ART — Analysis and Research Team

RESEARCH PAPER

Space: the new battleground of modern warfare

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Increased militarisation in orbit

Once regarded as a distant frontier, **space** is rapidly emerging as a new battleground of modern warfare. Recent developments – from the use of commercial space technology in active conflicts[1] to the rising importance of cyber attacks on satellites and their infrastructure[2] – underscore just how **vital and vulnerable** space has become **in the context of military operations**. The rivalry between the United States and the Soviet Union in the 1950s and 60s marked the advent of space as a potential theatre for warfare. After the integration of air with land and sea combat, within just a few decades space has emerged as a new arena, with the EU[3] and NATO[4] formally recognising it as an operational domain.

Since the Cold War, the landscape of space has evolved into a more complex and contested domain. With **over 90 countries now engaged in space programmes**[5], it serves as a crucial enabler for both military and civilian infrastructure, with the line between the two becoming increasingly blurred. The rise of private actors has further complicated this reality. The lower cost of satellites and launch vehicles[6] has shifted space activities away from state dominance toward **a more commercialised sector**, creating new dependencies on private actors. Meanwhile, **emerging space powers**, including those with limited resources and lower-tech capabilities, **are introducing new threats**, further raising the stakes.

While fewer than 1,000 active satellites orbited Earth in 2010, that number has now surpassed 9,000, with an accelerating trajectory. Some reports project that **over 60,000 satellites** could be in operation **by 2030**[7]. As space becomes **more congested and competitive**, its significance in modern conflicts will continue to grow. The Russian war of aggression against Ukraine exemplifies this shift, with some observers describing it as the first commercial space war[8], marked by critical satellite-based support provided by private companies. In parallel, actions such as Russia's 2021 destruction of one of its own satellites[9] – a show of force that echoed a similar move by China in 2007[10] – highlight the **increasing militarisation of space**.

This paper explores these developments by focusing on the **strategic dimensions of space**. It analyses how the unique nature of space and the critical importance of its assets create **vulnerabilities to hostile actions**. As reliance on space systems for critical infrastructures on Earth grows, such vulnerabilities pose significant risks to both military and civilian infrastructure – particularly in technology-dependent countries – demanding careful attention and reassessment.

The first part of the paper addresses space as a **critical enabler** in modern defence, providing a brief overview of current military capabilities in space. The second part explores space as a **potential theatre of war**, underlining how offensive operations are easier to deploy than defensive measures, posing significant risks. The conclusion highlights the importance of international cooperation to prevent an arms race in space, while acknowledging the obstacles to achieving this goal. Therefore, a **comprehensive strategy** is essential to **ensure preparedness** for potential hostile actions or even conflicts that may extend into space.

Space as an enabler

Space plays a vital role in contemporary defence, **encompassing various components** that perform critical functions across a wide range of military contexts[11]. From enabling secure communication networks to facilitating real-time surveillance and precise navigation, these elements are critical for **enhancing operational effectiveness** and strategic decision-making in modern warfare.

Satellites

Satellites are positioned in different orbital zones: low Earth orbit (**LEO**), medium Earth orbit (**MEO**), and geostationary orbit (**GEO**).

LEO satellites, which are often used for Earth observation and communication, have seen a surge in deployment due to initiatives by private companies. This has led to the formation of large constellations aimed at providing global coverage, but it has also increased orbital congestion.

MEO and **GEO** satellites serve various functions, including navigation (e.g. Galileo) and weather monitoring

Earth-based systems

are crucial for sending, receiving, processing and analysing data transmitted by satellites. These include ground stations equipped with receivers to capture satellite signals, as well as data centres where information is processed. Earth systems facilitate the transformation of raw satellite data into actionable intelligence.

Communication links

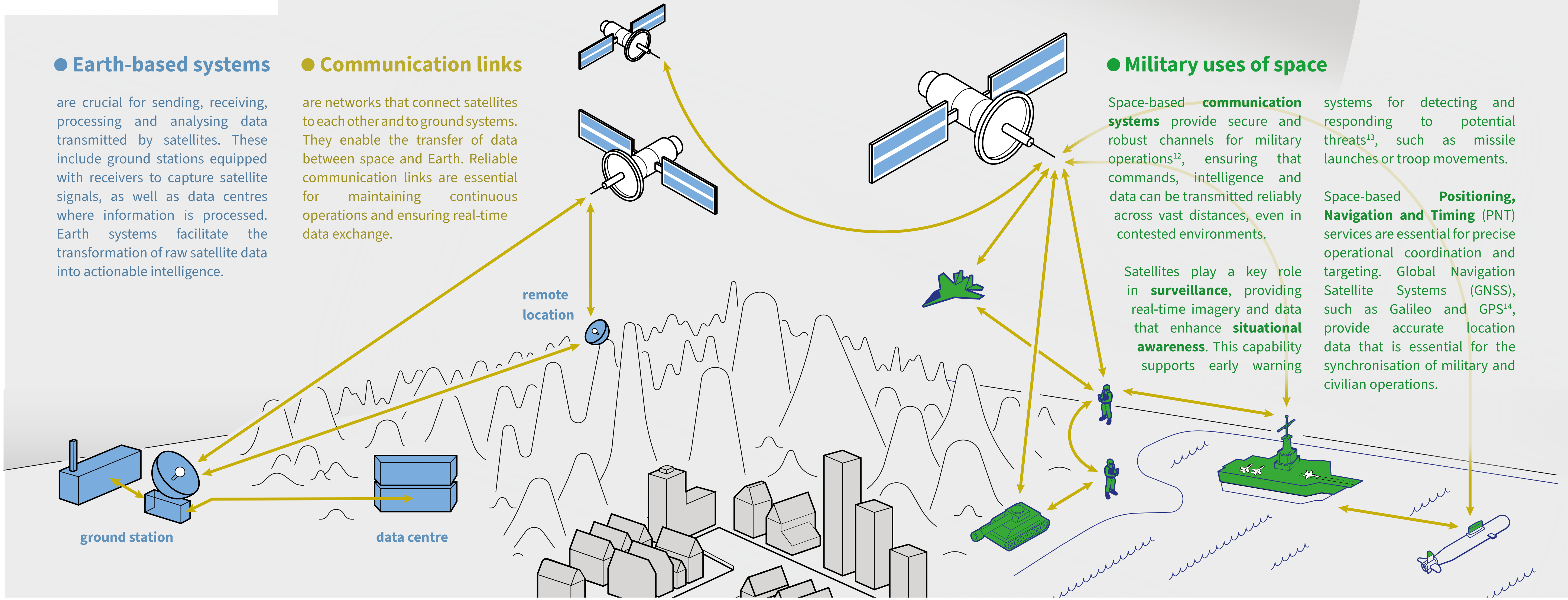
are networks that connect satellites to each other and to ground systems. They enable the transfer of data between space and Earth. Reliable communication links are essential for maintaining continuous operations and ensuring real-time data exchange.

Military uses of space

Space-based **communication systems** provide secure and robust channels for military operations[12], ensuring that commands, intelligence and data can be transmitted reliably across vast distances, even in contested environments.

Satellites play a key role in **surveillance**, providing real-time imagery and data that enhance **situational awareness**. This capability supports early warning systems for detecting and responding to potential threats[13], such as missile launches or troop movements.

Space-based **Positioning, Navigation and Timing** (PNT) services are essential for precise operational coordination and targeting. Global Navigation Satellite Systems (GNSS), such as Galileo and GPS[14], provide accurate location data that is essential for the synchronisation of military and civilian operations.



Dual-use

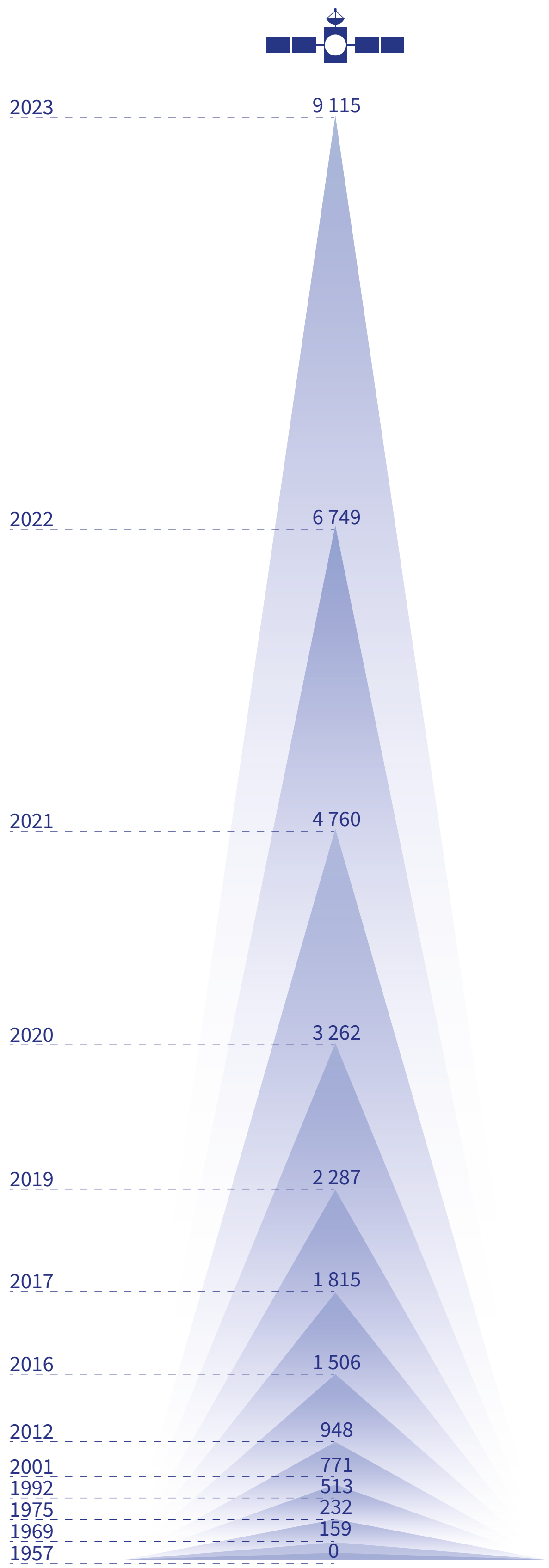
Space plays a crucial role in supporting a wide range of essential capabilities on Earth, with satellites serving **critical functions in both military and civilian domains** due to their dual-use nature. Given their involvement in everything from synchronising electricity grids to global communications or navigation systems, a day without space capabilities is nearly inconceivable for modern societies.

The **line** between military and civilian uses **is often blurred**, resulting in significant vulnerabilities, particularly for technologically advanced countries, in which dependence on space infrastructure is most pronounced.

Disruptions or attacks on space assets can have far-reaching consequences, threatening not only military operations but also civilian life and economic stability. Even satellites intended solely for civilian purposes may be at risk, with severe implications also for Earth-based infrastructure. In this context, the Directive on the resilience of critical entities[15] and the Directive on measures for a high common level of cybersecurity[16] establish resilience obligations for civilian ground-based space infrastructure owned by Member States or private companies within the EU. These Directives do not, however, extend to infrastructure in space itself, such as satellites.

An example highlighting the risks to space systems is Russia's explicit identification of Western commercial satellites used in military operations as **potential targets** during conflicts[17]. This underscores the severe vulnerabilities of these vital technologies and emphasises the need to safeguard them in an increasingly contested space environment.

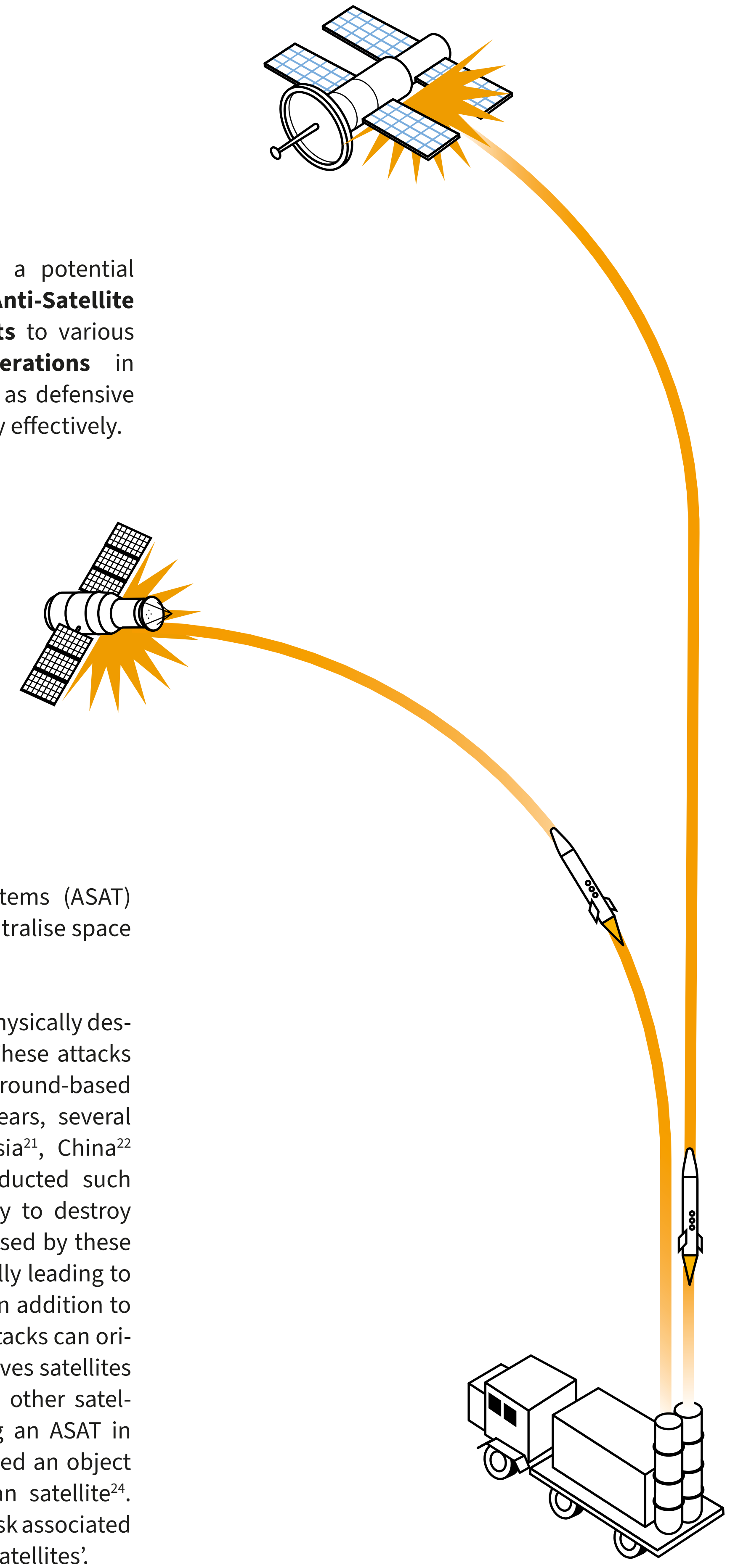
Number of active satellites from 1957 to 2023



Source: Statista[18]

Space as a theater

Space is increasingly regarded as a potential battlefield[19], with a range of **Anti-Satellite Systems posing significant threats** to various assets. Moreover, **offensive operations** in space often have a **strategic edge**, as defensive measures are more difficult to deploy effectively.

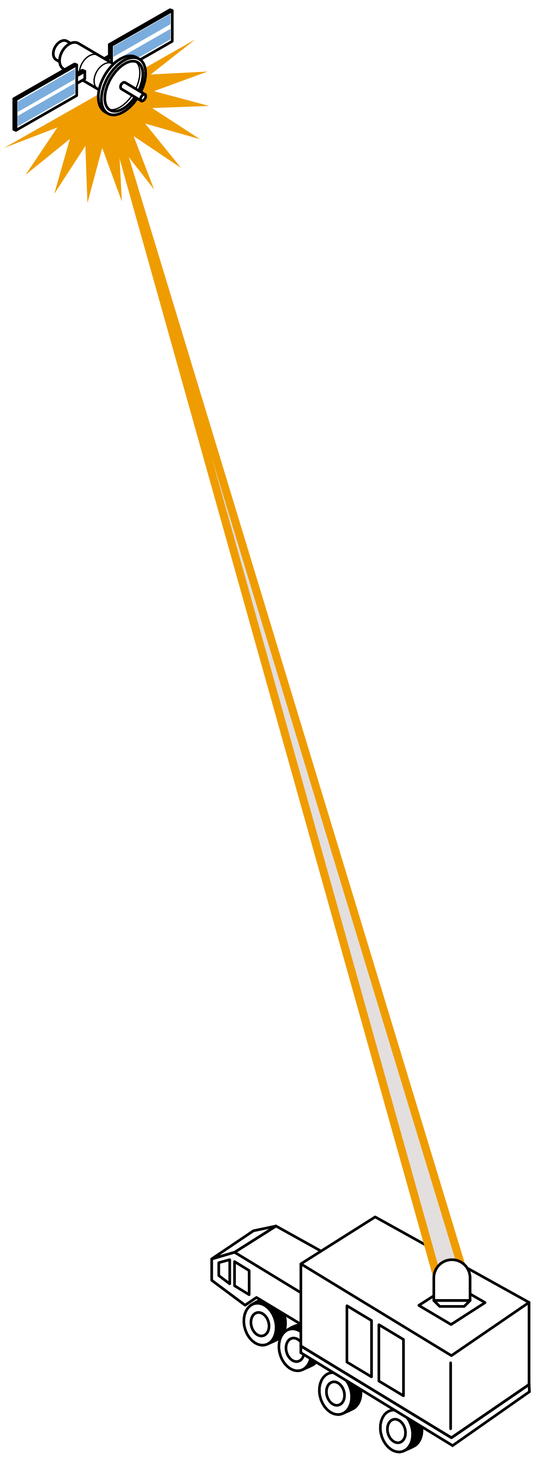


Anti-Satellite Systems

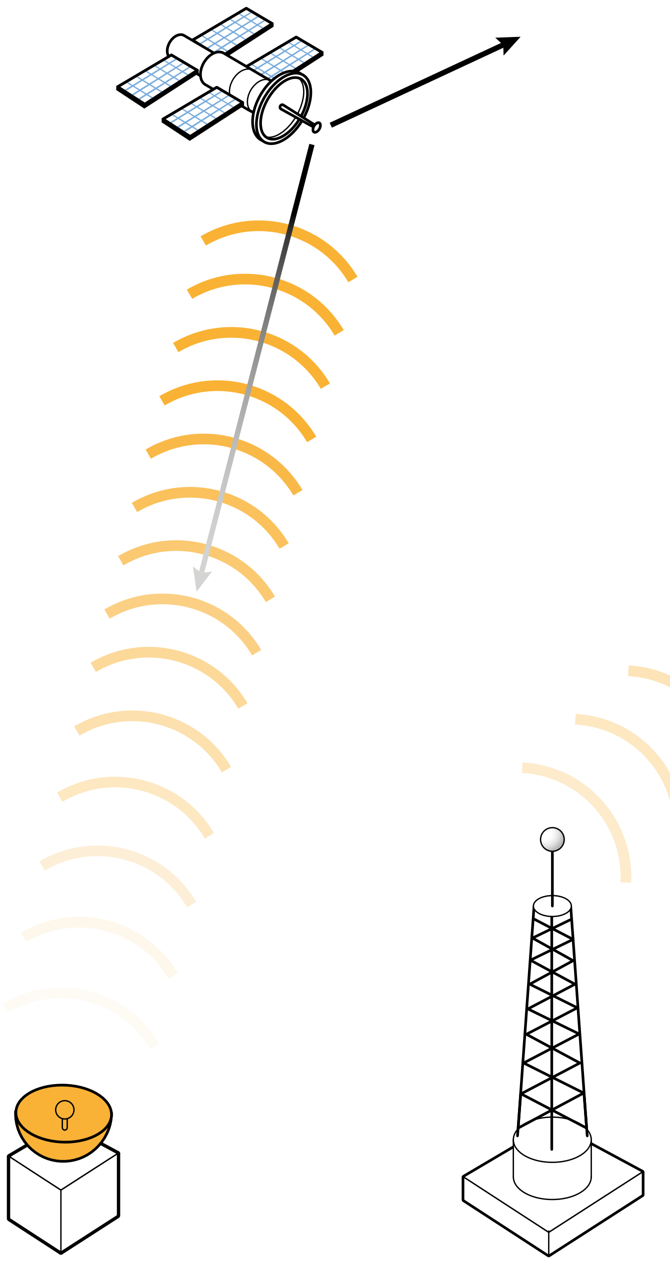
Various types of Anti-Satellite Systems (ASAT) have emerged, each designed to neutralise space assets in different ways.

- **Kinetic attacks** are designed to physically destroy space assets through impact. These attacks can, for instance, originate from ground-based missile systems. In the last few years, several countries, including the US[20], Russia[21], China[22] and India[23], have successfully conducted such tests, demonstrating their capability to destroy satellites. The creation of debris caused by these actions adds to the danger, potentially leading to cascading impacts on other assets. In addition to ground-launched missiles, kinetic attacks can originate directly from space. This involves satellites that can manoeuvre to collide with other satellites. Russia was accused of testing an ASAT in 2020 when a military satellite released an object that moved toward another Russian satellite[24]. This development underscored the risk associated with the creation of so-called 'killer satellites'.

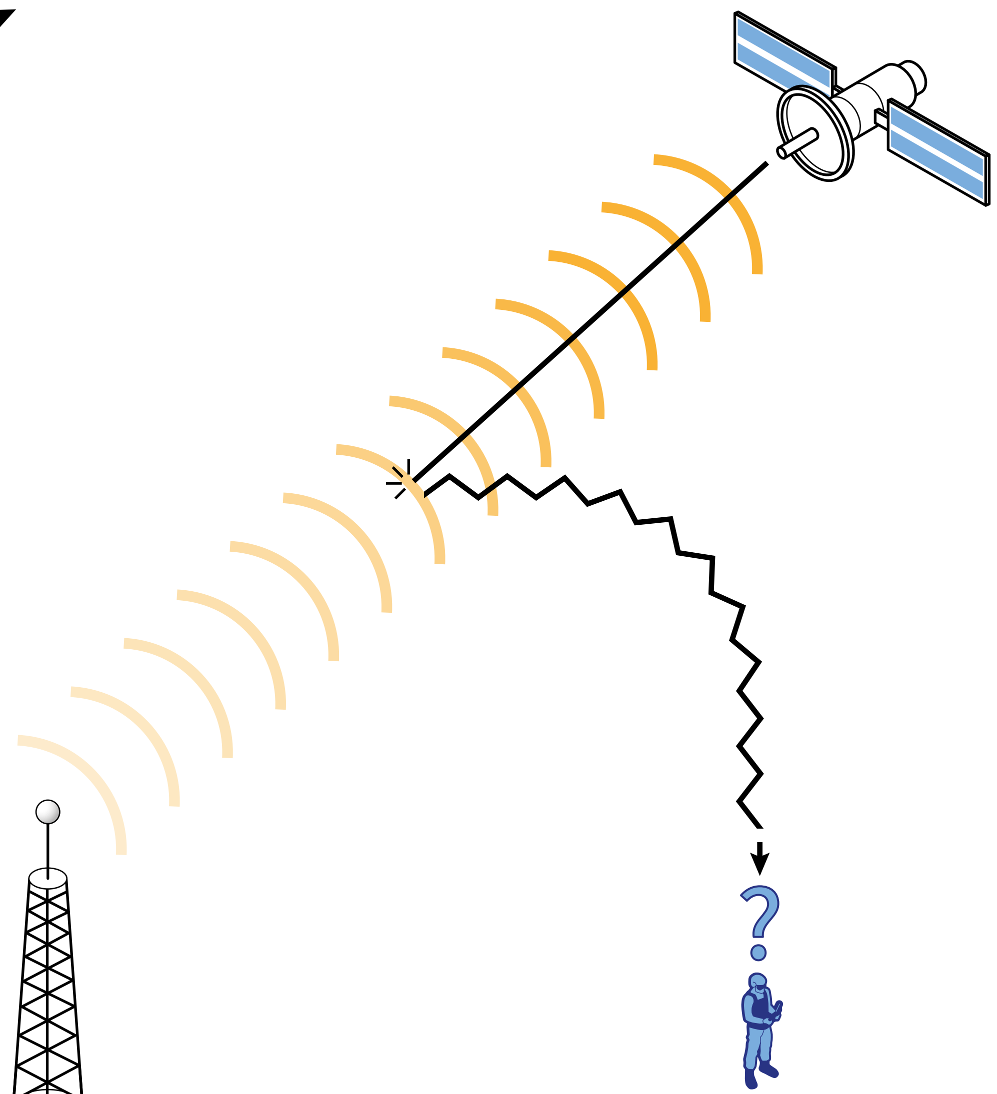
- **Laser weapons** are a form of ASAT technology that use directed energy to damage satellites by disrupting their optical sensors, or in some cases degrading physical components. These systems can interfere with satellite electronics, impairing functionality without generating debris, which makes them a potentially less destructive alternative to kinetic attacks. Laser systems may be ground-based, airborne, or even space-based, with countries such as the US[25], Russia[26] and China[27] having tested these capabilities over recent decades.



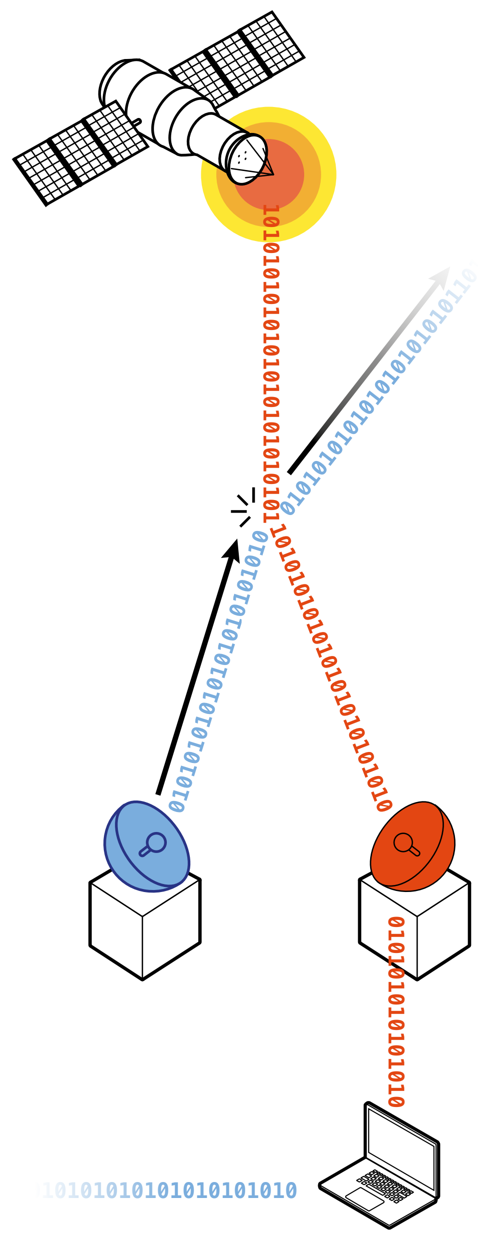
- **Jamming** is a technique that disrupts satellite communications by overwhelming the satellite's receivers with interference signals. This can prevent satellites from transmitting or receiving data. Unlike kinetic attacks, jamming is non-destructive, meaning it does not physically harm the satellite. It can, however, lead to operational disruptions, especially in military contexts, where continuous connectivity is essential. Examples of jamming activities include recent Russian actions in the Baltic Sea region affecting thousands of flight routes[28], Chinese activities during military drills in the South China Sea in 2018[29], North Korea's interference with South Korea's satellites in 2023 and 2024[30], GPS jamming tests in the US in 2019[31], and Iranian interference with international broadcasts in 2010[32].



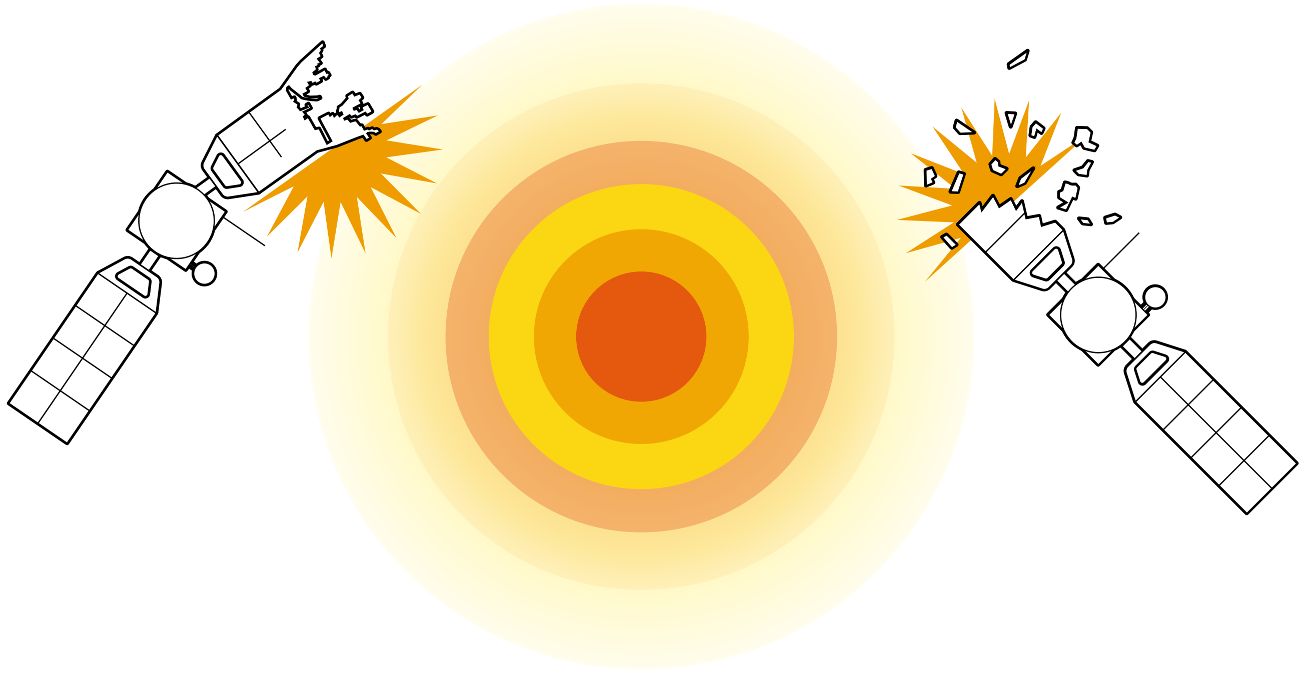
- **Spoofing** involves sending false signals to satellites to deceive their systems and mislead users. For instance, a spoofing attack on Global Navigation Satellite Systems could lead to inaccurate positioning, navigation and timing data, posing risks in military operations and critical infrastructure. Unlike jamming, which blocks or disrupts signals, spoofing manipulates them, allowing attackers to control the perceived information. Countries have increasingly recognised the potential of spoofing as a threat, with incidents reported in various contexts. Examples include an incident in the Black Sea in 2017, in which several ships reported GPS anomalies[33], as well as multiple cases linked to Russia[34], Iran's capture of a US drone in 2011[35], and Israeli spoofing measures used against threats from Iran in 2024[36].



- **Cyber attacks** can target the software and data infrastructure of satellites, ground stations and communication networks. Such attacks can compromise data integrity, gain unauthorised access to information, or even hijack control of a satellite. Cyber threats are more difficult to detect and attribute, complicating response measures. Incidents have increased in recent years, with various nations reportedly deploying cyber capabilities[37]. Examples include cyber attacks attributed to Russia that targeted Ukrainian satellite-reliant infrastructure in 2017 and 2022[38], cyber intrusions from Chinese sources breaching satellite networks in the US and Southeast Asia in 2018[39], and a 2023 attack that disabled a system used by the Russian military forces[40].



- **Nuclear attacks** are the most destructive form of ASAT, with a single blast in space capable of disabling numerous satellites. When detonated in orbit, a nuclear device generates electromagnetic pulses that can damage satellite electronics, impacting multiple systems over a broad area. Additionally, such explosions create persistent radiation belts that endanger satellites passing through the affected region[41]. Although the indiscriminate consequences of nuclear ASATs may limit their use, they still represent a threat from nuclear-capable states with less reliance on space assets, such as North Korea, which could be less vulnerable to the collateral damage caused by such attacks[42]. Historic tests such as the US Starfish Prime detonation above the Pacific in 1962 demonstrated the widespread impact of nuclear explosions in space[43].



The offensive edge in space

The wide range of ASAT capabilities shows the **multitude of risks** that space assets face. The vastness of space, combined with the unique technological challenges of the environment, creates an **asymmetrical landscape** in which it is often easier and more cost-effective to deploy offensive capabilities than to implement defensive measures[44]. These risks extend beyond satellites and their associated systems, as space stations could also become potential targets in the future. This reality poses considerable challenges, even for established space powers. Several cross-cutting factors contribute to the advantage held by attackers.

- **Detection**: Detecting and monitoring hostile actions in space is becoming increasingly complex as threats become more varied and sophisticated. Rapidly approaching objects can evade monitoring systems, complicating early warning efforts and raising the risk of surprise attacks. For instance, smaller objects or 'killer satellites', which could potentially close in on targets undetected, can be difficult to track. Non-kinetic systems add a further layer of difficulty, as they lack clear and immediately detectable physical signals. Such disruptions often go unnoticed until a satellite's data or trajectory is visibly impacted. In combination, these challenges make real-time monitoring both technically demanding and resource-intensive.

- **Attribution**: Determining accountability for attacks in space is challenging. The growing capabilities of smaller nations and private companies in developing space technologies further complicate the task of pinpointing perpetrators. While the origin of ground-based missiles can generally be traced, other threats – such as cyber attacks, jamming and spoofing – are more elusive. These attacks can be conducted from various locations and often at minimal cost, making it difficult to determine their source promptly and with certainty. This ambiguity restricts the ability of victims to respond, as they may struggle to identify appropriate targets for retaliation, and suspected perpetrators can easily deny involvement.

- **Impact**: The repercussions of an attack extend far beyond the immediate loss of one or more satellites. A successful ASAT operation could sever communication lines, disable navigation systems and halt data transfers, resulting in cascading failures across essential sectors. For instance, the loss of a single satellite could potentially disrupt Global Navigation Satellite Systems, impacting military operations and civilian activities. Damage to satellite networks could also affect internet services, financial transactions, and destabilise infrastructure that relies on precise positioning, such as air, sea and land transportation systems. Beyond the immediate effects, it could take years to repair or replace damaged assets, leaving satellite-dependent operations vulnerable to prolonged disruption.

- **Reaction**: Options for rapid intervention in space remain limited, leaving defenders highly vulnerable, with few avenues for immediate response once an attack is underway. Satellites and other space assets have limited manoeuvring capabilities and generally lack effective in-space defence systems to neutralise threats. Non-kinetic attacks present different but equally constraining challenges, as they are difficult to detect in real time, and often require complex technical countermeasures that cannot be implemented instantaneously. Earth-based responses are constrained by distance and signal latency, which further hampers prompt reaction. As a result, defenders are often left in a reactive position, forced to respond to the aftermath of an offensive action long after damage has occurred.

While these factors are relevant to deliberate attacks, space assets are also vulnerable to threats that do not stem directly from hostile intent, but pose similar challenges in terms of detection, impact and reaction. One significant threat is **space debris**, which consists of defunct satellites, rocket stages, and fragments from past collisions. For instance, in 2009 an inactive Russian satellite collided with a US commercial communications satellite[45]. The growing accumulation of debris increases the risk of collision, potentially leading to a destructive chain reaction known as the Kessler Syndrome[46], which could make certain orbital paths unusable. Additionally, **solar storms** pose another risk, potentially damaging satellites by impacting their electronic components. This can lead to malfunctions, data corruption, and permanent damage[47].

Looking further ahead: space as a strategic resource

The potential of exploiting space resources[48] is already shaping the actions of space powers such as the US, China and Russia. While the economic returns remain speculative, objectives such as mining asteroids or extracting water and oxygen are already key goals of major space programs.

Space mining: is it worth it? Many questions remain regarding the costs and benefits of space resource exploitation[49]. It is currently extremely costly to bring material mined from asteroids back to Earth. For example, NASA's OSIRIS-REx mission[50], which was designed to collect samples from a near-Earth asteroid, took seven years and cost over $1 billion[51]. However, the potential rewards are significant: some estimates suggest that the ten most promising near-Earth asteroids[52] could yield profits of up to $1.5 trillion[53]. In addition to Earth-bound resources, there is growing interest in using 'in situ' resources to support a sustained human presence in space, by providing essential materials such as fuel, habitation elements and life-support systems, which could be crucial for the future of space exploration.

Early signs of space-based resource competition? With technological advances, space mining could gain momentum for both military and economic applications. Space could become a strategic frontier for controlling valuable resources, sparking competition and even territorial claims among nations and private actors. Space powers and private companies may seek to secure future access to these assets by establishing control over orbital areas or strategic locations in space. Access to asteroids for metals or to lunar and Martian deposits for water and fuel could provide significant technological and economic advantages, marking these resources as assets of high strategic value. The US Artemis Program and the Sino-Russian International Lunar Research Station[54] already indicate potential tensions, as both initiatives target similar lunar regions with limited locations suitable for bases. Although the ESA participates in Artemis, the EU lacks an independent lunar program, which may affect its future presence in this arena.

Beyond resource exploitation, space is increasingly recognised as a critical domain for technological innovation. For instance, NATO's €1 billion Innovation Fund has supported ventures focused on manufacturing advanced materials, such as semiconductors, in orbit[55]. These technologies hold significant military potential, including applications that enhance radar capabilities, highlighting the strategic importance of maintaining an edge in space technologies.

Future scenarios. Major space powers are actively preparing for possible competition over space resources, potentially heightening geopolitical tensions. The French Ministry of Defence's Red Team has outlined a scenario of a space rush[56] between 2035 and 2075, where reduced costs make space mining viable, with both public and private players pursuing resources in space. In this vision, space could become a new Wild West, with conflicts escalating from sabotage to outright confrontation. Such scenarios underscore the future governance challenges, as policies regulating space mining remain limited, despite the high stakes involved[57].

Ensuring stability in space through cooperation and preparedness

Space has become indispensable to both military and civilian infrastructure, making its secure and **sustainable use essential for global stability**. Similar to other global commons, such as the oceans and the atmosphere, the preservation of space requires collective responsibility, in order to prevent overuse and avoid conflicts. Without careful management, space risks becoming a 'tragedy of the commons'[58], in which unrestricted militarisation and debris accumulation could compromise its future accessibility. Addressing these challenges demands a **dual strategy**: on the one hand, enhancing international cooperation to prevent escalation, and on the other, developing robust preparedness measures to counter evolving threats effectively. This is essential to protect both space systems and the associated critical Earth-based infrastructure.

Strengthening international cooperation

The increasing number of countries with space capabilities underscores the need for a **multilateral approach to promote the peaceful use of space**. Existing frameworks, such as the Outer Space Treaty of 1967, were designed to prevent the placement of nuclear and other weapons of mass destruction in space[59]. However, they fall short of adequately addressing contemporary security challenges, including the rise of anti-satellite systems and other emerging threats[60].

Efforts are underway to **modernise the international legal framework**, for instance within the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). These initiatives aim to establish norms for the sustainable use of space. Progress has, however, been limited, and no significant agreements have been reached to date[61]. **Divergent approaches** characterise the discussions, with the United States and the European Union advocating for a non-legally binding instrument that prioritises transparency and confidence-building measures to reduce the risk of conflicts in space[62]. In contrast, Russia and China support comprehensive treaties aimed at banning the placement of weapons in outer space[63].

These efforts to modernise space governance are complicated by differing national priorities and the current geopolitical landscape. The widespread atmosphere of **mistrust and global fragmentation** not only obstructs constructive dialogue, but also diminishes the likelihood of achieving a multilateral agreement that all parties would honour.

Increasing preparedness for space threats

While multilateral cooperation remains essential, current geopolitical tensions highlight the urgency of **increasing preparedness and readiness** to protect space assets and the associated critical Earth systems. Although the prevailing view suggests that attackers in space hold a strategic advantage, a multi-faceted approach could shift the balance towards defensive capabilities and effectively deter potential aggressors[64], thereby maintaining peace in outer space.

Monitoring: The strengthening of monitoring capabilities and the establishment of real-time alert systems are central to space security preparedness[65]. As part of this effort, the EU and Member States are developing Space Domain Awareness tools[66] that provide accurate information on space objects, with plans to further enhance these capabilities[67]. These tools are crucial for detecting, characterising and attributing potential threats, serving both military and civilian purposes. Additionally, the High Representative will prepare an annual space threat landscape analysis that includes updates on counterspace capabilities[68]. In the United States, the Space Surveillance Network, managed by the US Space Force, continuously monitors and catalogues all manmade objects orbiting Earth[69], providing essential capabilities for early threat detection and mitigation. Beyond developing independent monitoring systems, it is vital to enhance information-sharing and cooperation among partners in order to bolster global preparedness against space threats.

Reinforcement: In order to reduce vulnerabilities and ensure continuity of operations, it is essential to build resilient space infrastructure[70]. The reinforcing of satellites and space-based services so that they can withstand physical and cyber threats is central to this goal. For instance, one step in this direction is the EU's IRIS² programme, designed to enhance satellite communications by providing more resilient and secured connectivity[71]. In 2025 the European Commission also plans to propose an EU space law focused on the security and resilience of EU systems[72]. Reinforcement efforts could also focus on prioritising critical satellites[73], such as those used for global positioning and Earth observation, for instance Galileo and Copernicus, ensuring they are equipped with the most advanced defensive measures. Reinforcing resilience involves not only hardening satellite systems, but also securing ground stations and the communication links that connect them.

Redundancy: Developing redundant systems is crucial for absorbing potential attacks or disruptions, thereby ensuring that critical satellite functions continue even if certain assets are compromised[74]. By diversifying satellite constellations and leveraging lower-cost, small-satellite technologies, the risk of any single point of failure can be reduced. This approach is increasingly feasible due to technological advances that have lowered production and launch costs. For critical infrastructure, however, it is crucial to maintain independent systems and minimise reliance on private companies. In the US, the DARPA Blackjack programme enhances redundancy by creating a network of military satellites in low Earth orbit[75]. In the EU, the GovSatCom programme focuses on providing reliable, secure and cost-effective governmental satellite communication services[76]. Redundant systems act as a significant deterrent for aggressors, by demonstrating that space-based operations can continue seamlessly even if individual satellites are targeted.

Deterrence: Strengthening deterrence is essential for countering threats and discouraging aggressive actions. The EU is developing a dedicated toolbox for joint responses to hostile behaviours, ensuring readiness to act decisively if critical space assets are threatened[77]. Regular joint exercises play a key role in improving rapid response capabilities and cooperation with allies, ensuring that any aggressive activity can be swiftly neutralised[78]. Deterrence encompasses both defensive measures and, when necessary, retaliatory options that signal the serious consequences of aggression[79]. Importantly, attacks in space could amount to armed aggression against one or several Member States on their territory, and thus constitute grounds to invoke Article 42(7) of the Treaty on European Union[80]. Collectively, these elements help create a credible deterrent, preserving peace and safeguarding the EU's interests in outer space.

References

1 G. Massie, 'Elon Musk helps Ukraine with SpaceX's Starlink satellites', *The Independent*, 28 February 2022.

2 M. Miller, 'Officials plan for new age of cyber threats to satellites', *Politico*, 25 March 2024. See also W. Peeters, 'Cyberattacks on Satellites - An Underestimated Political Threat', *LSE*; and J. Morin, 'Is Space Becoming the Next Front for War—and Traffic Jams?', *Yale Insights*, 13 May 2024.

3 Council Conclusions on the EU Space Strategy for Security and Defence, *Council of the EU*, par. 5, p. 6.

4 NATO's approach to space, *NATO*.

5 B. R. Goodman, 'Offensive dominance in space', *Æther: A Journal of Strategic Airpower & Spacepower*, Spring 2024, p. 74, based on CIA World Factbook. See also J. Seibert, 'Countries with Space Programs: An Overview', *Space Impulse*, 27 November 2023.

6 N. Adilov et al., 'An Analysis of Launch Cost Reductions for Low Earth Orbit Satellites', *Economics Bulletin*, August 2022.

7 'The future space environment', *Gov.UK*, 16 May 2024.

8 Russia's cyberattacks on space communications immediately prior to its invasion of Ukraine, coupled with Ukraine's use of Starlink to bolster its defence, underscore the essential role of commercial space systems in military operations. Some observers referred to the war in Ukraine as the "first commercial space war", paralleling descriptions of the 1991 Gulf War as the "first space war". See R. Dickey and M. Gleason, 'Space and war in Ukraine – Beyond the satellites', *Æther: a Journal of Strategic Airpower & Spacepower*, April 2024. See also S. Erwin, "On National Security: Drawing Lessons from the First 'Commercial Space War'", *SpaceNews*, 20 May 2022; and J. Beale, "Space, the Unseen Frontier in the War in Ukraine", *BBC*, 5 October 2022.

9 Statement by the High Representative of the Union for Foreign Affairs and Security Policy on behalf of the EU on the Russian anti-satellite test on 15 November 2021, *Council of the EU*.

10 C. Zissis, 'China's Anti-Satellite Test', *The Council of Foreign Relations*, 22 February 2007.

11 R. Dickey and M. Gleason, op. cit., p. 21.

12 'Critical infrastructure resilience at EU-level', *European Commission*, 23 September 2024.

13 'Critical infrastructure resilience at EU-level', *European Commission*, 23 September 2024.

14 'Critical infrastructure resilience at EU-level', *European Commission*, 23 September 2024.

15 'Critical infrastructure resilience at EU-level', *European Commission*, 23 September 2024.

16 'Directive on measures for a high common level of cybersecurity across the Union (NIS2 Directive)', *European Commission*.

17 A. F. Rasmussen, 'Politicians must not ignore security threats in space', *Politico*, 11 March 2024. See also 'Russia warns West: We can target your commercial satellites', *Reuters*, 27 October 2022.

18 'Number of active satellites from 1957 to 2023', *Statista*.

19 European Space Conference: Opening speech by High Representative/Vice-President Josep Borrell, *EEAS*, 24 January 2023, "[…] space has become a key strategic domain. It is affecting not only all aspects of our life, but it is a key resource or a key battlefield for security and defence. […] I do not want to use the word "battlefield" but, yes, space will become a kind of battlefield: at least, a place where competition and confrontation will take place".

20 D. Day, 'Burning Frost, the view from the ground: shooting down a spy satellite in 2008', *The Space Review*, 21 June 2021. See also 'US spy satellite plan 'a cover'', *BBC*, 17 February 2008.

21 'Russian direct-ascent anti-satellite missile test creates significant, long-lasting space debris', *U.S. Space Command Public Affairs Office*, 15 November 2021.

22 C. Zissis, op. cit. See also B. Weeden, op.cit. '2007 Chinese Anti-Satellite Test', *Secure World Foundation*, 23 November 2010.

23 A. Tellis, 'India's ASAT Test: An Incomplete Success', *Carnegie*, 15 April 2019.

24 L. Martinez, 'Pentagon calls out Russia for testing anti-satellite weapon', *ABC*, 24 June 2020.

25 'In Test, Military Hits Satellite Using a Laser', *The New York Times*, 21 October 1997. See also J. Hecht, 'US plans anti-satellite lasers', *New Scientist*, 3 May 2006.
26 D. Malyasov, 'New details emerge on Russia's secret laser weapon system', *Defence Blog*, 3 August 2024.
27 A. Salerno-Garthwaite, 'Is China's Korla laser ASAT site hacking Western satellites?', *Army Technology*, 1 May 2023.
28 E. Grynszpan and C. Pietralunga, 'Russia's GPS jamming intensifies over the Baltic Sea', *Le Monde*, 2 May 2024. See also S. Waterman, 'Russian Jamming Is Wreaking Havoc on GPS in Eastern Europe. But Is It Hybrid Warfare?', *Air & Space Forces Magazine*, 10 July 2024.
29 M. R. Gordon and J. Page, 'China Installed Military Jamming Equipment on Spratly Islands, U.S. Says', *WSJ*, 9 April 2018. See also A. Panda, 'South China Sea: China Deploys Jamming Equipment', *The Diplomat*, 10 April 2018.
30 Kang Hyun-kyung, 'South Korea's spy satellite vulnerable to North's jamming, cyberattacks', *The Korea Times*, 16 December 2023. See also 'North Korea accused of GPS jamming attacks on South Korean ships and aircraft', *The Guardian*, 9 November 2024.
31 D. Namowitz, 'GPS jamming scheduled across US', *AOPA*, 27 February 2019.
32 I. Black, 'BBC joins international protests against Iranian TV interference', *The Guardian*, 14 January 2010.
33 D. Hambling, 'Ships fooled in GPS spoofing attack suggest Russian cyberweapon', *New Scientist*, 10 August 2017. See also M. Jones, 'Spoofing in the Black Sea: What really happened?', *GPS World*, 11 October 2017.
34 'Study maps 'extensive Russian GPS spoofing', *BBC*, 2 April 2019.
35 S. Ragan, 'Reports Say U.S. Drone was Hijacked by Iran Through GPS Spoofing', *Security Week*, 18 December 2011.
36 S. E. Rasmussen and A. Peled, 'Israel Scrambles GPS Signals as Country Girds for Potential Retaliation From Iran', *WSJ*, 4 April 2024.
37 M. Miller, 'Officials plan for new age of cyber threats to satellites', *Politico*, 25 March 2024.
38 W. Peeters, 'Cyberattacks on Satellites - An Underestimated Political Threat', LSE. See also A. Greenberg, 'The Untold Story of NotPetya, the Most Devastating Cyber-attack in History', *Wired*, 22 August 2018.
39 L. Saalman, L. Saveleva Dovgal and Fei Su, 'Mapping cyber-related missile and satellite incidents and confidence- building measures', *SIPRI Insights on Peace and Security*, November 2023, p. 4.
40 'Cyberattack knocks out satellite communications for Russian military', *The Washington Post*, 30 June 2023. See also L. Saalman, op. cit., p. 6.
41 R. Stone, 'U.S. tests ways to sweep space clean of radiation after nuclear attack', *Science*, 26 December 2019.
42 Ibid.
43 A. Parshall, 'What Happens if a Nuke Goes Off in Space?', *Scientific American*, 13 June 2024.
44 M. Krepon and J. Thompson, 'Anti-satellite Weapons, Deterrence and Sino-American Space Relations', *Stimson*, September 2013., p. 30, 85, 90. See also B. R. Goodman, 'Offensive dominance in space', ***Æther: A Journal of Strategic Airpower & Spacepower***, Spring 2024.
45 B. Weeden, '2009 Iridium-Cosmos Collision', *Secure World Foundation*, 10 November 2010.
46 P. Ropert, 'Le syndrome de Kessler : piégés sur Terre', *Radio France*, 22 novembre 2014. See also A. Nötzold, 'Governance and security in outer space', *The European – Security and Defence Union*, 16 July 2024.
47 'Solar storms : a new challenge on the horizon?', *ART – Council of the EU*, November 2023.
48 Resources in Space, *Luxembourg Space Agency*.
49 Jan Cilliers et al., 'Toward the utilisation of resources in space: knowledge gaps, open questions, and priorities', *Npj Microgravity*, 25 March 2023.
50 OSIRIS-Rex, *NASA*.
51 Cost of OSIRIS-Rex, *The Planetary Society*.
52 S. Yarlagadda, 'Economics of the Stars: The Future of Asteroid Mining and the Global Economy', *Harvard International Review*, 8 April 2022.
53 C. Taylor, 'The Asteroid Boom', *Mashable*, 2019. For more information, see *Asterank*, a database of over 600,000 asteroids.
54 See Artemis, NASA, and F. Anqi, 'Putin signs into law joint building of lunar base with China as Beijing expands circle of friends in Moon exploration', *Global Times*, 13 June 2024.
55 M. Meaker, 'NATO's Tech Scouts Are Fortifying Europe for a World With Donald Trump', *Wired*, 14 November 2024.
56 The space rush, *Red Team Defense*.
57 J. Osburg and M. Lee, 'Governance in Space: Mining the Moon and Beyond', *RAND*, 18 November 2022.
58 M. Byers and A. Boley, 'Who Owns Outer Space?', *Cambridge University Press*, April 2023, p. 7.
59 R. P. Rajagopalan, 'The Outer Space Treaty - Overcoming Space Security Governance Challenges', *Council on Foreign Relations*, February 2021.
60 R. Quinland, 'Galactic governance: From the Outer Space Treaty to modern regulations', *The Space Review*, 19 August 2024. See also A. Irish, 'The Legality of a U.S. Space Force', *OpinioJuris*, 13 September 2018; J. Rozpedowski, 'Every War Is a Space War Now', *Geopolitical Monitor*, 12 March 2024; R. Pope, 'Space Weapons and the Increasing Militarisation of Outer Space: Whether the Legal Framework Is Fit-For-Purpose', *Auckland University Law Review*, 2021, p. 281.
61 R. P. Rajagopalan, 'The Quad Commits to Regulating Space', *The Diplomat*, 1 October 2021.
62 'European Union Space Strategy for Security and Defence', *Joint communication to the European Parliament and the Council*, 10 March 2023, p. 14.
63 R. P. Rajagopalan, 'The Quad Commits to Regulating Space', op. cit.
64 B. Townsend, 'Strategic Choice and the Orbital Security Dilemma', *Strategic Studies Quarterly*, Spring 2020. See also E. Ferguson and J. Klein, 'The future of war in space is defensive', *The Space Review*, 19 December 2016; T. X. Hammes, 'The Tactical Defense Becomes Dominant Again', *Joint Force Quarterly*, 14 October 2021.
65 X. Pasco, 'Évolution des stratégies d'utilisation de l'espace à des fins militaires', *IRSEM*, July 2021, p. 87.
66 See 'Space Situational Awareness at a glance' and 'EU Space Surveillance and Tracking', European Commission.
67 'European Union Space Strategy for Security and Defence', op. cit. Also see Council Conclusions on the EU Space Strategy for Security and Defence, *Council of the EU*, par. 21, p. 14.
68 Ibid.
69 T. Sgobba and E. Levin, 'Orbital Operations Safety', *Safety Design for Space Operations*, 2013.
70 X. Pasco, op. cit., p. 88.
71 IRIS²: the new EU Secure Satellite Constellation, *European Commission.*
72 EU Space Law – new rules for safe, resilient and sustainable space activities, European Commission. See also D. Stefoudi, 'EU Space Law – Three reasons against, three reasons in favour', *EJIL*, 29 April 2024.
73 S. Fetter, 'Protecting our military space systems', *The U.S. in Space: Issues and Policy Choices for a New Era*, 1988, p. 1.
74 B. Townsend, op. cit., p. 78. See also T. X. Hammes, op. cit.; M. Byers and A. Boley, op. cit., p. 368.
75 S. Erwin, 'DARPA to begin new effort to build military constellations in low Earth orbit', *SpaceNews*, 31 May 2018.
76 GOVSATCOM - Satellite Communications, *European Commission*.
77 Council Conclusions on the EU Space Strategy for Security and Defence, *Council of the EU*, p. 13.
78 'European Union Space Strategy for Security and Defence', op. cit., p. 9.
79 C. Ellis, T. Ogden and Black, 'China and space: How space technologies boost China's intelligence capabilities as part of hybrid threats', *Hybrid CoE*, 21 October 2024, p. 18. See also B. Tingley, 'Space is now 'most essential' domain for US military, Pentagon says', *Space.com*, 17 January 2024.
80 Council Conclusions on the EU Space Strategy for Security and Defence, *Council of the EU*, p. 16.

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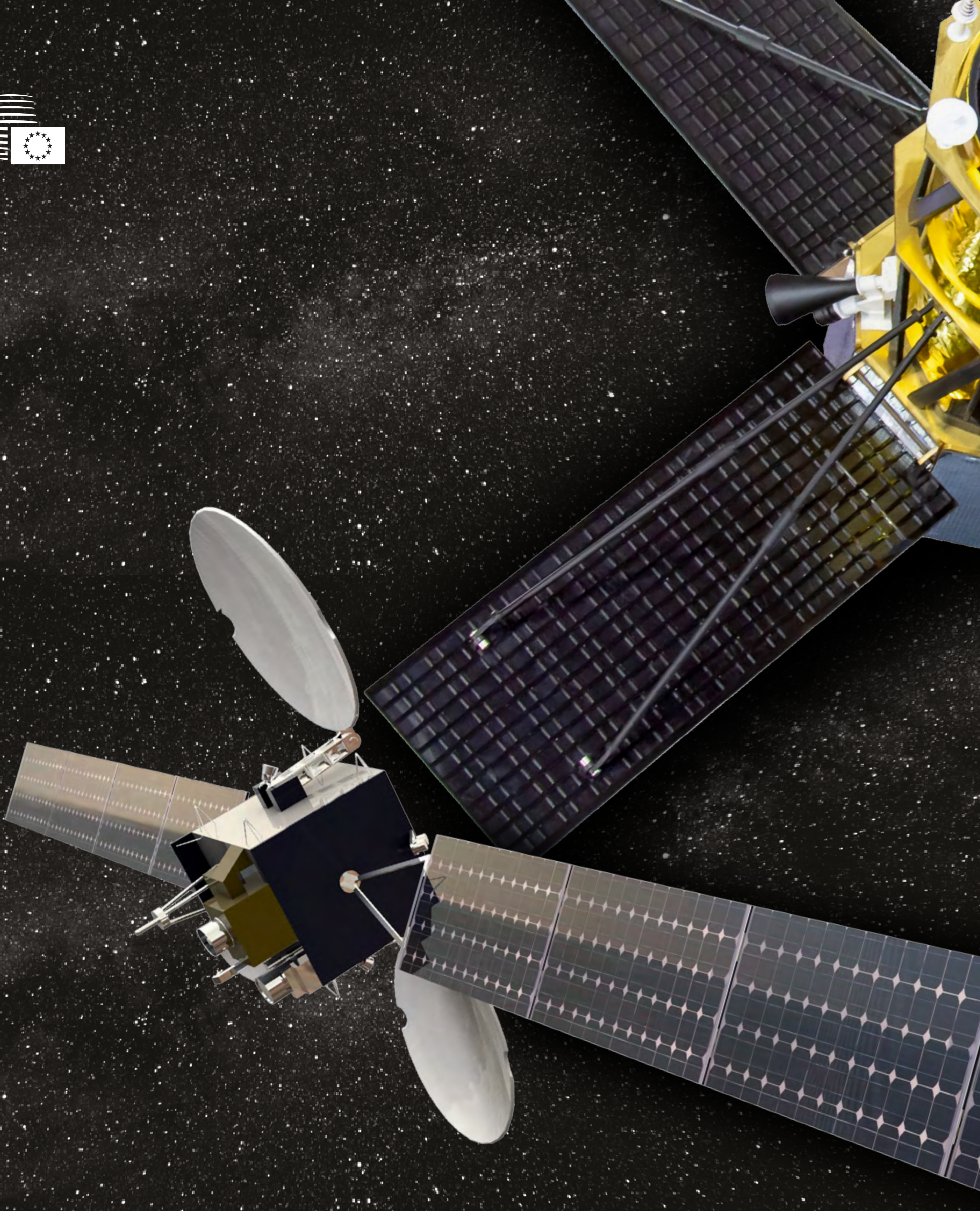

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