and objective picture of the adversary's true capabilities, decreasing the sense of threat perception stemming from wrongful assumptions of a "capability gap" in the context of strategic arms race, as well as acting as reliable "national technical means" for monitoring the correct implementation of treaty provision, enhancing transparency, predictability of the intentions, and early warning capabilities whose inherent effect of dissuading the adversary from conducting a pre-emptive first strike largely contributed to Cold War stability.

Recognizing that today's space activities have greatly expanded in scope, capabilities and number, and type, of actors, the Cold War period could nonetheless provide some form of guidance to today's ongoing discussions and challenges over the threat of arms race in space. As outlined by Silverstein, Porras and Borrie, while sharing similarities with Cold War strategic arms race dynamics, the arms race of the New Space Age present additional important considerations. Firstly, the arms race during the Cold War was the result of inter-state power dynamics fueled by competition and fears compelling each actor to increase the quality and quantity of its arsenal to gain or maintain a strategic advantage. In today's context, however, such aspects might not be sufficient anymore to explain the motivation behind modern competition. Secondly, unlike previous arms races, counterspace capabilities in the New Space Age do not follow a linear system-vs.-system dynamic present in past arms races. In this regard, counterspace systems are generally not designed to defend against peer-systems; in many cases they are part of a broader infrastructure, and not necessary with military applications in mind (Silverstein et al., 2020). Additionally, it can also be argued that, as opposed to the Cold War where both the US and Soviet Union had similar strategic arms capabilities (albeit differing in numbers depending on the category under analysis), the capabilities of today's space faring nations, in terms of launch capabilities, mission types, and development and deployment of counterspace systems vary substantially, with the US well ahead in the lead in terms of yearly launched payloads (Aerospace Security, 2022), as well as in terms of doctrinal development of its Space Force through the definition of mission, operational environments, types of warfare and relationship with other forces, and even commercial space actors (United States Space Force, 2025b). China, however, while not having launched a comparable number of payloads, has demonstrated the same capabilities as the US. Considering China's technical achievements in launching its own space station (the Tiangong) open to all UN members in 2021, landing a rover on the Moon in 2007, as well as its ambitious goal to land humans on the Moon by 2030, it appears the gap with the US will continue to narrow in the near future. Finally, unlike nuclear weapons, space weapons are difficult to classify and to legally define, both due to their often dual-use nature, as well as the inherent difficulty in clearly discerning the scope, mission and intended use of the space technology under scrutiny (Beard, 2017). This is the case, for example, with ABM systems, who have an inherent duality as defensive and ASAT missile systems. From a legal standpoint, States have always found difficulties in agreeing to definitions such as "space weapons," or even where the demarcation of space begins, which further complicates discussion over space activities (Pascuzzi, 2023).

While taking into account all peculiarities characterizing the New Space Age, and the increasingly multipolar and uncertain international system, past experiences with arms control treaties, and other measures, can assist us to find a possible approach around the stalemate surrounding space weaponization. While the highly destructive and widespread effects of nuclear explosions are dependent on a retaliatory response, the destruction of satellites, especially by direct-ascent ASAT, and the collateral damage its debris would cause, would not only be immediately detrimental to the attacked party, but also to the attacker. In this regard, the numerous US assets (particularly SpaceX's) risk being the most affected. Hence, a first strike in space against an adversary's systems would lead to a lose-lose scenario where the attacker is forced to also take into account the collateral damage impacting its own space architecture. Nonetheless, all space actors are aware of the potentially devastating effects of ASAT and space debris, and are actively taking mitigating measures to limit and track them. However, this approach seems to be reaching a limit due to the rising number of objects according to a study conducted by RAND (McClintock et al., 2023).

To effectively address the detrimental effects of ASAT systems and further limit space debris generation, legally binding provisions that set specific obligations in a clearly defined way are required. As Beard argues, hard law instruments, while difficult to achieve, are nonetheless necessary in "providing assurances to prevent defensive defections from international regimes, or creating clear obligations to serve as the basis for effective monitoring and verification regimes designed to prevent offensive defections" (Beard, 2017). Consequently, adapting Cold War arms control provisions to today's context, while following the guidance set by international space law principles and treaties, can provide a suitable template for limiting harmful effects of counter space activities. In this regard, the LTBT and ABM treaties (though the latter is defunct since 2002) provide a strong framework for framing a newly adapted treaty on ASAT systems. During the Cold War, evidence of the disruptive effects of nuclear detonations in space led both US and Soviet Union to ban testing in outer space. This opened the door to future discussions over strategic arms limitations, which stalled when the US and focused its negotiating efforts in developing a comprehensive treaty addressing both offensive and defensive arms. Similarly to how LTBT placed a limit on nuclear testing in outer space, a similar treaty banning ASAT tests can be foreseen. Considering the interlinked nature of military and civilian technologies that can be used as counterspace system, a comprehensive ASAT test ban would likely be ineffective due to the difficulties in clearly classifying and ascertaining the intended use and scope of this weapon. The alternative, proposed by Beard, to narrow the focus on the prohibition over the offensive conduct, rather than the technology itself, would likely prove more fruitful, such as by banning the testing of DA ASAT systems using kinetic energy to destroy satellites (Beard, 2017). In the last two decades, while the US, Russia, China and India performed disruptive ASAT tests, 155 states committed not to pursue ASAT testing by overwhelmingly adopting RES 77/41 (United Nations, 2022). At the same time, in 2022 many space-faring nations, including the US, Japan and several EU states pledged to not undertake destructive DA-ASAT tests. The Open-Ended Working Group (OEWG) on reducing space threats established in 2021 is another important development toward a DA ASAT test ban. In fact, one of the Committees tasks is to make recommendations on possible norms, rules and principles of responsible behaviors relating to threats by States to space systems, including, how they would contribute to the negotiation of legally binding instruments, including on the prevention of an arms race in outer space (United Nations, 2021). In parallel, an *Ad Hoc* governmental group of experts (GGE) was established for the first time by United Nations (2018). Convening once a year, and operating by consensus, the GGE was established to support the CD by discussing further practical measures for the prevention of arms race in space providing a yearly report on the main areas where work is needed and considerations identified by the States parties. While arguably the majority of States agree on the detrimental effects of DA ASAT tests, efforts to further regulate space military activities should not be limited to such category only. Just as the decoupling of the SALT and ABM treaty allowed the US and Soviet Union greater flexibility in negotiating specific provisions for offensive and defensive arms respectively, a similar approach focusing on other specific space-based and ground-based counterspace systems should not be excluded. In both cases, the new space domain awareness concept afforded by the expanded scope, technical capabilities and networked architecture of satellites, by also leveraging the use of commercial satellites, is more than sufficient to continue acting as strategic early warning system, as NTM tool to verify treaty compliance, and, in addition, as orbital objects tracker.

Another lesson that can be learned from Cold War strategic arms negotiations is the importance of continuous multilateral and bilateral dialogue through technical, political and emergency channels. While some technical committees were short-lived, like the 1958 Conference of Experts, or eventually lost their purpose others like the SCC, others such as the UN sponsored PAROS, COPUOS, and the more recent OEWG, provide a continuous forum for discussion over the pressing space challenges, while also providing for the development of common, albeit not always clear-cut, understanding and guidelines for space-related activities. Bilateral channels of communication, similar to the Cold War Hot Lines and Nuclear Risk Reduction Centers, can be adapted to the space environment to both ease tensions and reduce risk of misunderstanding over ambiguous space activities, as well as acting as platform for sharing information on space traffic and space debris, and for providing mutual rescue assistance based on the principles outlined in the Rescue Agreement (Armagno et al., 2025). At multilateral level, drawing lessons from the Nuclear Risk Reduction Centers, a possible channel could be realized through the creation of an international space information exchange center under the UNOOSA framework, whose purpose is the continuous monitoring of space activities, including ASAT tests, debris and space traffic, and the registration of activities in an open database. While the adoption of a treaty with clear obligations is ultimately the best way to ensure compliance and limit dangerous arms escalation, in the absence of progress over neither a comprehensive ban nor a limited one, soft law approaches, and specialized initiatives such as the Artemis Accords or ESA Zero Debris Approach, currently remain the only viable options to, at the very least, have a continuous discussion over space security, space sustainability and arms control; all fragmented or repeated under different fora, each tasked with tackling specific topics.

When it comes to arms in space, as it currently stands, PAROS is the committee specifically designated to discussing the prevention of arms in space. Though works have lost traction, with long-standing disagreements over the perceived threat of arms race in space, the best approach to address them, as well as well as general States' reluctance to prohibit military uses of outer space (Meyer, 2011), discussions have nonetheless continued over the years through the *Ad Hoc* GGE. Over the years, the GGE has fostered PAROS discussions producing yearly reports on the main challenges and possible mitigating elements, including the prohibition of DA-ASAT testing as part of a possible "element on obligating" to limit or eliminating acts that damage or destroy satellites. The adoption by consensus of the 2024 GGE report (GGE, 2024) for the first time since its inception in 2018, is a small but important step in recognizing that space security and sustainability can only be attained through the establishment of mutually binding, clear, and targeted provisions preventing certain space military activities. Such rules, need not to be contained in an all-encompassing treaty from the start. Rather, as it was the case during the Cold War, specific limitations on the way that specific ASAT are employed, such as DA-ASAT test, as well as their verifiability and monitoring through NTM (satellites in particular) offer a simple and more practical approach, which can eventually spring into additional, general or specific, forms of space weapons control treaties. At the same time, the recent announcement by U.S. President Donald Trump regarding the development of a new space-based missile defense architecture (referred to as "Golden Dome") illustrates a renewed political and technological effort to weaponize space as a means to increase strategic deterrence. While presented as a defensive shield, pursuing such system carries profound strategic implications. As it was the case with the destabilizing concerns raised by the Soviet Union following the proposed deployment of the Strategic Defense Initiative, the implementation of highly advanced, space-based interceptors risks decreasing the credibility of a State's second-strike capabilities. This, in turn, may incentivise adversaries to invest in additional offensive capabilities to overwhelm defenses, through for example MIRVs, or even contemplate first-strike options. The strategic asymmetry introduced by these unbalanced technological breakthroughs could exacerbate the very instability they are intended to mitigate.

# 6 Conclusions

This study attempted to demonstrate how Cold War strategic and technical talks could offer important lessons for mitigating today space weaponization. Historical precedents, particularly satellite reconnaissance enabling arms control verification and providing intelligence over true adversarial capabilities, provide a template for modern measures. However, contemporary challenges demand adaptations: unlike the superpower duopoly, today's congested orbital environment features state and private actors, dual-use technologies, and ambiguous counter-space tactics that complicate trust-building. As space becomes a pivotal domain for both civilian and military activities, the escalation in counterspace capabilities and lack of regulatory mechanisms pose substantial risks to strategic stability. Drawing on Cold War experiences, the paper highlighted that a soft law approach through continuous technical and political dialogue and exchange, direct communication channels, and technical verification frameworks adapted to the space domain can play a role in mitigating misunderstandings and deterring conflict in space. While soft law alone can be fertile ground for establishing a common language and understanding of space-related challenges, it remains *per se* insufficient to limit the weaponization of space. As it was the case with Cold War arms treaties, clear, verifiable and binding provisions are required to effectively limit, or even ban, certain types of weapons, particularly the most disruptive one such as DA-ASAT. However, meaningful progress will depend on political will and shared threat perception. While "astropolitics" will continue to drive States actions to increase their strategic advantage (most notable the US and China), just like in the past, realist, and multilateral considerations will likely continue to influence one another. As with the past, technical cooperation, mutual transparency, and a common sense of threat posed by a particular technology or behavior can lay the groundwork for a more secure and sustainable future in outer space.

# Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

# Author contributions

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