European Parliament

EU capabilities in space: Scenarios for space security by 2050

IN-DEPTH ANALYSIS

EPRS | European Parliamentary Research Service

Author: Zsolt G. Pataki
Policy Foresight Unit

PE 765.792 – March 2025

EN

The EU's strategic autonomy and role in space depend on evolving geopolitical dynamics, ranging from peaceful cooperation to competition or conflict among global powers. The geopolitical landscape of space is characterised by competition between incumbents like Russia and the US and rising powers like China, India, Japan and South Korea. These countries can be seen both as partners and adversaries of the EU in space exploration and exploitation, and in making technological advancements.

Reflecting the importance of the subject, the European Commission plans to submit a proposal for an EU space act later in 2025. This paper explores the geopolitical context of the EU's space activities, with a focus on security and defence, and the response to space-related risks. It presents four future scenarios, highlighting challenges and opportunities, while also examining policy considerations for EU action.

AUTHOR

This paper has been drawn up by Zsolt G. Pataki of the Policy Foresight Unit (PFOR) within the Directorate-General for Parliamentary Research Services (EPRS) of the Secretariat of the European Parliament.

To contact the author, please e-mail eprs@ep.europa.eu

LINGUISTIC VERSION

Original: EN

Manuscript completed in March 2025.

PE 765.792
978-92-848-2631-5
doi: 10.2861/8152081
QA-01-25-054-EN-Q

http://www.eprs.ep.parl.union.eu (intranet)
http://www.europarl.europa.eu/thinktank (internet)
http://epthinktank.eu (blog)

Executive summary

Space has emerged as a focal point on the geopolitical stage, promising both economic prosperity and strategic importance in the coming decades. The EU's pursuit of 'strategic autonomy' and its future role in space hinge upon evolving geopolitical dynamics, ranging from peaceful cooperation to heightened competition or conflict among global powers. Recent events foreshadow potential challenges to the EU's aspiration to maintain the peaceful use of space. The geopolitical landscape of space is characterised by notable competition between historical rivals like Russia and the United States (US), alongside rising powers such as China, India, Japan and South Korea.

By 2050, space could become a major battlefield, although it could also remain a domain primarily for peaceful exploration, scientific discovery, and international collaboration. The space economy could grow beyond rockets and satellites, encompassing a broad ecosystem of space-based and terrestrial markets and activities, and space technologies could contribute to peace and prosperity. Launch costs could dramatically decrease, making space travel and transport more accessible. There could be mining colonies on the Moon and manufacturing in space, where air pollution is not a concern. Development of space-based solar farms to generate clean energy could become a reality. Hotels and resorts in Earth's orbit could make space a tourist destination. Space-based agriculture could support lunar colonies.

Nevertheless, by 2050 we may also see increased weaponisation efforts such as the increased deployment of military satellites for reconnaissance, communication and navigation purposes. There could also be advancements in anti-satellite weapons and space-based defence systems. There will likely be efforts to prevent the weaponisation of space to maintain stability and prevent conflict escalation.

The European Commission has announced its plans to submit a proposal on an EU space act in the second quarter of 2025 (which will subsequently be discussed in the European Parliament, as part of the legislative procedure). This paper aims to describe the geopolitical context of space activities affecting the current and future capabilities of the EU in space endeavours, with a focus on the use of space for security and defence and the response to space-related risks. Further to this, the paper presents four plausible future scenarios in which the EU's ambitions in space could play out, while also highlighting challenges and opportunities and laying out policy considerations for EU action.

Table of contents

1. Background ____ 1

2. Introduction ____ 1

2.1. Geopolitical landscape in space ____ 1

2.2. Technological dimension ____ 3

2.3. EU endeavours in space ____ 6

2.4. European Parliament's stance ____ 8

3. Scenario planning for EU space security ____ 9

3.1. Time horizon, key drivers and assumptions ____ 10

3.2. Building scenarios ____ 11

4. Possible space scenarios by 2050 ____ 12

4.1. Scenario 1: Inertia ____ 13

4.2. Scenario 2: Collaborative space ____ 15

4.3. Scenario 3: Strategic space race ____ 16

4.4. Scenario 4: Undefended ____ 18

5. Policy considerations ____ 19

6. References ____ 24

List of figures

Figure 1 – Anti-satellite tests performed by countries between 1959 and 2023 ____ 3

Figure 2 – How space applications relate to the UN Sustainable Development Goals ____ 6

Figure 3 – Space power index of nations possessing a strong space sector ____ 8

Figure 4 – Cost of non-Europe in the space sector (GDP impact in € billion) ____ 10

Figure 5 – Four possible space scenarios ____ 13

List of tables

Table 1 – Counterspace capabilities of the world's spacefaring countries ____ 2

Table 2 – Overview of the four space scenarios for the EU by 2050 ____ 20

1. Background

Space has emerged as a focal point on the geopolitical stage, promising both economic prosperity and strategic importance in the coming decades. The EU's pursuit of 'strategic autonomy' and its future role in space hinge upon evolving geopolitical dynamics, ranging from peaceful cooperation to heightened competition or conflict among global powers. Recent events foreshadow potential challenges to the EU's aspiration to maintain the peaceful use of space. The geopolitical landscape of space is characterised by notable competition between historical rivals such as Russia and the United States (US), as well as rising powers such as China, India, Japan and South Korea, which can be seen as both partners and adversaries for the EU. There is also a race in space exploration and exploitation, as well as technological advancements in several key domains.

When it comes to the soft power dynamics that govern space, international bodies and organisations such as the United Nations Committee on the Peaceful Uses of Outer Space and initiatives by its secretariat, the United Nations Office for Outer Space Affairs (UNOOSA), play a crucial role in shaping the basic principles of global cooperation in space. According to their latest annual report, UNOOSA had registered 2 588 satellites by the end of 2023, a 25 % increase from 2022 and an 89 % increase in all operational space objects registered since the start of the space age. Registrations of mega-constellations are the driving force behind this growth, which is expected to continue to amplify in the future. The emergence of non-traditional space entities of a private legal nature (such as SpaceX, Virgin Galactic, Blue Origin, etc.) has revolutionised space access and applications, leading to the 'New Space' paradigm, a burgeoning space market. However, challenges such as complex regulatory frameworks and space debris proliferation accompany this transformation. Emerging risks have prompted several national security strategies and policies to conceptualise outer space as a specific defence domain leading to the development of military capabilities aimed at both protecting national security and countering adversaries' space systems. However, the dual-use nature of many capabilities poses a challenge, as technologies designed for peaceful purposes can also be repurposed for hostile actions.

2. Introduction

2.1. Geopolitical landscape in space

Recent developments in the ongoing war in Ukraine, especially the unprecedented extent and magnitude of the use of space to support military operations on Earth, underscore the pressing need to address the weaponisation of space. Efforts to regulate space activities face hurdles due to a lack of consensus and the ambiguous delineation between civilian and military space uses within the paradigm of space arms control and legal frameworks. Harmful interferences, such as satellite jamming and cyberattacks, emphasise the need for robust legal frameworks to safeguard space assets. To safeguard outer space, additional normative frameworks are required to prevent the escalation of armed conflicts and the weaponisation of this domain. The Russian cyberattack on ViaSat's KA-SAT satellite network, which occurred just hours before the invasion of Ukraine, serves as a poignant example of the weaponisation of both space and cyberspace.

A key concern is the potential for military confrontation among major powers, fuelled by the involvement of new space players, the increase in space objects and dual civil-military space services, and armed forces' growing reliance on space systems. The increasing counterspace

capabilities and the presence of kinetic, non-kinetic, and electronic weapons,[1] along with ever-growing cyber operations and the potential for nuclear activities in space, pose inherent security threats. The prospect of armed conflict in outer space raises grave concerns, including the multiplication of space debris and the disruption of critical civilian infrastructure essential for global communication, observation, navigation and timing. Unfortunately, the growing risks to space systems have not been reduced by successful arms control and disarmament dialogues. These risks are particularly pronounced for emerging spacefaring nations that may lack adequate situational awareness and manoeuvring capabilities to address potential threats effectively.

There is a broad range of destructive and non-destructive counterspace capabilities in multiple countries, yet only non-destructive capabilities are being actively used against satellites in current military operations. Table 1 below summarises the capabilities of a select number of countries that are leaders in this domain.

Table 1 – Counterspace capabilities of the world's spacefaring countries

Source: Secure World Foundation, Global Counterspace Capabilities 2024.

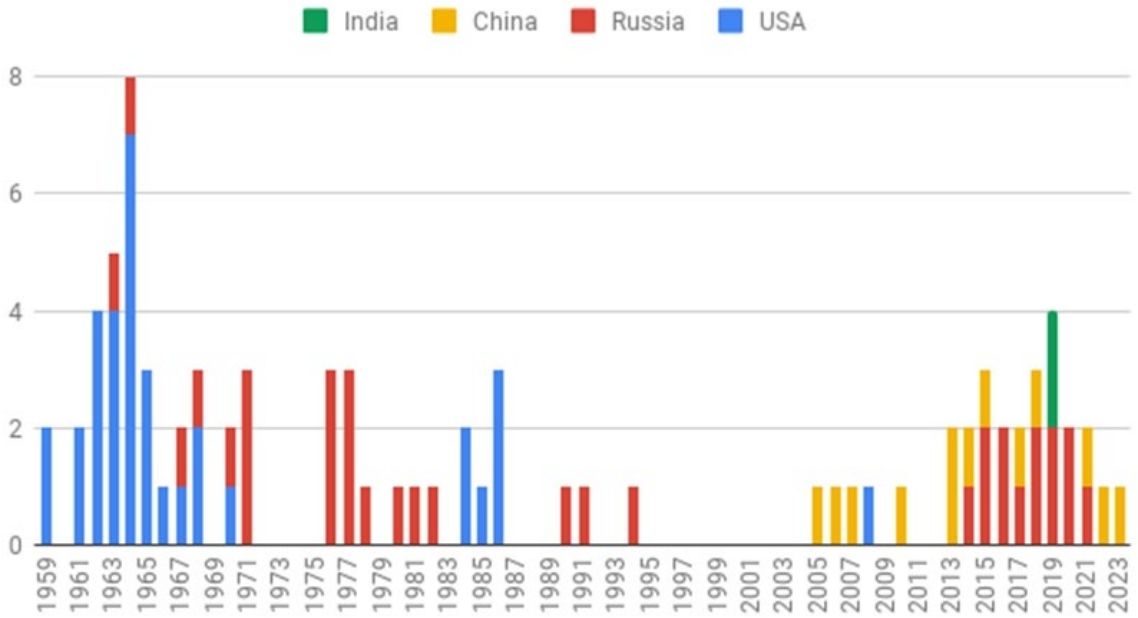
There is an unquestionable geopolitical power shift occurring as the world transitions towards a multipolar landscape, with economies like China and India emerging as powerful challengers to the Western-led international order. Increasing geopolitical tensions in recent years have accelerated the militarisation of space and the development of counterspace capabilities, raising concerns about space cooperation. China and India are making significant progress, while Japan, Korea and the Gulf States (particularly the United Arab Emirates and Qatar) are also increasing their ambitions. Chinese space endeavours are advancing, as evidenced by the successful landing of the lunar rover Yutu-2 in 2019 at the Von Kármán Crater. This mission represents the first comprehensive scientific exploration of the far side of the Moon from its surface. Furthermore, the Chang'e 4 mission represents the latest step in China's ambitious agenda to land humans on the Moon by 2036, aligning with its broader strategic aim of achieving global technological superiority by 2040. This initiative is

[1] According to the UN Office for Disarmament Affairs (UNODA), **kinetic space weapons** are devices that use physical force to destroy or damage objects in space, such as anti-satellite missiles, space-based interceptors, and kinetic energy weapons. **Non-kinetic space weapons** are those that do not use physical means to disrupt or destroy objects in space (high-powered lasers, microwave weapons, or particle beam weapons). **Electronic space weapons** are devices using electromagnetic energy to disrupt or destroy objects in space, such as electronic countermeasures, jamming systems, and electromagnetic pulse generators. **Cyber operations in space** are using computer networks and electronic systems to disrupt, disable, or destroy space-based assets, such as hacking, cyber-attacks and electronic warfare. Source: UN Office for Disarmament Affairs (UNODA), Report on Preventing an Arms Race in Outer Space, New York, 2009.

intricately linked with the Belt and Road Initiative, forming part of China's strategy to establish its economic influence across the globe.

Major space powers, such as the US, Russia, China and India, have demonstrated capabilities to disrupt or disable adversary space assets. However, no EU power has officially conducted anti-satellite or counterspace weapon tests. Russia's war in Ukraine has not only spurred EU unity but has also served as a wake-up call for space security, with Germany, France,[2] Spain and Italy having recently set up their national military space commands. The fact that critical space infrastructure lies beyond the limits of the EU's decision-making powers poses risks to the Union's economy and sovereignty. The EU is lagging behind in various aspects of space utilisation, most notably in protecting its assets and interests, despite protection being of key importance for achieving strategic autonomy and reducing dependence on external players for space access and intelligence.

Figure 1 – Anti-satellite tests performed by countries between 1959 and 2023



Source: Secure World Foundation, Global Counterspace Capabilities 2024.

2.2. Technological dimension

Continuous technological advancements are necessary to overcome current limitations in the space sector. Among these, breakthroughs in nuclear fusion technologies and advances in propulsion technologies would have critical impacts, bringing solid and disruptive technological innovations for humankind both on Earth (for instance, to address issues related to energy security, climate change and the twin transitions) and in space (for instance, to provide cheap and sustainable energy in and from space). However, the potential for conflict in space exists due to the strategic importance of space assets for communication, navigation, and surveillance. This could lead to heightened tensions and occasional incidents involving further militarisation of space assets. Consequently, space may become an actual battlefield with active combat.

[2] The French space command was established in the summer of 2019, well before the start of the war in Ukraine in 2022. Source: https://www.defense.gouv.fr/actualites/il-y-cinq-ans-france-lancait-son-commandement-lespace.

The EU faces the risk of falling behind technologically, which could lead to missed opportunities for scientific projects and economic impact. Public investment in space technologies – both military and civilian – is roughly six times higher in the US than in the EU. Josep Borrell, the EU's former High Representative for Foreign and Security Policy/Commission Vice-President, estimated this gap to be as high as 10 times. Recent years have seen the US and China outpacing the EU in critical technologies essential for future prosperity and security, including satellite constellations, reusable launchers, micro-launchers, space transport for humans, encrypted connectivity, quantum computing, artificial intelligence (AI) and military space capabilities.

The EU space sector remains predominantly civilian-focused, unlike its counterparts in other countries that are driven by defence contracts. The EU's cost of access to space is influenced by global developments, underscoring the importance of investing in cutting-edge technologies to reduce costs. Developing techniques for space farming[3] is crucial for long-term human survival on celestial bodies like the Moon and Mars.

Medical and agricultural advancements aimed at addressing challenges in space also have applications on Earth, showcasing the dual benefits of space research. The EU is currently grappling with challenges in maintaining its technological edge and securing sovereignty in space. However, collaborative efforts and technological advancements provide opportunities to address these challenges and harness space exploration for both societal and economic benefits.

At the same time, it is important to note that the EU's civilian space applications have been highly supportive of efforts to achieve the UN Sustainable Development Goals (SDGs) for several decades. The efforts listed below demonstrate not only the EU's commitment to supporting the SDGs but also the fact that its space applications address some of the world's most pressing challenges and promote sustainable development, poverty reduction, and environmental protection.

Climate Action (SDG 13): The EU's Copernicus programme provides critical data and services for monitoring climate change, tracking greenhouse gas emissions and predicting extreme weather events, thereby supporting climate mitigation and adaptation efforts.

Sustainable Agriculture (SDG 2): The EU's space-based Earth observation systems, such as Copernicus, provide valuable data and insights for precision agriculture, crop monitoring, and yield prediction, thereby helping to increase food security and reduce environmental impact.

Disaster Risk Reduction (SDG 11): The EU's Copernicus Emergency Management Service provides critical support for disaster response and recovery, including damage assessment, emergency mapping and situational awareness.

Ocean Conservation (SDG 14): The EU's Copernicus monitors ocean health, tracks marine pollution, and supports sustainable fishing practices, thereby helping to conserve marine ecosystems and promote the sustainable blue economy.

Water Management (SDG 6): The EU's Copernicus Water Service provides critical data and insights for water resource management, including monitoring water quality, quantifying water usage and predicting water scarcity.

[3] Space farming, also known as space agriculture or astro-agriculture, refers to the practice of growing plants and other organisms in space or in controlled environments that mimic space conditions. This can include techniques such as hydroponics, aeroponics and controlled environment agriculture (CEA) to grow crops in space stations, lunar or planetary bases, or other off-Earth locations. Source: https://www.nasa.gov/exploration-research-and-technology/growing-plants-in-space/ and https://www.esa.int/esearch?q=space+farming.

Sustainable Urbanisation (SDG 11): The EU's Copernicus Urban Atlas provides valuable data and insights for urban planning, transportation management and environmental monitoring, thereby supporting sustainable urban development and reducing the environmental impact of cities.

Health and Wellbeing (SDG 3): The Copernicus Atmosphere Monitoring Service provides critical data and insights for monitoring air quality, tracking disease outbreaks, predicting health risks, thereby supporting public health policy and decision-making.

Biodiversity Conservation (SDG 15): Copernicus monitors land use changes, tracks deforestation and supports conservation efforts, thereby helping to protect and preserve biodiversity and ecosystems.

Food Security (SDG 2): The EU's Copernicus Agricultural Monitoring Service provides critical data and insights for crop monitoring, yield prediction and agricultural decision-making, thereby supporting food security and sustainable agriculture.

Resilient Infrastructure (SDG 9): The Copernicus Infrastructure Monitoring Service provides valuable data and insights for infrastructure monitoring, including tracking structural integrity, monitoring environmental impacts and predicting maintenance needs, thereby supporting resilient and sustainable infrastructure development.

Figure 2 – How space applications relate to the UN Sustainable Development Goals

Source: UN Office for Outer Space Affairs, For all humanity – the future of outer space governance.

2.3. EU endeavours in space

The EU's pursuit of autonomous access to space and its ability to mitigate space threats are paramount for ensuring its strategic autonomy. The need for a coordinated EU space policy and strategy has never been more pressing, as space and its applications play a decisive role in Ukraine. Furthermore, the EU's competitiveness is at risk due to the potential loss of its industrial capability

in space and the possibility of further disruptions to its supply chains, which could affect its access to critical raw materials. As the geopolitical relevance of space continues to grow, the EU faces a critical juncture in shaping its space policies and capabilities. Since 2016, when it set its European Space policy objectives, the EU has experienced significant geopolitical shifts and a new level of commercial dynamics, both of which are directly affecting it. Initiatives like the European Defence Agency's strategic infrastructure support the development of defence capabilities through a coherent prioritisation framework and identify crucial areas with a view to strengthening EU's strategic autonomy.

The long-standing technical expertise and research capabilities of the European Space Agency (ESA) can revolutionise European space security. Their commitment to developing the safety and resilience aspect of European space assets and increasing cooperation with the EU are necessary steps to enhance space security. Their new concept of space security, known as 'defence for space' (rather than solely focusing on 'space for defence') aims to reduce vulnerabilities in strictly non-aggressive areas to align with the peaceful uses of outer space. Recently, ESA and the EU signed an agreement – Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS^2) – to use space for keeping information secure, promoting digital autonomy and providing a strategic asset for the EU. In the first stage, European public authorities and businesses would use a constellation of satellites, the aim being to make connectivity available and secure. ESA's new security role may however overlap with some competences of EU bodies, particularly the European Union Agency for the Space Programme (EUSPA). This could be due to variations in safety and security standards, as well as differing responsibilities for training military personnel in the security aspects of non-military EU space assets.

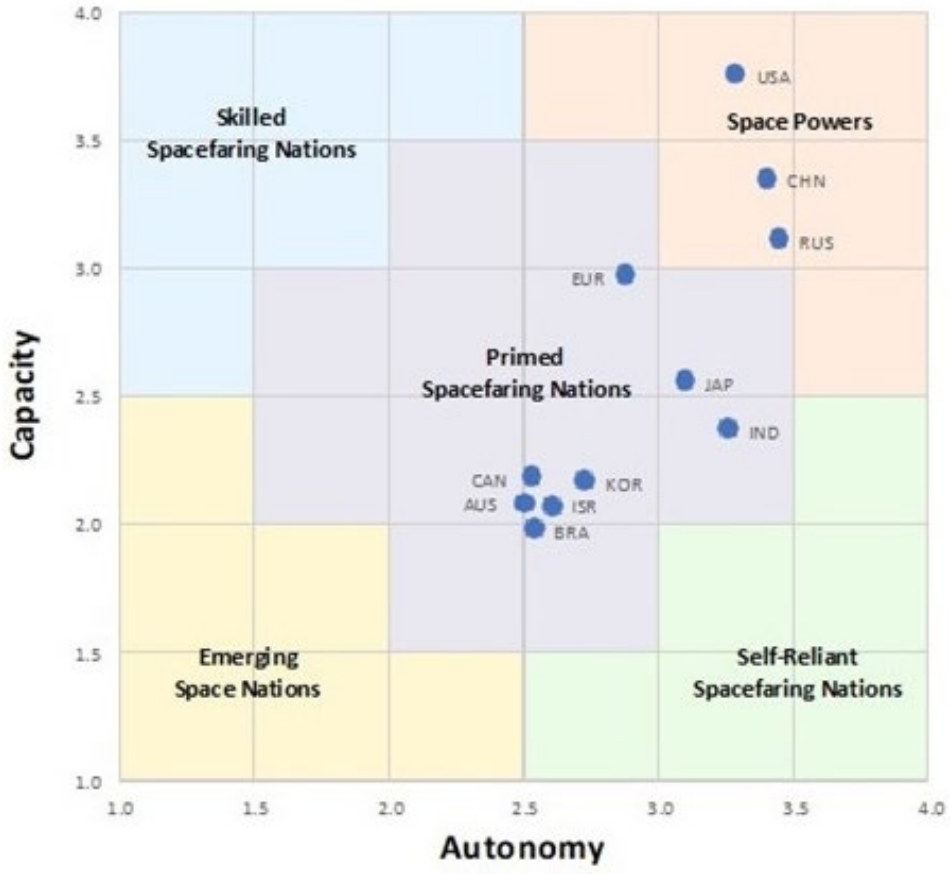
The emergence of private space companies, known as 'New Space', offering more cost-effective solutions, is reshaping the global space landscape in the 21st century. Estimates for the space economy range from US$580 billion to US$2.7 trillion. European governments are encouraging stakeholders, including start-ups, universities and established commercial entities, to allocate resources for enhancing the spill-over effects of space-related innovations such as AI, nuclear energy, propulsion technologies, life sciences, quantum technologies and communication. The EU is co-funding space initiatives, including through CASSINI, a €1 billion EU fund supporting start-ups and SMEs. This fund covers both upstream (nanosatellites, launchers, etc.) and downstream (products/services enabled by space data, etc.). However, EU space investment currently stands at 0.07 % of GDP, significantly lower than the US's 0.25 %, which does not mirror the EU's actual economic strength.

Is the EU a space power? In a publication titled 'Power, State and Space', the European Space Policy Institute (ESPI) defined **space power** as possessing the means to autonomously deploy, operate and benefit from any space-related capability in order to support the achievement of national objectives that it has autonomously determined. The author developed a space-power index to evaluate a nation's capacity and autonomy in space operations and governance through 94 aggregated indicators across four categories: hard capacity, soft capacity, technical autonomy and political autonomy. Hard capacity covers tangible resources for space capabilities, while soft capacity measures the effective use of resources within national policies.

Autonomy involves the ability to independently conduct space operations, assessed through technical and political dimensions. According to the assessment through the lens of this index, only the US, China, and Russia are currently considered full space powers. Europe, while possessing some space capabilities, falls short in military applications and hard autonomy, especially in crewed

missions. However, with strategic investment and coherent policies, the EU could enhance its space capabilities and potentially achieve space power status.

Figure 3 – Space power index of nations possessing a strong space sector



Source: The space power index, according to the European Space Policy Institute.

2.4. European Parliament's stance

The European Parliament has, for a long time, been a strong supporter of a more robust EU space sector, emphasising the role of space in bolstering EU competitiveness and enabling EU strategic autonomy. In 2022, EU leaders recognised space as a strategic domain in the Strategic Compass[4] and called for an EU space strategy for security and defence. Building on this political momentum, the first-ever EU space strategy was adopted in March 2023, to underscore the EU's commitment to enhancing its space capabilities. In the current geopolitical context of increased competition among powers and intensification of threats, the strategy, which is part of the implementation of the EU Strategic Compass, provides an ambitious framework to safeguard the EU's space assets and interests, deter hostile activities in space and strengthen the EU's strategic autonomy.

In its resolution of 9 May 2023 on critical technologies for security and defence, Parliament called on the Commission to include its findings on the EU strategic dependencies in space in its forthcoming classified report to the Member States on critical technologies and risks. In an own-initiative report on the Strategic Compass and EU space-based defence capabilities of 23 November 2023,

[4] An ambitious plan of action for strengthening the EU's security and defence policy by 2030, providing a shared assessment of the strategic environment, and making concrete and actionable proposals so as to improve the EU's ability to act decisively in crises and to defend its security and its citizens.

Parliament recognised space systems as critical infrastructure and welcomed the findings and high level of ambition in the recommendations on security and defence laid out in the EU space strategy. Furthermore, Parliament recommended designing a comprehensive strategy that encompasses a wide range of risks, including space debris and cyber-attacks. The resolution welcomed the proposal for an EU space law, which should aim to provide a common, harmonised and coherent security, safety and sustainability framework. This should improve the resilience of EU space services while tackling the space market's excessive fragmentation. The report was Parliament's response to the above strategy, focusing on five priority areas: 1) protection and resilience of systems; 2) response to threats; 3) competitiveness and investment; 4) governance; 5) cooperation.

The Council has meanwhile adopted conclusions on the EU space strategy for security and defence, welcoming it and supporting its main points. Furthermore, Parliament's Committee on Industry, Research and Energy (ITRE), during its meeting of 30 September 2024, discussed the Commission's implementation report of the EU Space Programme and on the performance of the European Union Agency for the Space Programme and gave a favourable opinion on these developments. Parliament will discuss the EU's role in space again following the Commission's plan to submit a proposal on an EU space act and publish it in the second quarter 2025.

3. Scenario planning for EU space security

Through scenario planning and strategic foresight, EU stakeholders can navigate uncertainties and chart a resilient course for the future of the EU's space sector. Scenario planning offers policymakers a structured approach to understanding alternative future outcomes and their implications. Scenarios help us make decisions about the present by looking through the lens of the future, rather than just trying to understand the future from the perspective of the present. Scenario planning uses storytelling to craft engaging images of the future that encourage decision makers to challenge their assumptions about the future and to inspire action. This process can help organisations widen their strategic perspective and devise strategies that are more resilient to various possible versions of the future. Several key trends, drivers of change, weak signals, challenges and opportunities are identified during this process, and the main axes for building the scenarios are defined.

Many national and international stakeholders that are active in the space realm – such as the UNOOSA, the US Air Force Space Command, the European Space Policy Institute (ESPI) with the Copenhagen Institute for Future Studies, the World Economic Forum and many others – have recently published ideas about the future of space and developed various types of scenarios. These scenarios are based on strategic anticipation of selected drivers for the timeframes of now until 2040, 2040-2060 and even up to 2100. A common feature among them is the proposal of a vision for humanity in space, either globally or specifically for Europe. Furthermore, they outline how space exploration can offer solutions to respond to the unprecedented global challenges the world is currently confronting, and how it can serve as a source of inspiration to overcome these challenges.

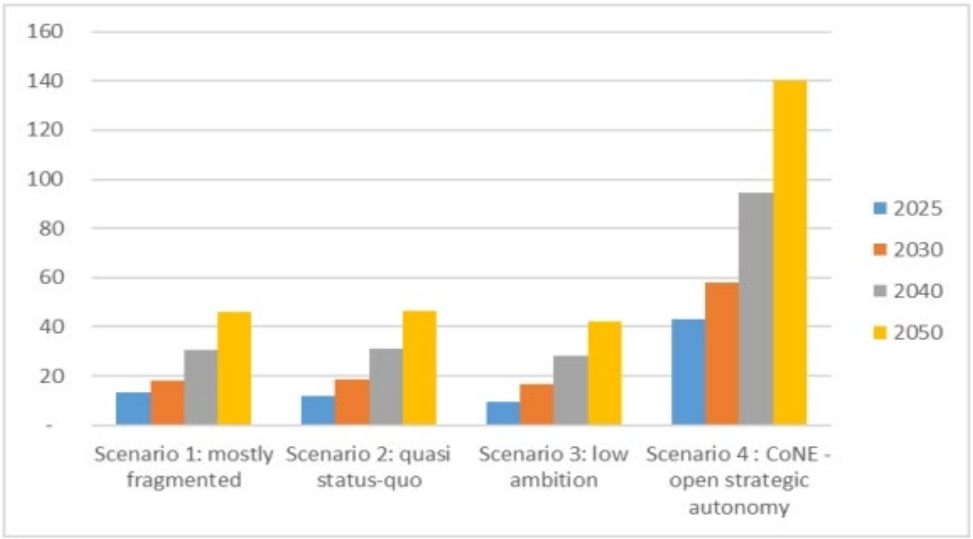
The author's thinking has been inspired by key trends and issues highlighted in these scenarios, such as those resting on the assumption that space may become a major battlefield by 2050, while expressing hope that space will be used primarily for peaceful exploration, scientific discovery and international collaboration. The space economy may continue to expand beyond the production of rockets and satellites, to encompass a broad ecosystem of space-based and terrestrial markets and activities. Space technologies could contribute to peace and prosperity, and launch costs could dramatically decrease, making space travel and transport more accessible. There could be mining colonies on the Moon and manufacturing in space, where air pollution is not a concern. Development

of space-based solar farms to generate clean energy could become a reality. Hotels and resorts in Earth's orbit could make space a tourist destination. Space-based agriculture could support lunar colonies. Nevertheless, by 2050 humanity could also witness increased weaponisation efforts such as the deployment of military satellites for reconnaissance, communication and navigation purposes (already the case in 2025, but not an impediment to the development of parallel peaceful activities). There could also be advancements in anti-satellite weapons and space-based defence systems. However, there will likely be ongoing debates and efforts to prevent the weaponisation of space to maintain stability and prevent conflict escalation.

The use of macroeconomic drivers for modelling results of space policies is not a novelty; among others, it was applied in a 2023 study on space by Parliament, trying to assess and quantify the 'cost of non-Europe' of the EU space sector (cost of non-Europe (CoNE) reports examine the consequences of taking or not taking any action at EU level in a given policy area). The report finds that the potential benefits of efficient, ambitious and united EU-level action could bring large benefits, amounting to at least €140 billion per year by 2050. It operates with four models that are built by using four macroeconomic drivers (real GDP, private consumption, employment and capital stock).

The case examined in this paper is different, as the above-mentioned report focused mainly on the financial aspects of the space sector and did not utilise foresight methodology. In contrast, this paper does not assess or quantify the potential benefits of EU-wide united action in space. Instead, it creates its own scenarios by adopting the perspective of the European Parliament.

Figure 4 – Cost of non-Europe in the space sector (GDP impact in € billion)



Source: Cost of non-Europe in the space sector, EPRS, European Parliament, 2023.

3.1. Time horizon, key drivers and assumptions

The author of this paper deliberately chose the time horizon of 2050 for the space security scenarios, to align with the Commission's long-term strategic planning. This timeframe allowed him to consider the potential consequences of current decisions and investments. The EU's Climate Law, for instance, sets a target for climate neutrality by 2050, which will have implications for space security as well, as the transition to renewable energy sources will rely on space-based assets like Earth observation satellites. The latter can efficiently track climate-related phenomena and optimise energy sources, but also create new security risks, such as cyberattacks or jamming. Ensuring the

security and resilience of these assets is critical to achieving the EU's climate goals. This highlights the need for a comprehensive approach to space security, addressing the intersection of climate change, energy security and space policy. By doing so, the EU can mitigate potential risks and ensure a stable transition to a climate-neutral economy.

Similarly, the European Green Deal aims to make Europe the first climate-neutral continent by 2050, while the energy and climate policy framework to 2050 provides a roadmap for reducing greenhouse gas emissions. Furthermore, the Commission's white paper on the future of Europe also looks ahead to 2050, emphasising the need for a unified and resilient Europe. The EU's space programme, Horizon Europe, and the Digital Europe programme both have components[5] that extend to 2050. The EU's global governance and globalisation strategies also look ahead to 2050, highlighting the need for a coordinated and forward-looking approach. Furthermore, the European Defence Fund and permanent structured cooperation (PESCO) are also working towards a 2050 timeline.

Aligning the space security scenarios outlined in this paper with the above initiatives ensures a cohesive and forward-looking approach. The choice of 2050 makes it possible to explore potential synergies and trade-offs between these policies and space security. It also makes it possible to anticipate and prepare for emerging challenges and opportunities. By considering a 25-year time horizon, it is possible to identify potential game-changers and wildcards that may have an impact on space security. This long-term perspective is essential for developing robust and resilient scenarios. Ultimately, the choice of 2050 reflects the author's commitment to long-term thinking and strategic planning, allowing the presentation of plausible future situations and the building of scenarios based on them.

Several key structuring factors and main drivers were considered in developing the four space security scenarios. These factors include the level of weaponisation of space, the extent of EU engagement in the space sector, and EU economic growth – a precursor to achieving technological maturity for further space expansion. All of these factors serve as critical determinants of future scenarios, or axes, delineating potential threats and opportunities for the EU space sector. The author has screened current and future geopolitical, technological, environmental, societal and demographical issues, to identify key future issues related to the external environment of the EU space sector, and analysed the trends and driving forces that make these up. After an initial exploration of the critical uncertainties and their possible impacts, they have tried to qualify and/or quantify those, and finally defined axes of uncertainty as the outset for scenario building.

A list of 15 such possible drivers was initially considered. However, with a view to reducing interdependencies, the number of the key drivers was reduced to three. A stakeholder consultation took place between June and September 2024, with a focus on the EU's pursuit of autonomous access to space and its ability to mitigate space threats. The scenarios were partly built on these inputs, in combination with an extensive literature review.

3.2. Building scenarios

The process of scenario building for the future of space security began with an assessment of the impacts and uncertainties of the selected drivers, followed by the definition of the two axes of a 2 x 2 grid scenario matrix. This rather straightforward method was chosen after considering

[5] These are all multiannual programmes that have components extending to 2050, such as a long-term vision for the development of a European space traffic management (STM) system, or the Digital Europe: High-Performance Computing and the Digital Europe: Artificial Intelligence initiatives, both of which have aspects covering space-related applications.

alternative approaches such as a futures table with multiple drivers and future states, which resulted in overly complex situations. For the scenario matrix, the X-axis was defined as the **level of weaponisation of space by 2050**. Weaponisation of space involves the expansion and diversification of military and dual-use assets and activities in space by global players. Their goal is to deploy defensive or offensive force, effectively turning outer space into a military platform and battlefield. This poses a significant security challenge, not only for Europe but for humanity as a whole. While the weaponisation of space is often the result of complex processes, the author of this paper focused on its underlying drivers. These were categorised into three unique aspects: the geopolitical dimension, the technology dimension, and the EU's engagement in space, reflecting its economic power and political will. Exploring these dimensions provides a better understanding of the factors contributing to the weaponisation of space and the development of more informed scenarios for the future. Furthermore, the author acknowledged that 'weaponisation' may not be considered as a driver *per se* but rather a result of long and very complex processes.

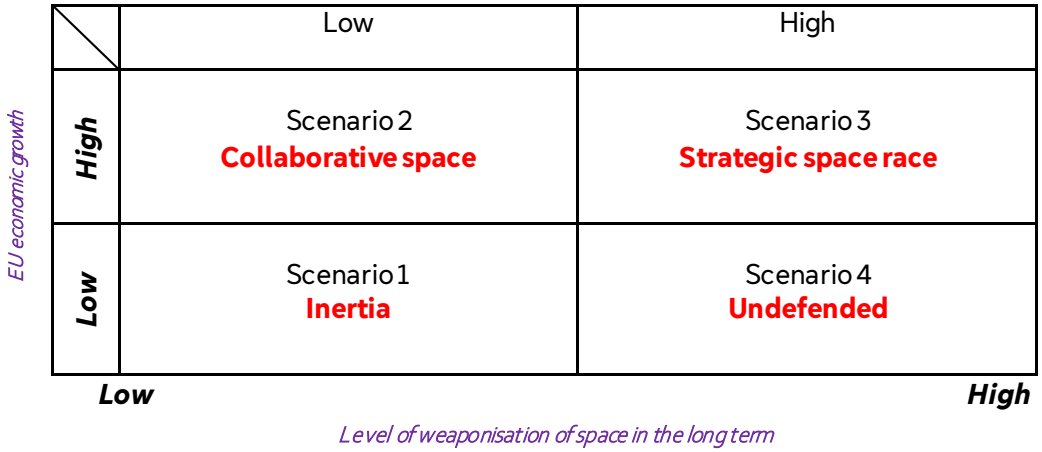
The Y-axis for the scenario matrix was chosen to represent **EU economic growth**, which refers to the increase in the size of the EU's economy over time, typically measured by GDP. Economic growth is determined by the utilisation and efficiency of capital and labour. In Europe, it has historically been characterised by increased capital use and high productivity growth. This factor is closely tied to the overall health of the EU economy, including GDP growth and tax revenues. The level of EU economic growth is strongly correlated with and has a significant impact on the EU's technological maturity in space, which allows for advances in space science and technology enabling complex space operations to be conducted independently. Key technology trends that will influence this maturity include satellite constellations, reusable launchers, quantum computing and novel space power systems.

However, it is essential to note that a steady moderate-to-high GDP growth is not the only prerequisite for EU space expansion. Massive political and popular support across the EU is also necessary from citizens, Member States and institutions for the EU to be able to conduct space operations independently, including military applications and crewed missions. Moreover, while higher economic growth may drive technological maturity, it is not a guarantee, and breakthroughs can occur even in times of low growth or negative outlooks.

4. Possible space scenarios by 2050

By combining the level of weaponisation of space by 2050 with the level of EU economic growth, the author of this paper created a scenario matrix that provides a comprehensive framework for exploring the future of EU space security. This resulted in the following scenarios:

Figure 5 – Four possible space scenarios



Source: Author's compilation based on the scenarios presented, 2025.

4.1. Scenario 1: Inertia

The year 2050 has arrived, and the space landscape has evolved significantly over the past few decades. Unfortunately, the ongoing and past conflicts have left a lasting impact on space cooperation, with power rivalry continuing to simmer in the aftermath of the wars in Ukraine and the Middle East. The militarisation of space has stagnated, with no new geopolitical power acquiring counterspace capabilities. Against this backdrop, the EU has struggled to maintain its footing amid growing competition in space, hindered by lack of investment and lack of unity.

By 2050, the EU has fallen behind in many key areas related to the utilisation of space for the benefit of its population and humanity, as well as for the protection of its interests. The EU has missed out on shared scientific results from common space projects due to a lack of technological advancements and its inability to find partners. The increased commercial activities in space have led to a surge in active satellites, posing risks of collisions, loss and debris. The dominance of private companies with mega-constellations in orbit has created unequal partners, with governments and space agencies struggling to regulate and limit the launch of new satellites through international agreements.

Key drivers and assumptions

There is a low weaponisation of space, which is however steadily growing outside the EU;

the EU's economic growth stagnates (0–2 % per year) and protectionist trade policies bear a high risk of recession, coupled with a loss of the EU's global competitiveness;

immigration and defence are dominating the EU agenda and societal discourse, leading to low public acceptance of EU space expansion;

following a brain drain from the EU, its workforce is not equipped to compete in the global space industry;

proliferation of satellites not designed with environmental considerations;

major competitors possess anti-satellite capabilities of critical importance, but the EU does not. This poses threats to its satellite networks and platforms.

Despite these challenges, technological progress has been made in areas such as AI, robotics, battery technology, connectivity and biotechnology. However, breakthroughs in propulsion technologies, fusion power and space military technology have been elusive. The major spacefaring nations, including the US, Russia, China and India, have demonstrated their military

capabilities in space, including Earth-launched anti-satellite rockets and other counter-space weapons. This has created a fragile balance of power in space, with these nations threatening to weaponise outer space and establish military bases on the Moon and Mars. In contrast, the EU has not developed such capabilities, instead focusing on modernising and replenishing its depleted military arsenals following the Russian war against Ukraine. The EU space programme is still hampered by lengthy political decision-making processes, administrative burdens, and a lack of cutting-edge technologies. As a result, the EU has to rely on public-private partnerships to fund its space investment, which has led to a slow take-off of its space programme. Other spacefaring nations have been faster and more successful, leaving the EU (and EU-based private companies) with only 3 % of all satellites in the Earth's orbit by 2050. The lack of coordinated investments in military space activities and the shift of space funding to other policy areas have further deteriorated the EU's position in the competition in space.

The EU's decline in space capabilities has resulted in a brain drain of talented individuals seeking opportunities in other regions. The lack of investment in space education and awareness has resulted in a workforce that is not equipped to compete in the global space industry. Furthermore, the EU's reliance on private companies for space services has created a sense of disconnection among citizens, who feel that the benefits of space exploration are not being shared equitably. The unequal distribution of resources and opportunities has caused social unrest and dissatisfaction, with many citizens questioning the EU's ability to cater for their needs and protect their interests.

With the exponentially increasing number of satellites in orbit, the problem of space debris is still growing and the potential for contamination has become a major concern. The lack of regulation and oversight has allowed private companies to prioritise profits over sustainability, resulting in a proliferation of satellites that are not designed with environmental considerations in mind. The long-term effects of this trend are uncertain, but the EU's failure to address these issues has put its entire space ecosystem at risk.

The EU's population continues to decline, leading to an even bigger shortage of skilled workers in the space industry. This, accompanied by lack of space education and limited inspirational discourses among younger generations, further exacerbates the EU's lag in space competition. Societal trends, such as aging populations and increasing urbanisation, have led to a shift in priorities, with more emphasis on solving terrestrial problems, such as climate change, rather than pursuing space exploration.

4.2. Scenario 2: Collaborative space

By 2050, the world has witnessed a remarkable transformation in the space sector. A peace deal including a demilitarisation of Eastern Europe has brought Russia's war against Ukraine to an end. As a result of confidence-building measures and policies of détente, the US, Russia, China, the EU, India and Japan have come together to support common space programmes, opening a fresh chapter of cooperation and mutual understanding. This collaborative effort has not only brought about significant advancements in space technology but has also had a profound impact on the global economy and citizens' daily lives. Rising concerns about space debris and an increasing recognition of the benefits of Earth observation have led to greater international cooperation, with space-based technologies enabling greater communication and collaboration across borders, creating a more harmonious and cooperative world.

By 2050, the world has entered a new era of space exploration, with the EU emerging as a leader in major space projects. The EU's focus on rebuilding mutual trust and its commitment to long-term space exploration have paid off, with the region achieving tremendous advances in critical technologies. The establishment of permanent bases on the Moon and the development of space-based defence systems have marked a new age of space exploration, with the EU, US and China at the forefront.

Key drivers and assumptions

The EU has a low rate of weaponisation of space, but other regions are experiencing steady growth in this area;

the EU economy is growing steadily (5-6 % per year), being on a path marked by unparalleled growth and two successfully managed transitions (the green one and the digital one);

climate change, defence and technologies are dominating the agenda and society, leading to high public acceptance of EU space expansion;

the EU has successfully tested its anti-satellite capabilities and shown that it can partially protect its satellite networks;

a new generation of space professionals is driving innovation and progress, and the EU's leadership contributes to a sense of EU identity and unity;

the EU as a technology leader is the first to put quantum communication satellites in orbit;

to track space debris, the EU has developed AI-driven space surveillance that is augmented by enhanced analytics in order to decrease potential threats.

The journey to this milestone began in the aftermath of Russia's lost war against Ukraine, which also led to the demise of NATO but allowed Europeans to shift their focus towards civilian space investments. Shielded by France's (and partially the UK's) nuclear arsenal, the EU has been able to integrate Ukraine and other eastern neighbours, improving its relative competitiveness in the global arena. By 2040, the space economy has grown exponentially, reaching US$7.9 trillion and yielding US$160 billion in benefits annually. The resulting collaborative approach has inspired a new generation of scientists, engineers and innovators, who are driven by a sense of wonder and curiosity about the universe. The EU has played a leading role in this development, investing heavily in green energy technologies, satellite constellations, reusable launchers and space transport for humans. The International Thermonuclear Experimental Reactor (ITER project), which started producing cheap and sustainable fusion power in 2039, has been a major breakthrough in this regard.

These developments have had a profoundly positive impact on society, with the increased cooperation and mutual understanding among nations bringing about a more peaceful and stable world. The growth of the space economy has created new opportunities for employment and education, with a new generation of space professionals emerging to drive innovation and progress. The EU's leadership in civilian space development has also contributed to a sense of EU identity and unity, with citizens from different Member States working together towards a common goal.

Furthermore, the benefits of space exploration and development are being shared more equitably, with the EU's commitment to peaceful cooperation and mutual trust ensuring that the advantages of space technology are available to all, regardless of their background or location.

The growth of the space economy has resulted in an increase in space debris and climate impacts from the launch of large numbers of satellites in orbit (up from 2 000 in 2018 to around 150 000 by 2050). However, the EU's investment in green energy technologies and sustainable space practices has helped to mitigate these effects, and the development of reusable launchers and other sustainable technologies have reduced the environmental footprint of the space sector. Additionally, the use of space technology for environmental monitoring and management has improved humanity's understanding of the Earth's systems and enabled more effective conservation and protection of natural resources. The benefits of space technologies are available to all, as shown by the EU's strong cooperation with African countries on several climate-related matters, especially on water management and extreme weather warnings due to climate change.

The unparalleled evolution of the space economy has opened up new opportunities for employment and education, particularly for young people. The EU's investment in space technology and innovation has created a new generation of space professionals, with a diverse range of skills and backgrounds. The collaborative nature of the space sector has also led to increased mobility, with professionals from different countries and regions working together on space projects. Furthermore, the benefits of space exploration and development are being shared more equitably, with the EU's commitment to peaceful cooperation and mutual trust ensuring that the advantages of space technology are available to all, regardless of their age, gender or socioeconomic status. This has helped to promote social cohesion and inclusion, and has contributed to a more diverse and dynamic society. Developments showed that economic growth and environmental protection were not mutually exclusive, and that sustainable development could be achieved through cooperation and innovation.

4.3. Scenario 3: Strategic space race

In the middle of the 21st century, the world is on the brink of a new era in space exploration, spurred by the ground-breaking success of the ITER project in 2039. The project's massive implications for the Green Deal and energy usage have sparked a significant increase in the EU's involvement in space, supported by both public and corporate investment. This surge in interest has coincided with the emergence of private space companies within a new innovative ecosystem, offering more affordable solutions for space exploration.

By contrast, at the threshold of this new space age, the global landscape is also marked by devastating conflicts, including Russia's ongoing war against Ukraine and other conflicts in the Middle East and the Indo-Pacific. Societal trends have shifted towards a more nationalist and competitive mind-set, with countries prioritising their own space programmes over international cooperation. The decade-long conflicts have had a profound impact on the world, bringing it to the brink of nuclear war. The use of Earth-launched anti-satellite rockets and other capabilities to disable or blind enemy space assets has created an atmosphere of tension and mistrust. However, the exhaustion of military and economic power may eventually force adversaries to return to collaboration, leading to a reformed UN framework. Despite this, the international atmosphere remains marked by selfishness, with major powers like the US, China, India and Japan focusing solely on their national space programmes.

Key drivers and assumptions

Space is highly weaponised, with an ever growing number of space weapons. However, the EU is a major space power;

the EU has developed and owns a space-based missile defence system for protecting its space assets and neutralising any human-made threats;

the EU economy is on a path of unparalleled growth (5-6 % p.a.). The EU has successfully accomplished the twin (green and digital) transitions;

as defence and space technologies dominate the agenda and society, there is a very high public acceptance of activities leading to EU space expansion;

the EU's leadership in space exploration contributes to a sense of pride and unity among its citizens;

a new generation of space professionals is driving innovation and progress, and the EU's leadership nurtures a sense of EU identity and unity;

the EU, in its role of a technology leader, is the first to launch quantum communication satellites in orbit;

the EU has developed AI-driven space surveillance for tracking space debris. The surveillance systems are augmented by enhanced analytics to decrease threats.

The EU space sector, however, has taken a different approach, with a common narrative for space exploration emphasising the importance of rebuilding mutual trust. This approach has allowed the EU to find new partners in Africa and the Middle East and regain its position as a leader in major space projects. The EU has made tremendous advances in critical technologies like AI, robotics, quantum technologies, medicine and genetic technology. These breakthroughs have had a significant impact on the EU's prosperity and security, and by 2040 Member States have achieved a level of investment in military and civilian space technologies comparable to that of the US or China. The commercial space sectors of all major powers are now driven by defence and civilian contracts, fuelling innovation and growth. The EU has recently established a permanent base on the Moon, following in the footsteps of the US and China. It has developed space-based missile defence systems to neutralise long-range missile threats. European quantum communication satellites have been launched, marking a new era in strategic communications, and long-term life support in space has become possible, even on the Moon.

Very significantly, the EU's leadership in space exploration cultivates a sense of pride and unity among its citizens. The EU is open to collaborations but the incumbent space powers do not engage. In these circumstances rebuilding mutual trust and cooperation is extremely difficult. For a more collaborative and inclusive approach to space exploration, the EU is ready to share its knowledge and experience with other spacefaring nations. It is working closely with them and relevant international organisations to achieve common goals. However, the EU is the only one readily sharing the benefits it receives from space exploration, demonstrating its commitment to sustainability. Other space powers refrain from doing so. The EU's focus on critical technologies has resulted in significant advancements in fields such as medicine, energy and transportation. These advancements have improved the quality of life for citizens, contributed to a more prosperous and competitive economy, and ultimately led to a more stable and secure space ecosystem.

The EU's focus on sustainability and long-term thinking has resulted in a more responsible and environmentally friendly approach to space exploration. The development of space-based solar power and other renewable energy sources has decreased the EU's reliance on fossil fuels, contributing to a significant reduction in greenhouse gas emissions and pollution. The EU's commitment to reducing space debris and promoting sustainable space practices has also helped decrease waste in orbit, protecting the space ecosystem and preserving the environment for future generations.

The EU's leadership in space exploration has significantly contributed to a brain gain of talented individuals seeking opportunities within its territory. The EU's commitment to long-term projects and sustainability has laid the foundation for a more stable and secure economy, capable of attracting young people and families in search of a better quality of life. This resulting demographic balance has positioned the EU strongly to invest in space exploration and development, creating a virtuous cycle where the growth of the space industry contributes to a growing and prosperous population. With its own launcher, spaceports and fleet of in-orbit shuttle services, the EU is well positioned to maintain its leadership in space exploration, driving innovation and growth in the second half of the century.

4.4. Scenario 4: Undefended

Halfway across the 21st century, the world is marked by multipolarity, increased tensions and conflicts among its leaders. The militarisation of space is a pressing concern, with major powers developing counterspace strategies and anti-satellite weapons. The EU, once a prominent player in the global arena, struggles to keep pace with its competitors. External and internal fragmentation has taken a toll on the EU's economic, technological, and military capabilities, leaving it vulnerable to the whims of other players. Societies experience a decline in trust in institutions and a rise in populist movements, further exacerbating the EU's disintegration.

The EU's critical space infrastructure is largely outside its control, putting its economy and sovereignty at risk. Despite this, space has remained a vital domain for developing EU strategic autonomy and reducing dependence on other players. The US' isolationism of the early 21st century, combined with Russia's devastating war against Ukraine, have served as a wake-up call for EU countries' unity in the military sector, including in space. Germany, France, Spain and Italy have all established national military space commands, which are loosely coordinated under the EU's common foreign and security policy umbrella.

The peace deal reached between Russia and the US has put an end to Russia's war against Ukraine, averting a greater and longer war, yet leaving the EU struggling to cover the costs for Ukraine's reconstruction. Furthermore, the world is still plagued by conflicts in the Middle East and East Asia, with China aggressively seeking to gain 'back' territories that were once in its former 'empire'. The dissolution of NATO in 2030 and the eventual collapse of the EU institutions by 2040 due to huge internal conflicts and a long-lasting recession, have been significant turning points. The major space powers – the US, Russia, China, India and Japan – have continued to advance their individual space programmes. However, the EU's fragmentation has prevented it from partnering with any of these powers. EU countries are grappling with finding ways to cooperate within the European Space

Key drivers and assumptions

Space is highly weaponised, with an ever growing number of space weapons. However, the EU is not among the space powers;

the EU has no counterspace systems for neutralising any threats, while all its competitors have them;

the EU's economic growth is steadily negative (-1-5 % p.a.), leading to a long recession coupled with definitive loss of global competitiveness;

conflicts over immigration and the budget are dominating the EU agenda and societal discourse, leading to a very low public acceptance of the EU's space expansion;

the EU's decline and fragmentation is leading to a sense of disunity and disillusionment among its citizens;

while major competitors possess anti-satellite capabilities of critical importance, the EU does not, which poses threats to its satellite networks and platforms;

the EU is the only one not to have in orbit quantum communication satellites.

Agency (ESA), for instance, regarding the removal of space debris resulting from their previous joint operations.

The internal conflicts and economic polycrises mentioned above initially resulted in the collapse of the euro-zone in 2035, followed by the definitive dissolution of EU institutions by 2040. This had multiple significant impacts on the former EU Member States, causing them to fall behind not only economically but also technologically and militarily.

The dissolution of the EU has led to a sense of disunity and disillusionment among EU citizens. The lack of a common narrative and shared goals has resulted in a fragmented and polarised society, with different nations and groups pursuing their own interests at the expense of others. The militarisation of space has also led to a culture of fear and mistrust, with citizens feeling increasingly insecure and vulnerable to the threats of space warfare. The brain drain of talented individuals seeking opportunities in other regions has further exacerbated the problem and left the EU's former Member States with a shortage of skilled workers and a lack of competitiveness in the global space industry.

The growing weaponisation of space has resulted in a proliferation of space debris and the degradation of the space ecosystem. The lack of regulation and oversight has allowed major powers to prioritise their military interests over environmental considerations, causing a significant increase in pollution and waste in orbit. The EU's demise has removed a key player from the global effort to promote sustainability and environmental responsibility in space.

The lack of opportunities and resources has led to a steep decline in fertility rates, as young EU citizens have been seeking opportunities elsewhere. The resulting demographic imbalance has put a strain on the social security systems and pension funds of former EU Member States, making it even more challenging for them to invest in space exploration and development. The EU's demise has also triggered a significant increase in migration and displacement, as people have been trying to escape the conflicts and instability ravaging the region.

The EU's dissolution has left its Member States struggling to defend their space assets individually. The European Space Agency (ESA) continues to operate but is hindered by budget disputes and resource allocation issues. Without joint security and defence cooperation, former EU Member States are vulnerable to threats from a heavily weaponised outer space. The European space programme, once promising, is now a simple accumulation of national efforts struggling to survive in a competitive and hostile environment.

5. Policy considerations

This paper presented four scenarios for the EU space sector by 2050, which can serve as a framework to provide insight into the potential challenges and opportunities, critical choices and trade-offs. They can also serve to inform the forthcoming discussions and legislative work of policymakers.

The four scenarios have the following key shared challenges: 1) **space debris and sustainability:** the increasing number of satellites in orbit poses a significant risk to the space ecosystem, leading to potential collisions, debris and environmental degradation. Environmental concerns related to space debris should be seriously addressed, and all risks should be managed to prevent collisions and maintain a sustainable space environment; 2) **weaponisation of space:** the development of counterspace capabilities and anti-satellite weapons threatens the stability of the space environment and raises concerns about the potential for conflict; and 3) **the level of global**

cooperation on agreements to regulate space activities: a coordinated global effort involving governments, private entities and international organisations could ensure the space sector's growth is responsible, sustainable and beneficial for all, and help avoid conflicts over space resources and territories.

Table 2 – Overview of the four space scenarios for the EU by 2050

	Scenario 1 **Inertia**	Scenario 2 **Collaborative space**	Scenario 3 **Strategic space race**	Scenario 4 **Undefended**
Geopolitics	Low weaponisation of space; Unlike its main competitors, the EU has no counterspace capabilities, which exposes its satellite networks and platforms to threats	While the weaponisation of space is low, powers (but not the EU) are making quick progress; The EU can only partially protect its satellite networks	Space is highly weaponised and the space race is gathering momentum; The EU owns the most powerful counterspace capabilities	Space is highly weaponised but the EU is lagging behind and has no A-SAT capabilities; The EU has no space-based missile defence systems
Economy	EU economic stagnation (0-2% p.a.), recession and loss of global competitiveness	The EU's economic growth is steady; success with the twin transitions; Sufficient permanent EU public funding	Steady economic growth and successful implementation of the twin transitions; EU public funding is sufficient and stable	The EU is hit by economic recession and has definitively lost its global competitiveness; Shortage of skilled workers
Technology	Need to develop AI-driven space surveillance for tracking space debris; The EU does not have a quantum communication satellite	The EU has AI-driven space surveillance for tracking space debris; The EU has launched its first quantum communication satellites in orbit; Technological breakthroughs (propulsion, fusion)	Defence and space technologies dominate the EU's agenda. The EU is the first to place quantum communication satellites in orbit; Major breakthroughs in propulsion technology and fusion power	Inefficient space surveillance and threat analytics; The EU does not have a quantum communication satellite
Environment	Proliferation of satellites without environmental considerations	Responsible and environmentally-friendly approach to space exploration	Responsible and environmentally friendly approach to space exploration; The EU employs solar and fusion power & renewables, which results in reduced GHG.	Proliferation of space debris and degradation of the space ecosystem
Society and demography	Low public acceptance of EU space expansion; Brain drain from the EU; workforce not	A new generation of space professionals driving innovation and progress;	High public acceptance of EU space expansion; The EU's leadership in space inspires a	Decline and fragmentation of the EU fuels a sense of disunity

	equipped to compete in the global space industry	EU leadership nurtures a sense of EU unity	sense of pride and unity	and disillusionment; Brain drain of talents; decline in fertility rates

Furthermore, there are several scenario-specific challenges and opportunities: **Scenario 1 (Inertia)** describes an EU development path characterised by current parameters and conditions evolving towards the future without fundamental changes in space policies and governance. In this scenario, the key challenge is the lack of investment, unity and technological advancements, hindering the EU's ability to stay abreast of the global space competition. The key opportunity is that the EU can still leverage public-private partnerships to fund space investment and promote sustainable space practices. The emergence of mega-constellations and the increase in private companies' influence on space access raise the question of how governments can regulate the space sector, particularly regarding satellite proliferation and debris management.

The EU is confronted with trade-offs when it comes to the key question of 'investment vs. austerity'. This means deciding whether to continue investing in space technology and infrastructure during periods of stagnation, or to allocate limited resources to other priorities, such as addressing domestic economic challenges. While investing in space could yield long-term benefits, the lack of immediate returns could be seen as wasteful if the EU faces economic downturns.

In **Scenario 2 (Collaborative space)** the key challenge is to effectively manage the growth of the space economy while also mitigating the environmental impacts of increased space activities. An important opportunity is that international cooperation and mutual understanding can result in significant advancements in space technology, economic growth and social cohesion. In this scenario, the EU must find a balance between its ambitions for leadership in space governance and the need to maintain cooperation and shared development, all while integrating private industry into space activities. A dilemma for the EU in this scenario is whether to prioritise joint projects with other global powers, such as the US, China and India, or focus on building independent space technologies. Shared development could lead to valuable synergies but limit the EU's ability to pursue its own specific interests.

In **Scenario 3 (Strategic space race)**, a key challenge for the EU would be to navigate a complex geopolitical landscape, balancing its own interests in a complex context of international cooperation and sustainability. The main opportunities in this scenario are that the EU can emerge as a leader in critical technologies, such as AI, fusion, and quantum technologies, and promote a responsible and environmentally friendly approach to space exploration. A key dilemma facing the EU is that the cost of access to space is closely tied to global developments. Through strongly coordinated policies and increased investment in its space sector facilitated by steady GDP growth and a willingness to invest, the EU may achieve true strategic autonomy in space and become a space power by 2050.

Another dilemma may revolve around security versus economic expansion, specifically the choice between safeguarding EU assets through military space capabilities and promoting leadership in space exploration. This balancing act involves managing short-term competition alongside long-term sustainability. In other words, the question is whether investments should prioritise space defence and security (including defensive satellite systems and autonomous space defence capabilities) or focus more on economic opportunities like space tourism and commercial satellite systems. Both options require significant resources but differ in their long-term objectives.

As stressed by both Scenario 2 (Collaborative space) and Scenario 3 (Strategic space race), the EU could potentially possess the means to autonomously deploy, operate and benefit from any space-

related capability, including military, in order to support the achievement of objectives that it has autonomously determined. According to these two scenarios, genuine EU space expansion may occur with not only at least moderate GDP growth but also massive political and popular support from EU citizens and Member States. In other words, a sufficiently high GDP growth, combined with technological advancements, could translate into strategic investment and coherent policies to enhance the EU's space capabilities, potentially enabling it to achieve the status of a space power. In other words, Scenarios 2 and 3 have come true because the EU has managed to secure appropriate funding for space investment to be realised (public funds' spill-over effect on private funding). Contrary to the presence of collaboration under Scenario 2, the EU is going its own way towards space sustainability in Scenario 3.

Scenario 4 (Undefended) describes an EU development path characterised by continuous internal conflicts over resources, migration, etc., with highly inefficient institutions and self-centred behaviour displayed by the Member States. This implies that the EU is fragmented and eventually falling apart, and that the whole region is regressing technologically and militarily. In those circumstances, there is no longer joint security and defence cooperation for defending space assets and other common interests. The most critical challenge for the EU here is to overcome internal fragmentation and economic crises in order to remain a key player in the space sector. The EU's increasing fragmentation and the collapse of its institutions could result in a loss of control over critical space infrastructure. Without the ability to coordinate and protect its assets, the EU could face significant security and economic challenges, with its space assets at the mercy of competing nations or private corporations. Other key uncertainties in this scenario include the EU's decline and lack of strategic autonomy and the rapid increase in space debris, which must be addressed through regulation or international collaboration. An opportunity for the former Member States would be to start cooperating on removing space debris resulting from their earlier operations after 2050. This could be the nucleus of a future joint activity aimed at reducing risks, preventing collisions and maintaining a sustainable space environment.

In each scenario, the EU's critical choices revolve around security, economic growth, autonomy and collaboration. The trade-offs involve deciding how much risk the EU can and is willing to accept in the face of external competition or instability, as well as how it can align its space policy with broader political, economic, and strategic goals. These decisions will shape the EU's role in space as well as its future security, technological advancements and geopolitical influence.

The EU is one of the most experienced players in the space realm and has adequate capabilities across a huge array of activities in space. However it cannot be considered a fully-fledged space power due to disparities in several critical areas such as human space exploration, security and defence. The critical choices and trade-offs that the EU faces in each of the four space scenarios revolve around balancing risks and opportunities, investment and return, and short-term goals versus long-term strategic planning. These choices may determine the EU's ability to manage its role in space in a way that promotes both its security and global leadership. Several critical choices are recurring across the four scenarios, linked to trends and indicators that policymakers could monitor to identify potentially threatening developments and take safe and effective actions that involve low risk but also high potential for success and no significant trade-offs.

Fostering **international collaboration on space governance** helps shape the future of global space regulations and ensure peace and sustainability in space, as well as equitable access to space resources for all nations. The main question would be how the EU can navigate the complexities of global cooperation, weighing the benefits of collaboration against the risks of dependency and the need to protect its own interests.

Fostering **innovation and technological advancement** in key areas such as satellite technology, propulsion and space data analytics is highly important. Additionally, further investment in space situational awareness is crucial to protect the EU's space assets and reduce the risk of accidents in orbit. The main question for investment in space would be how to allocate resources for military and civilian space programmes, balancing the need for strategic autonomy with the pursuit of sustainable development and international cooperation.

When it comes to **sustainability and environmental responsibility**, it is crucial to prioritise sustainable space practices. This involves balancing the growth of the space economy with the need to mitigate environmental impacts and protect the space ecosystem. Enhancing space sustainability and effectively managing debris are essential to ensure that space remains safe and accessible for all users.

A major question regarding the EU's **strategic autonomy in space** is how to achieve and maintain it fully: whether through the development of its own capabilities, or through cooperation with other nations and international organisations. Supporting the growth of the EU space industry would undoubtedly strengthen the EU's competitive edge in the commercial space sector and ensure it technological sovereignty.

Ultimately, the EU's choices and trade-offs depend on its values, priorities, and vision for its role in the global space landscape. By considering the challenges, opportunities, choices and trade-offs presented in each scenario, one can reflect on the main elements needed for a comprehensive and forward-looking space policy that promotes its interests, supports sustainable development, and contributes to a more peaceful and stable world. An EU space policy and strategy, with adequate levels of political will and resources, are prerequisites to prevent the EU from falling behind on the global competitiveness scale, both in space and in other sectors enabled by space services. The EU can strengthen its position in space by taking several safe and effective actions that may be beneficial across all four space scenarios.

6. References

Aliberti, M., Capelli, O. Praino, R. 'Power, State and Space', Springer and European Space Policy Institute (ESPI), 2023.

Center for Strategic and International Studies (CSIS), Space Threat Assessment 2024.

European Commission, Implementation of the EU Space Programme and on the performance of the European Union Agency for the Space Programme, 2024.

European Commission, Commission staff working document. Evaluation accompanying the implementation of the EU Space Programme and on the performance of the European Union Agency for the Space Programme, 2024.

European Commission, European Union Space Strategy for Security and Defence, 2023.

European Parliament, Report on Strategic compass and EU space-based defence capabilities, 2023.

ESPI, High time for an EU Space Strategy for Security and Defence, Vienna, 2023.

ESPI, Future of Space Exploration: Strategic Scenarios for European Space Exploration 2040-2060, Vienna, 2023.

Friends of Europe, Running out of Space, Brussels, 2022.

EPRS, First EU space strategy for security and defence: What implications for EU strategic autonomy? Brussels, 2023.

Secure World Foundation, Global Counterspace Capabilities, 2024.

UNOOSA, For All Humanity – the Future of Outer Space Governance, Vienna, 2023.

QA-01-25-054-EN-Q

Space holds promise for both economic prosperity and the attainment of strategic goals. The EU's future role in space is contingent on fast-changing geopolitical dynamics, which can range from peaceful cooperation to heightened competition or conflict among global powers. Given the importance of this subject, the European Commission has announced plans to propose an EU space act in the second quarter of 2025.

This paper aims to describe the geopolitical context of space activities that affect the EU's current and future capabilities, with a specific focus on the use of space for security and defence and the response to space-related risks. Four distinct future scenarios present contextual conditions that may shape the EU's ambitions in space. The scenarios also highlight challenges and opportunities, while considering policy considerations for EU action.

This is a publication of the Policy Foresight Unit (PFOR)
EPRS | European Parliamentary Research Service

ISBN 978-92-848-2631-5 | doi: 10.2861/8152081 | QA-01-25-054-EN-Q