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Strategic Autonomy in EU Space Policy

Securing Europe's Final Frontier Through Launches, Laws, and Space Mining

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Source: Figure generated by DALL-E 3 via ChatGPT with own prompt.

The European Union (EU) is currently poised to enter the "new space race" with several regulatory and policy initiatives. However, Europe's space policy suffers from its overly civilian approach, a fragmented institutional base, and a launcher crisis. To achieve strategic autonomy in space, the EU should formulate a comprehensive strategy for European launchers, prioritise a space-related industrial policy with the European preference principle, establish rules on transparency, ownership, and debris in space, and incentivise space mining.

- ► It is imperative for the EU and its Member States to establish a coherent and unified launcher strategy that reinforces existing platforms and fosters technological advancements in launcher capabilities, including reusability, to ensure Europe has independent access to space and remains competitive in the future. Traditional procurement policies need to be re-evaluated to overcome inefficiencies and fragmentation and to align them more closely with commercial ambitions. A new EU industrial policy strategy should include measures for the protection of critical space infrastructure and promote synergies between civil and security space activities.
- ► Space debris poses not only an increasing environmental burden but also strategic challenges. Technical solutions to remove and recycle larger debris objects should be financially supported by aggregating European institutional demand. The Space Law should establish an internal market for debris avoidance data and oblige non-European actors to comply with the requirements if they want access to the European market.
- ► The EU needs clear and binding rules regarding ownership of space resources, and transparency to secure access and avoid conflicts. Firstly, the EU should work towards common international rules, and a binding international registry on space mining activities should be set up. Secondly, the EU should provide for ownership of space resources to avoid fragmentation and unfair competition within the EU.

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1 Introduction: the EU must enter the new space race

A space data strategy, a forthcoming space law, and ongoing consultations: **The European Union (EU) currently aims to enter the "new space race" with several regulatory and policy initiatives**.[1] In particular, in March 2024, the European Commission plans to propose an EU Space Law and an associated strategy for the space data economy, in order to establish common EU rules on the safety, resilience, and sustainability of space activities and to ensure the competitiveness of its space sector.[2] While details are scarce, the measures will likely include collision avoidance and debris removal in space, risk management rules for cybersecurity and the physical protection of space assets, and measurement methods for the environmental impact of space activities over their life cycle. EU leaders identified space as a strategic domain back in 2022 and called for an EU Space Strategy for Security and Defence.[3]

However, space is an increasingly contested area. Due to recent advances in astronautical engineering, the success of private companies, such as Elon Musk's Space X or Jeff Bezos' Blue Origin, as well as military demands, both the United States (US) and China have become prominent figureheads of the contemporary space race.[4] In this context, **this cepInput analyses the prospects and challenges for an EU space policy from the perspective of "strategic autonomy"** – defined as the EU's ability to make decisions independently while taking into account its own interests and values[5] – **and formulates several demands for upcoming regulatory actions in space**. Strategic autonomy in space is fundamentally determined by a nation's ownership and control over critical space infrastructure, particularly in the context of launching capabilities, which serve as the backbone for independent economic operations and national security. This autonomy is further reinforced through long-term capacity building and the cultivation of specialized competencies, i.e. the highly technical and operational expertise required to design, implement, and manage space missions and related technologies. The EU should therefore go beyond investing in traditional priorities such as satellite navigation, Earth observation, and space situational awareness but formulate a broader space strategy that emphasises the strategic importance of developing specific competencies within a coherent institutional European framework.

With a view to the EU Space Law announced for March, **this policy brief examines how the EU can develop such a strategy and what elements it should include in order to secure its strategic autonomy in space**. Access to space, i.e. launch capabilities, play a special role, as the EU has become heavily dependent on external actors – especially the US – in the last two years. We also point to the potential for space mining, which seems to be underexposed in the current discourse on critical resources. Ultimately, it is a question of having a "regulatory framework" for economic activities in space, as it will be private actors who will increasingly gather there, rather than nation states as in the past. We know from institutional economics that elements such as transparency and property rights are essential for market development – such elements now need to be designed quickly for the emerging space economy and anchored as internationally as possible. Before looking at the individual elements of the strategy, the remainder of this introduction will set out the main institutional, historical and legal aspects of the

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1 Sandulli, A. (2023), The Growth of Space Regulation in Europe, Weekend Edition №165 - EU Law Live, pp. 3-4.

2 Targeted consultation on EU Space Law - European Commission (europa.eu).

3 Joint Communication to the European Parliament and Council, the Commission, European Union Space Strategy for Security and Defense (Mar. 10, 2023), Register of Commission Documents - JOIN(2023)9 (europa.eu).

4 Jay Bains (2022), Has Mars become the new space Race? - ScienceDirect, REACH 27–28.

5 Armin Steinbach (2023), EU's Turn to 'Strategic Autonomy': Leeway for Policy Action and Points of Conflict | European Journal of International Law | Oxford Academic (oup.com), p. 2.

background to EU space policy. **From an historical perspective, European space policy has developed in several stages**.[6] Prior to the 1960s, space exploration was predominantly a national endeavour, with significant contributions from France and the United Kingdom. This landscape shifted in 1975 when ten European countries formed the **European Space Agency (ESA)**, marking a collaborative approach to space exploration. The Commission's involvement in space policy began in 1988, motivated by the influence of the single market on space activity regulation, and the societal benefits of space exploitation in areas like telecommunications and earth observation. The synergy between the ESA and the European Community was further emphasized in a 1998 resolution, entrusting the ESA with the development of long-term European space policy, while the European Community handled the legal and economic aspects impacting space-related markets. The dissolution of the Soviet Union and the emergence of new space powers in the early 1990s significantly altered the European space policy context. A more transversal approach to space policy was adopted in 1996, shifting focus from research and development to applications and services derived from space infrastructure. A milestone was achieved in 2003 with the establishment of a strategic partnership between the ESA and the European Community, which led to the creation of the Space Council, a joint secretariat, and a high-level space policy group. Establishing the Union Space Programme and the European Union Agency for the Space Programme (EUSPA) marks the latest significant evolution in EU space policy.[7] In policy terms, satellite navigation and earth observation have been the key priorities at the European level since the 1990s. The EU implemented these through its **flagship programs, Galileo and Copernicus**, which handle satellite navigation and earth observation, respectively. In addition, the Commission plans to launch a third constellation, via the **Union Security Connectivity Programme (IRIS²)**, for secure communications.[8] This public-private partnership between the Commission and the private sector will benefit from a contribution from the EU budget of €2.4 billion, with full operational capability for governmental services being expected for 2027. It reflects the current geopolitical shift in EU space policy, which underlines the need to formulate shared policies among Member States.

With respect to the **legal framework**, the Treaty of Lisbon created the first separate legal basis for space policy [Art. 189 TFEU]. It is part of the shared competences of the EU and its Member States with the feature that the Member States are not impaired in the exercise of their competence [Art. 4 (3) TFEU].[9] Although Art. 189 TFEU also contains further restrictions, namely that the EU's competences exclude any harmonisation of the laws of the Member States,[10] the mosaic of different competences found in the Treaties can be used to pave the way – at least in theory –for a comprehensive and cohesive European space policy.[11] In general, one must bear in mind that space law consists of international and European law as well as national legislation.[12]

6 Vincent Reillon (2017), 'European space policy; Historical perspective, specific aspects and key challenges', European space policy: Historical perspective, specific aspects and key challenges | European Parliament (europa.eu), pp. 3-28.

7 Regulation (EU) 2021/696 of the European Parliament and of the Council of 28 April 2021 establishing the Union Space Programme and the European Union Agency for the Space Programme, OJ L 170, 12.5.2021, p. 69–148. See also: Sandulli, A. (2023), European Union and National Space Regulation, Weekend Edition Nº165 - EU Law Live, p. 6.

8 Space: EU secure connectivity satellite constellation, IRIS² (europa.eu).

9 Trute/Pilniok, in: Streinz (ed.), EUV/AEUV, 3rd edition 2018, Art. 189 TFEU, para. 1 and Eikenberg, in: Grabitz/Hilf/Nettesheim (ed.), Das Recht der Europäischen Union, August 2023, Art. 189 TFEU, p. 1.

10 See also Schladebach, M. (2020), Weltraumrecht, p. 32.

11 See Samantha Potter (2023), Approaching Harmonization: Examining the European Union's Efforts to Create a Common EU Space Law and Assessing its Potential Legal Foundations, Stanford-Vienna European Union Law Working Paper No. 77.

12 International law consists of five international treaties that make up the basic architecture: The Outer Space Treaty forms the basis due to its fundamental nature. In addition, specific aspects are regulated in the Outer Space Rescue Convention,

As is already clear from this cursory overview, **the European institutional landscape with respect to space policy is highly fragmented**. This is mainly due to the fact that no original independent EU institutions are being created for EU activities in space. Instead, the capacities of the ESA, which has existed since 1975 as an independent international organisation, are being utilised. The ESA currently comprises 22 European states, whose membership is independent of their membership of the EU and includes non-EU states such as Norway, Switzerland, and the United Kingdom. As a result of the EU's cooperation with the ESA, EU space policy has essentially been externalised.[13] On the one hand, the ESA is skilled in carrying out space programs, focused on space science and exploration initiatives in Europe. On the other hand, the EU handles the regulatory aspects and encourages Member States to utilize EU space infrastructure, services, and data. The EU can unite Member States' demands and has the financial means to fund extensive, long-term space projects such as the Galileo program, but lacks the expertise to manage and operate these programs. In addition, governance of EU space policy is further complicated due to the nature of EU space competence as designed in the Treaties and the different procedures applicable to civil and security/defence aspects of space respectively.[14] Therefore, European space policy is currently conceptualised and implemented by several actors, above all the Commission, European intergovernmental organisations such as the ESA and the European Organisation for the Exploitation of Meteorological Satellites ("EUMETSAT"), as well as some key Member States with national space agencies (Table 1).

Tab. 1: European space policy priorities

Activities	EU	ESA	EUMETSAT	EUSPA	Member States	National space agencies	Industry
Define space policy	Yes	Yes	-	-	Yes	-	-
Define & fund space programmes	Yes	Yes	Yes	-	Yes	-	Private sector
Develop & implement programmes	-	Yes	-	-	-	Yes	Yes
Operate space programmes	-	Yes	Yes	Yes	-	Yes	Private sector
Fund space R&D activities	Yes	Yes	-	-	Yes	-	Yes
Perform space R&D activities	-	Yes	-	-	-	Yes	Yes
Conduct space exploration programmes	-	Yes	-	-	-	Yes	-
Regulate the space sector	Yes	-	-	-	Yes	-	-

Source: Own table, adapted from EPRS (2017). Note: Based on Commission Communications up until 2016. Abbreviations: ESA =European Space Agency; EUMETSAT = European operational satellite agency; EUSPA = European Union Agency for the Space Programme, formerly known as European Global Navigation Satellite Systems Supervisory Authority (GSA).

This fragmentation of the European landscape leads to a lack of clear long-term vision defined at the political level. In light of the EU's current policy "turn to strategic autonomy" and the upcoming draft EU Space Law and strategy for a space data economy,[15] **this cepInput proposes one such long-term**

the Outer Space Liability Convention, the Outer Space Registration Convention for objects launched into outer space as well as the so-called Moon Treaty. However, the latter has only been ratified by a few states and none of the major space-faring nations, rendering it practically meaningless. See altogether Schladebach, M. (2020), Weltraumrecht, p. 25-27.

13 See in summary Schladebach, M. (2020), Weltraumrecht, p. 32.

14 Chiara Cellerino, EU Space Policy and Strategic Autonomy: Tackling Legal Complexities in the Enhancement of the 'Security and Defence Dimension of the Union in Space', European Papers, Vol. 8, 2023, No 2, European Forum, Insight of 27 July 2023, pp. 487-501.

15 Armin Steinbach (2023), EU's Turn to 'Strategic Autonomy': Leeway for Policy Action and Points of Conflict | European Journal of International Law | Oxford Academic (oup.com).

vision for a strategic and autonomous EU space policy. It places two elements centre stage, namely **autonomous launching capabilities and access to critical resources for space mining**. This is in line with the idea that in the future, the space domain will be a key "enabler of EU strategic autonomy"[16] because space applications are a fundamental technology contributing to the security and defence of the Union. In particular, to achieve strategic autonomy in space, the EU should formulate a comprehensive strategy for European launchers and prioritise a space-related industrial policy. Moreover, technical solutions to remove and recycle larger debris objects should be financially supported by aggregating European institutional demand. Finally, the upcoming Space Law should oblige non-European actors to comply with the rules and establish an internal market for debris avoidance data.

The remainder of this paper is structured along the lines of a prototypical space economy endeavour, i.e., beginning on earth, moving to actions in space, and then returning with commercially viable resources. It starts by discussing how to secure independent launch capabilities (section 2), as future exploration, business, and security in space will be dictated by how efficiently Europe can secure access to low-earth orbit (LEO). We then discuss the practical as well as legal challenges of moving in space, highlighting the problems of debris that motivate the EU's current proposals for a sustainable Space Law (section 3). Finally, we discuss the legal problems related to the status of ownership of space resources and transparency, as this constitutes a crucial element for the EU's future strategic autonomy (section 4). In particular, we look at the prospects for platinum, which is highly relevant, especially in a future hydrogen economy, for its increased use in automotive and industrial applications as well as in PEM technologies (i.e. so-called Proton exchange membrane (PEM) electrolysis)[17]. The last part summarises and formulates several demands for the EU's new space policy (section 5).

2 Securing space access: independent launching capabilities

In space-faring nations, there is typically a connection between the civilian and defence-related elements involved in space travel.. In Europe, however, security and defence matters have traditionally been viewed as issues of national sovereignty. The **EU's civilian approach to space has been undermined by the conflict in Ukraine and the rise of disruptive technologies owned by private actors**, highlighting significant geopolitical oversights and vulnerabilities in Europe's space capabilities. As the European Space Policy Institute noted in its latest Yearbook, the EU's traditional approach did not adequately consider the geopolitical and technological shifts over the past decade, leaving European space endeavours exposed to significant risks.[18] As warfare evolves, the importance of space capabilities, including the use of large fleets of small satellites, will increase, making space a more accessible yet contested area. Space assets are anticipated to be crucial in shaping military operations across traditional domains by enhancing capabilities like real-time surveillance, communication beyond line-of-sight, precision weapon guidance, and intelligence gathering for effective command

[16] Chiara Cellerino, EU Space Policy and Strategic Autonomy: Tackling Legal Complexities in the Enhancement of the 'Security and Defence Dimension of the Union in Space', European Papers, Vol. 8, 2023, No 2, European Forum, Insight of 27 July 2023, pp. 487-501.

[17] On this see Kumar, S. / Himabindu, V. (2019), Hydrogen production by PEM water electrolysis – A review: "Water electrolysis is one of the most promising alternatives to store energy from renewable energy resources (…) [and] PEM water electrolysis provides a sustainable solution for the future clean production of high pure hydrogen."

[18] ESPI Yearbook 2022 – Space policies, issues & trends, p. 19.

and control.[19] Future military strategies will increasingly rely on space capabilities to achieve cognitive superiority and direct operations.

Europe's vulnerabilities must be addressed through large-scale European efforts to **enhance strategic autonomy and independence** in its space program, as is slowly but increasingly recognised by some EU policymakers. For instance, in a speech given by EU Commissioner for the Internal Market, Thierry Breton, at the 14th European Space Conference in early 2022, the strategic importance of space and the necessity for a resilient space policy were central topics. Drawing parallels to cyberspace, he emphasized the need to enhance the defence aspect of existing EU infrastructures like Galileo. He also called for the creation of new infrastructures that inherently serve dual purposes and incorporate defence elements from the beginning, such as equipping the secured connectivity infrastructure with satellites for space monitoring. The key objective expressed in this speech was to reduce technological dependencies to bolster the resilience of EU space infrastructure.[20] In late 2023, Breton reiterated that "we must have the means to defend our strategic interests and protect our space infrastructures."[21] This is particularly urgent in light of China's space program, which has not only closed the gap with American capabilities in orbit but is directly tied to the military and includes applications such as anti-satellite weapons and space nukes.[22] In late 2021, Beijing's test of a nuclear-capable hypersonic missile caught US intelligence by surprise.[23] Most recently, at the 16th edition of the European Space Conference in January 2024, Breton described "sovereignty in terms of access to space" as "imperative" for the EU to remain a credible space actor.[24] However, it is not yet entirely clear what exactly could define a distinctive European approach.

From an historical perspective, **the need to make strategic independence and autonomy in space access a requirement and an objective, has been repeatedly voiced but only vaguely conceptualised and seldom implemented**. As early as 1979, when the European Parliament adopted its first resolution on European Community participation in space research, policymakers argued that Europe had to maintain its autonomy.[25] The expert report "Crossroads in Space", published for the Commission in 1992, acknowledged that Europe must retain its independent and reliable launch capability as a strategic necessity.[26] And in its white paper on European space policy in November 2003, the Commission called on all stakeholders and partners "to mobilise behind new goals and to rise to new challenges", especially the goal to secure Europe's strategic independence regarding access to space, space technologies and space exploration.[27] Again, in its April 2011 communication "Towards a space strategy for the European Union that benefits its citizens", the Commission noted that to achieve its

[19] European Defence Agency (2023), "Enhancing EU Military Capabilities beyond 2040", p. 22.
[20] Speech by Commissioner Thierry Breton at the 14th EU Space Conference, European Commission, January 2022, https://ec.europa.eu/commission/presscorner/detail/en/speech_22_561.
[21] European Commissioner Thierry Breton on Strengthening the European Defence Industrial Base (defense-aerospace.com).
[22] US Department of Defence (2023), 2023 Report on the Military and Security Developments Involving the People's Republic of China (CMPR) (defense.gov).
[23] China tests new space capability with hypersonic missile (ft.com).
[24] Speech by Commissioner Breton - EU Space: the Top 5 Priorities for 2024 and beyond, January 2024, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_24_368.
[25] European Parliament resolution on Community participation in space research, OJ C 127, pp. 42–43, 21 May 1979, EUR-Lex - JOC_1979_127_R_0024_01 - EN - EUR-Lex (europa.eu).
[26] Commission of the European Communities, The European Community crossroads in space, 1992, The European Community - Publications Office of the EU (europa.eu).
[27] Commission white paper 'Space: a new European frontier for an expanding Union – An action plan for implementing the European Space policy', COM(2003) 673, 11 November 2003, EUR-Lex - 52003DC0673 - EN - EUR-Lex (europa.eu).

objectives, the key was “to keep independent access to space”.[28] The space strategy for Europe adopted by the Commission in October 2016 aims to support “autonomous, reliable and cost-effective access to space”.[29]

The **most fundamental aspect of the envisioned independent access to space are space launch vehicles**. In a recent report outlining the strategic challenges that are likely to shape the operational environment for EU Armed Forces beyond 2040, EU defence planners note that new and cheap launchers that enable the “rapid commissioning of assets” will be “paramount to ensure a responsive access to space”.[30] Historically, the EU has relied on the Ariane and Vega platforms, embodiments of years of investment and accumulation of expertise. However, the development and deployment of Ariane 6, Europe’s next-generation heavy-lift launcher, has faced numerous technical and financial challenges. Additionally, the failure of the Vega C rocket on its second flight in December 2022 – following a successful maiden flight in June of that year – has added to the concerns about the reliability and readiness of Europe’s space launch infrastructure. According to the latest information from the ESA, the inaugural flights of Ariane-6 are now expected for mid-June and the end of July 2024, and the return flight of Vega-C should take place at the end of the year.[31] As a result, **Europe is currently facing a notable “launcher crisis”**, which has been exacerbated by the loss of the Russian Soyuz rockets. Russia withdrew from Europe’s French Guiana-based launchpad in Kourou in the spring of 2022 in retaliation for the EU’s imposition of sanctions following Russia’s attack against Ukraine. This has been a critical blow to European space launch capabilities and has led to an even **greater reliance on private US companies like SpaceX**.[32]

Figure 1 shows the annual number of objects launched into space by various countries and entities from 1957 to around 2022. The data includes satellites, probes, landers, crewed spacecraft, and space station flight elements launched into Earth’s orbit or beyond and is based on data published by the United Nations Office for Outer Space Affairs.[33] According to UN estimates, the data captures around 88% of all objects launched. The graph shows that the ESA has had a relatively stable launch activity over the years, which indicates a consistent presence in space. However, the figure also reveals a significant disparity between the number of objects launched by the ESA and the leading space-faring nations like the United States, China, and Russia. Especially in recent years, the US has seen a dramatic increase in launches, driven by the expansion of SpaceX’s Starlink system, which overshadows the activity of other countries and agencies, including the ESA. While the development of smaller, cheaper, and easier to deploy satellites promises to make space an “increasingly accessible and contested domain”[34], the key challenge remains how to launch them in sufficient numbers. To increase its autonomy in space, the EU should thus focus on enhancing its launch capabilities, investing in independent space technology, and perhaps expanding the scale and scope of its space missions.

[28] Communication from the Commission, 'Towards a space strategy for the European Union that benefits its citizens', COM(2011) 152, 4 April 2011, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0152.

[29] European Commission, Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Space strategy for Europe, European Commission, COM(2016) 705, 26 October 2016, EUR-Lex - 52016DC0705 - EN - EUR-Lex (europa.eu).

[30] European Defence Agency (2023), “Enhancing EU Military Capabilities beyond 2040”, p. 22.

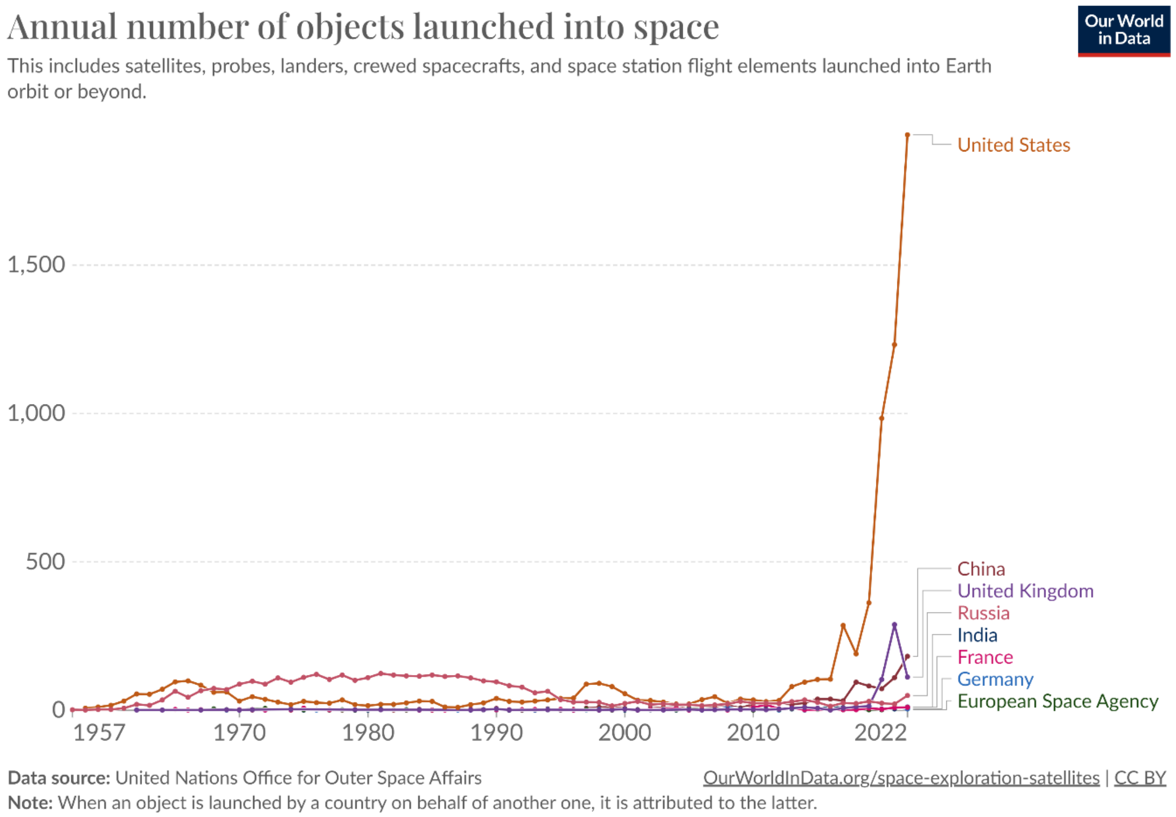
[31] Pugnet, A. (2024), Europe’s Ariane-6 rocket maiden flight expected by summer, space agency boss says – Euractiv.

[32] ESPI (2022), The War in Ukraine and the European Space Sector - ESPI, ESPI Executive Brief No. 57.

[33] Search OSOidx (unoosa.org). The data was scraped and harmonised by the “Our world in data” service.

[34] European Defence Agency (2023), “Enhancing EU Military Capabilities beyond 2040”, p. 22.

Fig. 1: Annual number of objects launched into space



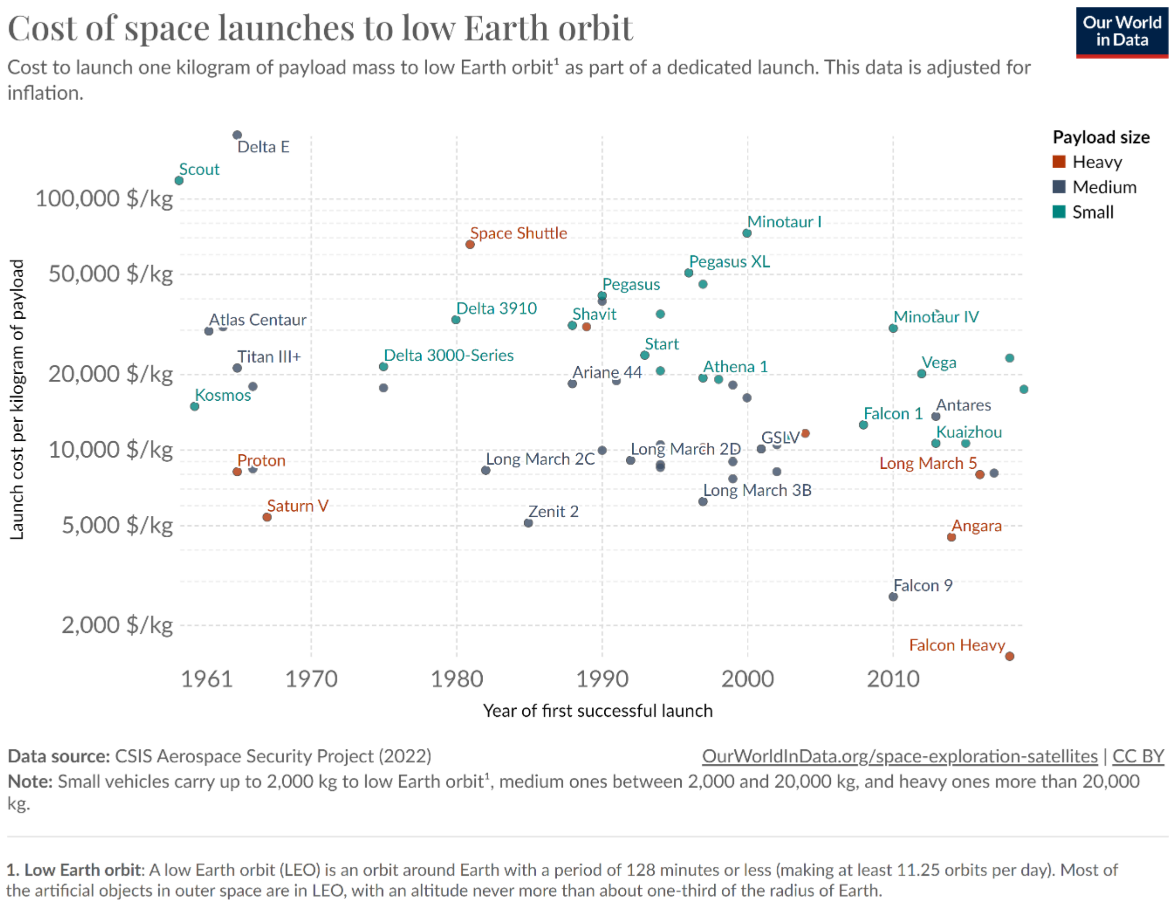
Source: Own Illustration. Data: Online Index of Objects Launched into Outer Space (2023).

However, not all launches and objects are comparable; from the perspective of EU space autonomy, the **capability to launch payloads to low Earth orbit (LEO) holds particular strategic and economic interest**. Strategically, LEO serves as a critical zone for military and intelligence satellites, providing advantages in surveillance, communication, and navigation. The 1.5 million customers that Starlink, SpaceX's growing network of LEO communications satellites, possesses as of today also includes the Ukrainian military.[35] The deployment of satellites in LEO enables real-time data acquisition, which is vital for military operations and national security, not least since it has been recently shown that Starlink signals can be reverse engineered to work like GPS.[36] China has developed ground-launched missiles that can hit satellites in LEO and its successful test of this capability in 2007 is nowadays described by military experts as a "turning point in the history of military space operations".[37] Economically, LEO is pivotal for the burgeoning commercial space industry. It is the gateway for satellite constellations that support telecommunications, earth observation, and increasingly, internet provision to remote areas. For instance, Amazon's prototype internet satellites, which will feature in its Project Kuiper (3236 Project satellites), contain infrared lasers that allow the transfer of data at 100 gigabits per second over a distance of nearly 1000 kilometres.[38] Finally, LEO is also essential for scientific research and exploration in fields like medicine, material science, and environmental

[35] Laursen, L. (2023), Satellite Signal Jamming Reaches New Lows - IEEE Spectrum.
[36] Starlink signals can be reverse-engineered to work like GPS—whether SpaceX likes it or not | MIT Technology Review.
[37] Harpley, U. L. (2023), Saltzman: China's Anti-Satellite Weapons Are 'Compounding Problem We Have to Figure Out' (airandspaceforces.com).
[38] Harris, M. (2023), Amazon Fires Up Its Space Lasers - IEEE Spectrum.

monitoring. Overall, this dual utility in both strategic and economic/scientific domains underscores the importance of LEO access.

Fig. 2: Cost of space launches to LEO



Source: Own Illustration. Data: Center for Strategic and International Studies.

Given that the Commission hopes to “fully exploit” upcoming LEO constellations “for new capabilities, including augmented services that may be of use to the military by offering piggybacking payloads”,[39] one wonders where Europe stands in this area. Figure 2 depicts **the cost of space launches to low Earth orbit over time**, a good proxy for the evolution of space technology efficiency and the economic aspect of satellite launches. The underlying data stems from the Center for Strategic and International Studies and standardizes costs by calculating the price to launch one kilogram of payload to LEO in a dedicated launch.[40] The launch costs encompass all direct and indirect manufacturing expenses, overheads, recurring engineering costs, sustaining tooling, and quality control. From the perspective of EU strategic autonomy in space, this data can be used as a benchmarking tool to assess Europe’s position. The cost of transporting heavy payloads to LEO has significantly decreased over time,

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[39] Joint Communication to the European Parliament and Council, the Commission, European Union Space Strategy for Security and Defense (Mar. 10, 2023), Register of Commission Documents - JOIN(2023)9 (europa.eu), p. 12.

[40] Cost for Space Launch to Low Earth Orbit- Aerospace Security Project (csis.org). The data was scraped and harmonised by the “Our world in data” service. Where direct figures are not available, the cost-per-kilogram figures are derived from the median total launch cost and the vehicle’s maximum payload capacity.

dropping over 95% from $65,000 to $1,500 per kilogram. This dramatic reduction in price is partly responsible for the recent surge in satellite launches by various companies and governments.

Crucially, the key driver behind this development is Elon Musk's SpaceX, with its ambitious Starlink project aiming to deploy up to 42,000 satellites to provide global broadband and additional services.[41] Clearly, **the launching capabilities of Space X – shown thorough the two dots representing Falcon 9 and Falcon Heavy in the lower right corner – are by far the most effective on the global market**, and easily surpass Europe's Ariane. In the case of China, its domestic "Long March" rockets provide it with a similarly effective but – again – more costly way to transport heavy payloads, including a new hypersonic glide vehicle, to orbit.[42] Tellingly, even Amazon's Project Kuiper initiative depends, at least partly, on support from its rival SpaceX in launching its more than 3,000 satellites into orbit.[43] Initially, Amazon booked nine launches with United Launch Alliance (ULA) in 2021, using the remaining stock of the retired Atlas V rocket. Later, the company acquired additional launches with Arianespace, Blue Origin, and ULA, including 18 launches with Ariane 6, 12 with New Glenn, and 38 with Vulcan.[44] Eventually, in December 2023, Amazon also commissioned three Kuiper launches using SpaceX's Falcon-9 rockets, due to development problems of the other rocket systems.[45] Notably, Amazon faced a lawsuit from an institutional shareholder for not initially choosing SpaceX's cheaper Falcon 9 rockets,[46] again underlining their crucial advantages in cost-effectiveness.

How will this market change in the coming years and where does this leave Europe? A recent simulation analysis of the space industry's growth up to 2030 involves three scenarios, each based on various factors like satellite deployments, mass, lifespan, and launch schedules, including commercial space stations.[47] The scenarios range from high to low demand, with the middle scenario predicting 27,000 active satellites by 2030, requiring 4,000 to 5,000 launches annually. A specific consideration is given to **SpaceX's huge influence**, particularly if its **Starship program** and Starlink V2 deployment face delays – this is increasingly likely as the two failed launch attempts of Starship illustrate.[48] If these problems persist, it could lead to a temporary launch shortfall, estimated at around 3,000 tons, equating to a year's worth of launches. The transition to next-generation launch platforms may thus **initially cause a supply shortage**, offering an opportunity for (European) providers to capture market share through quick operational ramp-up and cost control. However, over time, as launch frequency and reliability improve, the industry might even face oversupply, making cost control crucial for competitiveness.

In the face of these recent EU setbacks, robust competition, and changing geopolitics, it becomes imperative to **formulate a comprehensive strategy for European launchers** to ensure a more self-reliant and independent space access capability. Tellingly, a definition of the term "resilience" adapted for the space context includes "the ability to launch and quickly replace any critical space asset".[49] This

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41 Starlink satellites: Facts, tracking and impact on astronomy | Space.
42 China tests new space capability with hypersonic missile (ft.com).
43 Day, M. (2023), Amazon's Project Kuiper to Challenge Elon Musk's Starlink Satellite Internet - Bloomberg.
44 Jeff Bezos and Amazon just hired everybody but SpaceX for Project Kuiper | Ars Technica.
45 Amazon adds Falcon 9 to multi-billion-dollar Project Kuiper launch campaign - SpaceNews.
46 Amazon sued by shareholders for excluding SpaceX in Kuiper launch bid (spaceexplored.com).
47 Space launch: An oversupply or a shortfall? | McKinsey.
48 SpaceX Starship launch failed minutes after reaching space | Reuters.
49 Definition taken from: Eurospace Position Paper (2023), European space industry contribution to the future "EU Space Law", p. 10.

cepInput calls for the EU, the ESA, and their Member States to further develop and prioritise a **space-related strategic industrial policy** to safeguard Europe's economic requirements but also its independent operational capability over the next two to three decades. In fact, since the establishment of the Lisbon Treaty, the EU legally possesses the competence to develop and implement an industrial policy in the space sector. As far back as February 2013, the Commission envisioned an EU space industrial policy consisting of five objectives: establish a coherent and stable regulatory framework; further develop a competitive, solid, efficient and balanced industrial base in Europe and support SME participation; support the competitiveness of the EU space industry; develop markets for space applications and services; and ensure technological independence and independent access to space.[50] To accelerate a space-related strategic industrial policy for Europe, the Commission should collaborate closely with the ESA to support launch infrastructure, including through the instrument of public-private partnerships, and to promote R&D and tech start-ups in this sector through EU funds under the Horizon framework for research and innovation. The industrial policy strategy should also consider specialised support for launcher activities, protection of critical European space infrastructures, and more synergies between civil and security space activities to explicitly acknowledge the defence dimension of space activities.

To this end, Breton has proposed two ideas that may be valuable elements in this industrial strategy but have not, so far, been successful in convincing all Member States: Firstly, the **establishment of a European Space Launcher Alliance**, which could be instrumental in fostering a unified European stance on launchers and delineating a technological trajectory.[51] This is very important, as advanced launching capabilities (such as reusability) can only be developed if there is sufficient demand, which is currently lacking. Here we point to the Commission's current ambition to introduce, under its Green Deal Industrial Strategy, a "European preference" policy.[52] This would involve revising current public procurement regulations to give preference to European companies in certain contexts. This would mark a significant shift from the existing approach, where public contracts in Europe are generally open to both European and non-European companies, adhering to the principles of a free market. At the moment, there is no clear European preference in space-related contracts, i.e. external providers such as SpaceX can be (and are) chosen if they are cheaper, and important Member States such as France and Germany pursue different approaches and interests, which means that no European rival to SpaceX can be established.[53] By aggregating institutional demand from the EU and the different Member States, a critical level of demand could be reached to put the European space industry on a better long-term development path. Breton's initiative aims not only to reinforce the significance of existing launch platforms, but also to pave the way for the development of small and micro launchers. **Our analysis supports the establishment of a fully-fledged European launcher strategy**, but despite Commissioner Breton's interest in this area (voiced as early as 2022), the Commission's strategy on space and defence is currently lacking such an element. This unfortunate situation must be remedied by the upcoming Commission initiatives. In fact, in January 2024, Breton reiterated his demands for a European launcher policy within an EU framework and proposed to include, in the next EU Space Programme, a fully-fledged "access to space" component, covering all the aspects of a dedicated

[50] Communication from the European Commission, EU space industrial policy, European Commission – releasing the potential for economic growth in the space sector, COM(2013) 108, 28 February 2013.

[51] Speech by Commissioner Thierry Breton at the 14th EU Space Conference, European Commission, January 2022, https://ec.europa.eu/commission/presscorner/detail/en/speech_22_561.

[52] See Buy European Act: An effective response to the US Inflation Reduction Act? – Euractiv.

[53] See also: Rocket revolution threatens to undo decades of European unity on space (ft.com).

European Launcher policy from R&D to deployment.[54] In light of the cost savings reaped by SpaceX's reusable launch vehicles, which are transforming the economics of space travel,[55] **any new Space Launcher Initiative in Europe should aim to develop similar technical capabilities for reusability**, which might necessitate aligning the requirements across all EU territories where launches could be operated or where spaceport projects are planned.[56] Secondly, Breton's **flight ticket initiative**, which describes the use of public procurement to stimulate the ecosystem for mini- and micro-launchers by giving them launch service opportunities, is likewise laudable.[57] In this framework, new launch systems will have the possibility to provide launch services for certain institutional launches, starting with In-Orbit Demonstration and Validation. As can be seen from the examples of SpaceX and Blue Origin in the US, these forms of nurturing the private space sector can eventually pay off in the future.

However, to achieve these objectives in sufficient time, **Europe must change its approach to procurements in the space sector**, which has, historically, been based on the principle of "fair return" (*juste retour*), under which procurements follow a geographical distribution matching member state budgetary participation.[58] This approach, while ostensibly fair and helpful in integrating companies from smaller Member States, can lead to inefficiencies and fragmentation in the development of critical technologies. For instance, it seems that many of the delays regarding the Ariane-6 can be explained by the micro-management and inefficient incentive structure of the "fair return" approach, which might lead some suppliers to charge monopoly prices. As the space economy in the EU is witnessing a growing convergence of governmental objectives and commercial ambitions, **a key challenge for the coming decade will be to better align European entrepreneurial goals with EU policy objectives**, optimizing synergies between different actors in the space industry. Accordingly, European public procurement policies must undergo further changes to enable competition in emerging markets and allow for more public-private partnership models.[59] Some notable examples in this regard include the ESA ScaleUp programme,[60] the Commission's recent proposal for the European Defence Industry Reinforcement through Common Procurement Act (EDIRPA), the European Defence Fund's inclusion of space-related projects, as well as the ESA's "Boost! Programme". However, **a broader effort to adapt procurement strategies in the EU space economy is necessary**. In this regard, public procurements and fiscal benefits by Member States should be used as a mechanism to encourage compliance with the EU Space Law[61] but also as an incentive for developing a joint European launcher approach, which would include open competitions to develop SpaceX-like capabilities. Some promising signs in this direction were visible at the 2024 European Space Conference, as Breton called for **aggregating European institutional demand for launch services** from all public actors, including

[54] Speech by Commissioner Breton - EU Space: the Top 5 Priorities for 2024 and beyond, January 2024, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_24_368.

[55] See also: The Rise of Reusable Rockets: Transforming the Economics of Space Travel | KDC Resource.

[56] This is highlighted by industry participants, see: Eurospace Position Paper (2023), European space industry contribution to the future "EU Space Law", p. 7.

[57] Speech by Commissioner Thierry Breton at the 14th EU Space Conference, European Commission, January 2022, https://ec.europa.eu/commission/presscorner/detail/en/speech_22_561.

[58] See: European space policy: Historical perspective, specific aspects and key challenges | Think Tank | European Parliament (europa.eu), p. 4.

[59] For the following examples regarding European procurement policy, see: ESPI Yearbook 2022 – Space policies, issues & trends, pp. 8, 24, 42f.

[60] Consisting of two main pillars: "Innovate", which supports innovation and commercialization in space products/services, and "Invest", which aids in scaling up companies.

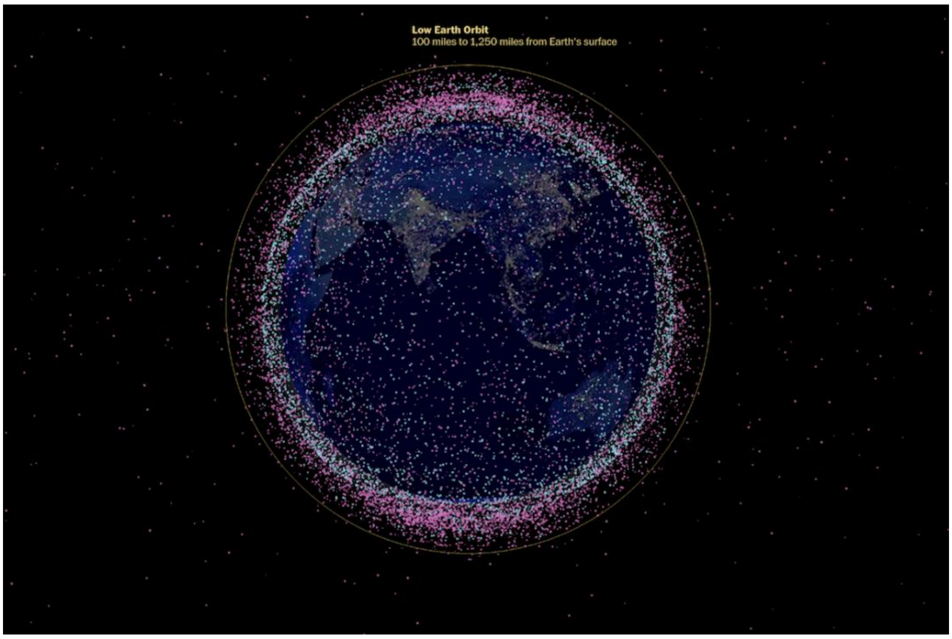
[61] This is also demanded by: Eurospace Position Paper (2023), European space industry contribution to the future "EU Space Law", p. 7.

the defence ministries of Member States, **in line with a clear European preference principle**.[62] He also promised further support for innovation in launch services through competitive challenges and pilot projects, although the amount of funding earmarked for this type of research support seems too small (€50 million).

3 Securing space safety: the role of debris

Space debris is an increasing problem and, according to the consultation, a key motivation behind the EU's current plans for a Space Law. As of mid-2023, there are roughly 14,000 small, medium, and large debris objects present in LEO, i.e., between 100 and 1,250 miles above the Earth. This does not include the millions of debris fragments that are too small to be tracked. According to data on known debris (illustrated in Figure 3), which includes unused satellites, fragments of rockets, and other remnants, about 90% of active satellites and a majority of space debris are located in LEO, i.e., in a strategically and economically viable zone (see argumentation in section 2 above). This heightens the possibility of collisions between space junk and functioning satellites and, more generally, potentially hinders the EU's future activities in space. Given the high speeds with which objects move in LEO (around 17,000 mph), even small debris can cause significant damage or catastrophic collisions.

Fig. 3: The current distribution of space junk in LEO



Source: The Washington Post via [Center for Data Innovation](). Note: Figure 3 depicts the distribution and abundance of space debris, with satellites being represented by blue dots, while space debris is marked by pink dots.

Crucially, this space debris poses not only an increasing environmental burden but also strategic challenges: As nations become reliant on space-based capabilities for communication, navigation, and surveillance, the risk posed by space debris directly translates into a threat to national security, making it difficult to distinguish between natural and hostile events. The presence of space debris thus necessitates the development of protective measures that go beyond mere manoeuvrability and orbiting capabilities, including advanced tracking systems, improved shielding, and debris removal

[62] Speech by Commissioner Breton - EU Space: the Top 5 Priorities for 2024 and beyond, January 2024, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_24_368.

technologies, which will help to safeguard European space assets and maintain strategic capabilities.[63] In line with this, EU Commissioner Thierry Breton recently proposed a European "Space Domain Awareness" system that would link relevant national and European assets together to ensure safety (protection against debris) but also security (detection of potential threats) in space.[64] This would also include a **capacity to "act in space"**, meaning space operations such as servicing, assembly, manufacture, and transportation of objects in space.

The current amount of debris, as shown in Figure 3, could become even greater in the near future due to conscious individual space policy decisions. For instance, when NASA's DART spacecraft was deliberately crashed into an asteroid in 2022 – in order to test how to knock an incoming near-Earth object off course – it created a lot of debris that could become more dangerous than the original threat itself.[65] Similarly, space mining (as discussed below in section 4) may lead to the presence of debris, especially if these mining exercises are conducted on a purely commercial, first-come-first-served basis without transparency, clear ownership rules, or corresponding liability. To avoid these extreme external effects, in an economic sense, one needs a strong legal framework. The dual nature of space debris as both an environmental and a strategic problem highlights the need for comprehensive international cooperation to address this growing challenge in space security.

The reduction of space debris is thus one of the most urgent tasks, even if many players are mainly interested in the economic benefits of space and the harmful residues are often ignored or minimised. In fact, space debris can be well understood through the lens of commons theory, which suggests that certain resources should be managed in a way that benefits all members of a community. Space, much like the high seas or the atmosphere, is considered to be "global commons", meaning that it is a shared resource beyond the jurisdiction of any one nation and therefore requires collective management and responsibility. As the proliferation of space debris poses a significant risk to satellites and future economic activity in space, we face a classic tragedy of the commons scenario, where individual interests in exploiting space for satellite deployment leads to collective harm to the space environment. The regulation of space debris thus requires international cooperation and regulatory frameworks to mitigate risks.

The problem: a binding regulation under international law to avoid or at least reduce space debris does not yet exist. Initial attempts have been made, for example, with the 2007 UN Space Debris Mitigation Guidelines or the 2018 Guidelines for the Long-term Sustainability of Outer Space Activities issued by the UN Committee on the Peaceful Uses of Outer Space. However, the disadvantage remains that there is no legally binding regulation, so that this remains "soft law".[66] This is where EU plans for a Space Law could come into effect and play a significant role.

In March, the Commission will most probably suggest an EU Space Law based on Art. 114 TFEU, to "improve the conditions for the establishment and functioning of the single market", the legality of which will be dependent on the actual design of the specific measures. Either way, according to the consultation, the goal will be to ensure the safe, secure, and sustainable use of space and increase the protection and resilience of all space systems, services, and operations. Apart from keeping the status

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[63] European Defence Agency (2023), "Enhancing EU Military Capabilities beyond 2040", p. 22.
[64] Speech by Commissioner Breton - EU Space: the Top 5 Priorities for 2024 and beyond, January 2024, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_24_368.
[65] DART Showed How to Smash an Asteroid. So Where Did the Space Shrapnel Go? | WIRED.
[66] See altogether Schladebach, M. (2020), Weltraumrecht, p. 144 and 149-151.

quo, the Commission may generally draft its proposal with three policy perspectives in mind, which of course are not mutually exclusive and could also be combined: 1) promoting adherence to non-binding measures, 2) setting a binding EU framework and 3) adopting bilateral agreements.

While details are lacking, our assessment of these preliminary plans is mixed. On the one hand, **policy and legal development has clearly lagged behind the swift expansion of the burgeoning commercial space industry** (think SpaceX or Amazon). These industrial actors show reluctance to adopt and efficiently integrate new technologies, owing to the unpredictable nature of the associated costs. Mere soft law does not appear to be sufficient for solving the problems. Interestingly enough, the existence of soft law, such as the UN Space Debris Mitigation Guidelines, has even led to the argument that further efforts for binding regulations are unnecessary.[67] Therefore, establishing clear legal rules for debris and space lifecycle management internalise the external effects and may increase welfare. If the Commission's Space Law can achieve a "Brussels effect"[68] similar to the GDPR, it could "push other countries towards more responsible space activities through market-access requirements. This would lead to an increase in the safe operation of European space and ground systems while helping to avoid "a further decay of the orbital environment which would pose a hazard to future missions and impact the coming generations of space users".[69] This seems to be the primary motivation of the Commission, as EU Commissioner Thierry Breton recently expressed his hope that the EU Space Law will "reinforce the position of Europe as a space power […] and our ability to shape norms and standards globally".[70] However, this first requires EU leadership, which is currently lacking – hence our proposal for a more comprehensive strategy towards EU space autonomy and launchers (see above).

Tab. 2: Ranking of states responsible for space debris

Space Debris Contributor	# of Space Debris
Russia (including USSR)	4,521
United States	4,317
China	4,137
France	370
India	62
Japan	48
China - Brazil	25
European Space Agency	22
Canada	5
Argentina	1
Germany	1
Other	24

Source: Own table, based on: tracking data from Space-Track.org, maintained by the US Space Force. Note: China-Brazil space debris stems from several cooperational space programs. All numbers are approximate.

67 See Schladebach, M. (2020), Weltraumrecht, p. 153.
68 The Brussels Effect describes how the EU indirectly influences global markets through its regulation of product standards in the large and prosperous single market, as both domestic and foreign companies have to follow these standards. See: Bradford, Anu (2020). The Brussels Effect: How the European Union Rules the World. Oxford University Press.
69 At least, according to industry members: Eurospace Position Paper (2023), European space industry contribution to the future "EU Space Law", p. 6.
70 Speech by Commissioner Breton - EU Space: the Top 5 Priorities for 2024 and beyond, January 2024, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_24_368.

On the other hand, the EU's focus on cleaning up space, instead of using it, is surprising, given that it is far from being the main source behind the emergence of space debris. Russia (previously as the USSR), the US, and China are primarily responsible for this clutter. Since these nations have been active in space since the mid-20th century, they bear the largest responsibility. As other authors have also argued, an international obligation to retrieve space debris would be the first-best solution to the problem which would include that, in accordance with the polluter-pays principle under international environmental law, each state shares in the retrieval costs according to its specific contribution.[71] According to recent data, Russia has currently about 4,521 pieces of space debris, and both the US and China have over 4,000 each (Table 2). Many pieces of debris are remnants of past missions, but certain events have dramatically increased their number. For instance, China's 2007 anti-satellite test, which destroyed a weather satellite, generated 3,500 pieces of debris.[72] Similarly, the 2009 collision of a Russian and a US satellite resulted in over 2,000 new debris fragments.

Given the clear asymmetry in responsibility for space debris, it is important to **design the EU Space Law – and any subsequent strategies – in such a way that they do not limit space-technology innovation in Europe and the potential of European start-ups for launchers and space-based services**. The best way to ensure this is to **oblige non-European actors to comply with the EU Space Law requirements if they want to have access to the European market**.[73] In general, there are two options for achieving such an alignment of external firms and actors. On the one hand, several regulations recently enacted by the Commission, such as the Digital Services Act or the Digital Markets Act, target businesses – regardless of where they are based – that offer services to EU citizens or businesses.[74] On the other hand, a phenomenon coined by Anu Bradford as the "Brussels effect" might help EU rules to influence business practices and national legislation around the world, namely if accessing the valuable European market leads non-European firms to adapt their conduct throughout their worldwide operations.[75] However, this works only if the benefits of adhering to a single standard outweigh the benefits of taking advantage of laxer standards elsewhere, which is unlikely to be the case in the space sector as, in contrast to the digital economy, it not only has high fixed costs but also high variable costs, such as those associated with each launch. Thus, the best course for the Commission would be to draft the EU Space Law in such a way that it applies to providers of space services irrespective of their place of establishment or residence, if they provide services related to the EU market.

In the future, technology and the commercial space debris removal industry might come to the rescue, if the legal framework allows the right incentives to develop. For instance, US researchers recently created a robot designed to remove space junk, including old satellites, rockets, and debris.[76] This robot employs a magnet to reposition the junk so that it can burn up in orbit. Other currently tested technologies include debris-cleaning tech like ground laser nudges, space tugs, and space lasers.[77] If legal obligations for the management of space debris are established, which is what the Commission

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[71] See Schladebach, M. (2020), Weltraumrecht, p. 151-153. Concrete plans are in existence, see ESA (n/a), Space Safety - Clearspace-1.

[72] This test is mentioned above, see section 2.

[73] This suggestion is also made by: Eurospace Position Paper (2023), European space industry contribution to the future "EU Space Law", p. 4.

[74] The global reach of the EU's approach to digital transformation | Think Tank | European Parliament (europa.eu).

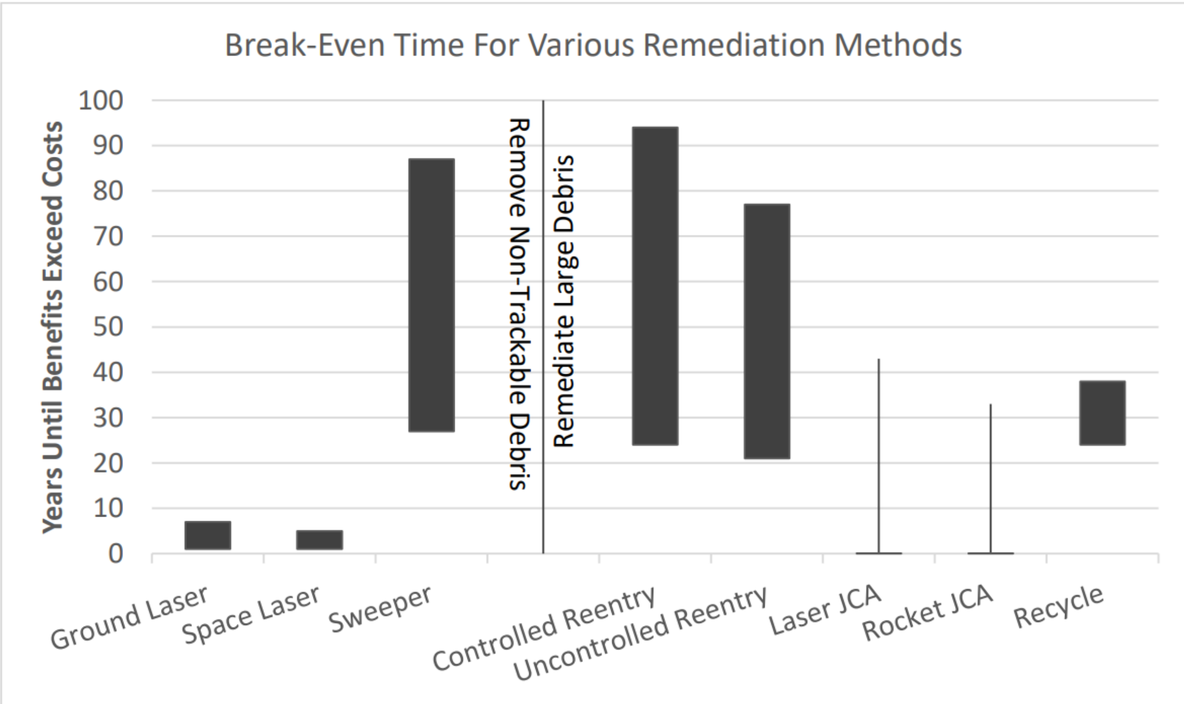
[75] Bradford, Anu, The Brussels Effect (2012). Northwestern University Law Review, Vol. 107, No. 1, 2012, Columbia Law and Economics Working Paper No. 533, Available at SSRN: https://ssrn.com/abstract=2770634.

[76] Robot developed by Utah professor helps clean space junk (fox13now.com).

[77] Iyer, V. (2023), How do you clean up 170 million pieces of space junk? - Federation of American Scientists (fas.org).

is apparently trying to do, these technologies could receive the necessary boost to reach market stage. A good example is the recent decision by the Federal Communications Commission (FCC) in the US, which issued its first-ever fine related to space junk.[78] In this decision, a TV provider was ordered to pay $150,000 for not repositioning one of its satellites into a safe orbit. This fine is noteworthy because it establishes a precedent for addressing entities that contribute to the problem of hazardous debris in orbit around Earth. It is expected to have a considerable impact on the satellite industry, as operators might now be more careful to avoid damaging their reputation.[79] Furthermore, this action by the FCC could invigorate the relatively small market for commercial space debris removal.[80]

Fig. 4: The most effective remediation methods to reduce risks to space operators



Source: Taken from NASA. See: Thomas J. Colvin, John Karcz, Grace Wusk (2023), Cost and Benefit Analysis of Orbital Debris Remediation, Figure ES-3.

One way to boost this development from a European perspective would be to expand[81] the **funding of removal or recycling projects for a set number of large debris objects annually**, thereby creating a reliable market context for space debris removal. Despite common concerns about the high initial costs and long wait times for benefits in remediation efforts, some strategies could yield net gains within ten years.[82] Figure 4, which is taken from NASA's recent financial analysis on space debris, illustrates the varied timeframes for different remediation techniques to become beneficial. In particular, it displays the break-even time for approaches to remove non-trackable debris (left) and remediate large debris (right). Clearly, techniques for clearing debris of 1-10 cm size tend to show quick net benefits. Likewise, strategies that reposition debris to prevent collisions have a broad spectrum of potential expenses, potentially extending the time to achieve net benefits to several decades. Nevertheless,

78 Sheetz, M. (2023), FCC enforces first space debris penalty in Dish Network settlement (cnbc.com).
79 O'Callaghan, J. (2023), Why the first-ever space junk fine is such a big deal | MIT Technology Review.
80 The fine essentially sets a benchmark price of $150,000, encouraging companies to develop services that remove defunct satellites or rocket parts from orbit by bringing them back into the Earth's atmosphere.
81 Generally already happening, see: https://www.esa.int/Space_Safety/ClearSpace-1.
82 Thomas J. Colvin, John Karcz, Grace Wusk (2023), Cost and Benefit Analysis of Orbital Debris Remediation (nasa.gov).

these methods also have a realistic chance of offering immediate net benefits once they start functioning.

On this basis, we therefore suggest that the EU's space strategy should include increased financing for technical solutions to remove and recycle larger debris objects. More specifically, **institutional anchor customers** (i.e. place-based institutions, here: European agencies and Member States' ministries) could help create and then retain the ability of European firms to develop capabilities for "space situational awareness", including ground infrastructure and sensors.[83] In other words, this means **aggregating European institutional demand** from all public actors, **with a clear European preference policy**.[84] This is again supported by experience in the US, where such a demand is already present. In the case of Europe, this approach would also necessitate **establishing an internal market for debris avoidance data**, going beyond the European Space Surveillance and Tracking partnership.[85]

4 Securing space resources: establishing ownership and transparency

Resources such as rare-earth elements, copper, and platinum are unequally distributed across the world. For example, China has more than 90% of rare earth supply, South-Africa has 80% of global platinum and Chile produces 30% of total copper. This creates dependency on certain countries which results in economic and political risks.[86] Furthermore, resources will become scarcer due to the growing demand. To secure access to certain resources, some countries such as the US, Luxembourg and Japan are working towards exploitation of resources from space. These space resources can be used in different ways. Using resources in space itself will, for example, make space launches more cost efficient because less resources need to be brought from earth.[87] Beyond that, resources can be extracted in space and returned to earth for use there. As resources on earth are limited and asteroids are full of valuable resources, such as platinum, mining these resources is becoming more attractive.[88] Subsequently, access to these space resources is becoming more important.[89] The global space mining market size is expected to grow from 1.48 billion in 2023 to 8.257 billion in 2032.[90]

Resources from space may eventually be used on earth when it becomes economically viable to do so.[91] The value of these resources has already led to investment from countries and private businesses. Given their value and potential profit, gaining access to these resources could lead to aggressive competition in the future between different companies and states.[92] Asteroids, for example, offer a source of rare earth elements, metals, and minerals in large amounts.[93] Platinum Group Metals, which

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83 This is emphasised by members of the space industry in Europe: Eurospace Position Paper (2023), European space industry contribution to the future "EU Space Law", p. 12.

84 Speech by Commissioner Breton - EU Space: the Top 5 Priorities for 2024 and beyond, January 2024, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_24_368.

85 Again, this is a key demand also voiced by industry participants, who, of course, would commercially benefit from such a market: Eurospace Position Paper (2023), European space industry contribution to the future "EU Space Law", p. 12.

86 Talalay, P.G./ Zhang, N. (2022), Antarctic mineral resources: Looking to the future of the Environmental Protocol.

87 De Zwart, M./ Henderson, S. /Neumann, M, (2023), Space resource activities and the evolution of international space law, p. 155, NASA (2023), In-Situ Resource Utilization (ISRU) and Cilliers, J./ Hadler, K./ Rasera, J. (2023), Toward the utilisation of resources in space: knowledge gaps, open questions, and priorities, p. 1.

88 Sarnacki, D. (2014), Property Rights of Space: Asteroid Mining , p. 124.

89 Christensen, I./ Lange, I./ Sowers, G. et al. (2019), New Policies Needed to Advance Space Mining.

90 Market Research Future (2024) Global Space Mining Overview

91 European Space Agency (2019) ESA Space Resources Strategy, p. 6.

92 European Commission (2023), Competition in Space.

93 European Commission (2023), Competition in Space.

are found in asteroids, are one of the most expensive materials known and are not mined in large quantities. For example, there is one type of platinum metal which has a market price of more than 500,000 dollar per kg, and only between 20 and 30 tons are mined each year on earth.[94] Furthermore, the global mining production of platinum is also very concentrated in certain areas of the world with 71% of global mining production in South Africa, followed by Russia with 16% and Zimbabwe with 6%. Global reserves of platinum are also concentrated in South-Africa which has 82%, followed by Zimbabwe and Russia with 7% and 6%, respectively.[95] It is an important resource used mainly in automotive catalysts, but a small portion is used in life-saving medicines such as anti-cancer drugs and medical devices for cardiac treatment.[96]

The potential value of asteroids is therefore enormous, which makes space mining attractive for private companies. For example, one asteroid which the US is planning to explore has a value of 10,000 quadrillion dollars.[97] This asteroid could contain enough metals for human consumption on earth for millions of years.[98] Private firms and national space agencies such as NASA already have plans to launch missions to investigate the potential for asteroid mining.[99]

However, the current costs are significant, and it is not yet economically viable to bring materials extracted from asteroids back to earth.[100] The Luxembourg Space Agency predicted in 2018 that the value chain for bringing resources back to earth will only be established in the long term.[101] Furthermore, there are challenges with extracting the resources as well as risks which come with such mining activity.[102] Still, if the EU hopes to secure its access and right to use resources from space, it should already be focussing on developing the pre-conditions needed for a successful space mining sector in the EU, which includes attracting private investment, particularly by introducing clear legal **rules on ownership and transparency**.

Transparency with respect to the location, duration, and nature of space resource extraction is important due to the high risks involved with space operations. For example, if two spacecrafts were to enter the same location this would create significant damage to both spacecrafts and also other space objects, such as satellites. Furthermore, as there is currently no lack of resources in space, all

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94 Cannon, K.M./ Gialich, M/ Acain, J. (2022), Precious and structural metals on asteroids, p. 2.
95 European Commission (2017), Study on the review of the list of Critical Raw Materials: Critical Raw Materials Factsheets, p. 279 and p. 280 figure 147. These numbers were averaged over the period from 2010-2014.
96 European Commission (2017), Study on the review of the list of Critical Raw Materials: Critical Raw Materials Factsheets, p.282 et seq. See figures 151 and 152 for use of platinum in 2015. See also International Platinum Group Metals Association (2023), Facts about PGMs and Medical.
97 Pershing, A.D. (2019), Interpreting the Outer Space Treaty's Non-Appropriation Principle: Customary International Law from 1967 to Today p. 167 and SHAREAMERICA (2017), NASA goes heavy metal with visit to iron-rich asteroid. A spacecraft launched by NASA on 13 October 2023 is travelling to metal-rich asteroid Psyche. It will begin exploring this asteroid in August 2029. For more information see also: NASA, 2024, Psyche Mission to a Metal-Rich World.
98 Christensen, I./ Lange, I./ Sowers, G. et al. (2019), New Policies Needed to Advance Space Mining
99 SPACENEWS (2023), Asteroid mining startup AstroForge to launch first missions this year and NASA (2023), Is NASA Mining Asteroids? We Asked a NASA Scientist: Episode 41. An example is AstroForge based in the US which has a plan for early 2024 to launch a spacecraft with the aim of exploring the moon and asteroids for commercial space mining. Other companies whose goal it is to mine the moon and asteroids are Moon Express in the US, iSpace in Japan and Europe (based in Luxembourg) and Asteroid Mining Corporation in the UK. See Mining.com (2023), Asteroid mining startup to launch mission in early 2024.
100 The Guardian (2018), Asteroid mining could be space´s new frontier: the problem is doing it legally.
101 Luxembourg Space Agency (2018), Opportunities for space resources utilization: future markets and value chains, p. 6 et seq.
102 European Commission (2023), Competition in Space.

stakeholders would benefit from transparency about space mining activities so that conflicts over the same resources can be avoided.[103]

International law, in particular the Convention on Registration of Objects launched into Outer Space, provides for some transparency regarding objects launched into space. The United Nations is responsible for maintaining a register with full and open access, and each Nation has a national register. Currently, 87% of all satellites, probes, landers, crewed spacecraft, and space station flight elements launched into Earth's orbit or beyond are registered in the international registry.[104] Yet, this does not cover space mining activities, and therefore a new international registry has been proposed in this regard.[105] As yet, however, there is no legal requirement to register all space mining activities. **Therefore, a binding international registry** for space mining activities should be established alongside an obligation to register. This new registry could form **part of the already existing registry of space objects,** which will then need to be expanded to contain information on public and private space mining activities.

With regard to ownership, the EU needs to pursue a two-fold approach: common international rules and common European rules. These are the prerequisite for a successful space mining ecosystem. **The first approach is to work towards common international rules**. In practice, international space treaties have not yet been tested regarding the rights over resources found in space as most missions have been for scientific purposes.[106] However, not all states are bound by the various international agreements mentioned earlier (see section 1). Hence, different rules apply in different situations.

A first step towards an international solution could be the establishment of an International Space Resources Authority, responsible for sharing the benefits from space mining, comparable to the International Seabed Authority (ISA). The ISA is an intergovernmental agency created by the UN Convention on the Law of the Sea (UNCLOS), which overseas deep-sea mining activities beyond national jurisdictions. Among other things, it is responsible for the development of a benefit-sharing mechanism which requires a portion of financial and economic benefits to be paid to ISA which is then shared among the states of the world.[107] Article 140 (1) UNCLOS requires sea mining activities to be carried out for the benefit of mankind as a whole and in particular considers the interests and needs of developing states. Article 140 (2) UNCLOS requires ISA to provide for an equitable sharing of financial and economic benefits. Together with the establishment of an International Space Resources Authority, a similar international law could be introduced for resources from space. This would involve **space mining companies paying a certain percentage of their economic and financial benefits to the International Space Resources Agency,** which would be distributed among the states of the world based on some form of equitable sharing criteria.

[103] School of Law, University of Washington (2024), The Laws of Space Mining, from minute 18.
[104] United States Office for Outer Space Affairs (2024), United Nations Register of Objects launched into Outer Space
[105] De Zwart, M./ Henderson, S. /Neumann, M, (2023), Space resource activities and the evolution of international space law, P. 159 et seq. For example, the Moon Village Association proposed the establishment of an international land use registry for the moon with the United Nations being the registrar. Also, the Hague International Space Resources Governance Working Group proposed a registry of priority rights in its guidelines and recommendations.
[106] Luxembourg Space Agency/ Le Gouvernement du Grand-Duche de Luxembourg, (2022), Contribution of the Grand Duchy of Luxembourg on the Mandate and Purpose of the Working Group on Legal Aspects of Space Resource Activities, p. 5.
[107] International Seabed Authority (2024), The Mining Code and Equitable sharing of benefits.

This could serve as a basis for the commonly accepted rules of a future space mining system. States and companies that act as “first movers” will gain a competitive advantage by securing ownership of the materials mined while having, at least, a common framework and a generally accepted benefit-sharing mechanism, familiar from the Law of the Sea, with regard to deep-sea mining activities.

Apart from this international effort, **the second approach is setting common European rules**. So far, there are only four states in the world that have domestic legislation which allows and regulates space mining. The only EU country with such a law is Luxembourg.[108] Other countries are the United States, the United Arab Emirates and Japan.[109] These four countries are also part of the Artemis Accords.[110] The development of national space mining law started in 2015 in the US with the Commercial Space Launch Competitiveness Act. It allows possession and use of space resources by US citizens[111] and was the first time that private companies were granted commercial rights to resources from space.[112]

Luxembourg is the first EU country and second country worldwide after the US, which officially allows space resources to be “appropriated” by commercial groups in Luxembourg.[113] More concretely, the national Law on the Exploration and Utilisation of Space Resources of 2017 allows space resources to be owned.

Luxembourg is currently leading in the space mining sector in Europe. The legal framework was established in 2017 and, additionally, bilateral agreements have been signed regarding the exploration and use of space resources between Luxembourg and other countries including the US, Japan, and certain EU Member States.[114] Between 2012 and 2018 there was a massive increase in the contribution of the space and satellite sector to national GDP in absolute terms,[115] with a gross value added of more than 800 million euro in 2018 compared to 670.8 million euro in 2012. The number of companies in the space sector increased from 16 in 2012 to 32 in 2018, with a significant increase between 2016 and

[108] Germany does not yet have a comparable national law regarding space resources, but in 2018 the Federal Association of German Industry (BDI) wanted to have a national space law comparable to the one in Luxembourg, making private investment and innovation in space mining possible. See Orth, M. (2018), Germany relies on space mining.

[109] De Zwart, M./ Henderson, S. & Neumann, M, (2023), Space resource activities and the evolution of international space law, p. 157.

[110] NASA (2023), The Artemis Accords. The Artemis Accords aim to facilitate space resource activities by introducing safety zones. Section 4 of the Artemis Accords requires transparency regarding their national space polices and space exploration plan in accordance with national rules and regulations. Also, section 11 on the “deconfliction of space activities” contains provisions regarding information to be made public on the operations taking place in “safety zones”. A safety zone is “the area in which nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference.” However, the Artemis Accords are not legally binding and signed by 32 countries only. See De Zwart, M./ Henderson, S. & Neumann, M, (2023), Space resource activities and the evolution of international space law, p. 158.

[111] De Zwart, M./ Henderson, S. / Neumann, M, (2023), Space resource activities and the evolution of international space law, p. 157 et seq.

[112] Pershing, A.D. (2019), Interpreting the Outer Space Treaty’s Non-Appropriation Principle: Customary International Law from 1967 to Today p.160

[113] Financial Times (2017), US and Luxembourg frame laws for new space race

[114] The Government of the Grand Duchy of Luxembourg (2020), National Action Plan 2020-2024 Space Science and Technology, p. 19. EU Member States which have a memoranda of understanding with Luxembourg are Czech Republic, Poland and Portugal. Luxembourg has a joint declaration with Belgium.

[115] There was a slight drop in relative terms from 1,7% to 1,5% between 2012 and 2018. See: The Government of the Grand Duchy of Luxembourg (2020), National Action Plan 2020-2024 Space Science and Technology, p. 33.

2017 from 22 to 30 companies.[116] **Part of this increase is due to companies involved in the exploitation and use of space resources, which have settled in Luxembourg since 2016.**[117]

Luxembourg has a relatively large space industry compared to its population size. The total space industry[118] in Luxembourg has about 50 companies and research labs, which employ more than 800 people.[119] Employment increased from 639 to 840 people from 2012 to 2018, representing a more than 30% increase.[120] Furthermore, the space sector´s contribution to GDP is among the highest in Europe.[121] Between 2012 and 2018, 1.5% to 1.8% of Luxembourg's GDP came from the space and satellite sector.[122] Luxembourg's success in attracting companies from the space mining sector must, at least in part, be attributed to allowing for the ownership of space resources as this provides a prerequisite for a successful space mining ecosystem. Furthermore, Luxembourg has introduced other incentives to attract the space mining industry. For example, the European Space Resources Innovation Center, established in 2019, is the first of its kind that is dedicated to space resources, and supports initiatives for commercialization of space resources and research.[123]

The EU should introduce a law using Luxembourg's legislation as a blueprint. The EU needs to be able to compete at global level while safeguarding EU internal competition. Therefore, **in order to avoid fragmentation and unfair competition, an EU Space law should provide for ownership of space resources,** rather than allowing national laws to apply which vary significantly in their rules on ownership. This would make the EU more competitive on a global scale.

5 Conclusion: increasing Europe's sovereignty in and through space

The EU's ambitious efforts to shape international space policy and the space economy through the formulation of an EU space law and a comprehensive space data strategy are certainly timely and essential in the face of a rapidly evolving global space race. The proposed initiatives, including the establishment of common rules for the security, resilience, and sustainability of space activities, as well as the development of a space data strategy, underline the EU's desire to achieve strategic autonomy and enhance its competitiveness on the global stage. The focus on collision avoidance, debris management, cybersecurity and environmental sustainability in the space sector not only addresses immediate challenges, but also sets a precedent for responsible and sustainable space exploration and use. By prioritising these areas, the EU will position itself as a key player in the international space community, seemingly advocating a balanced approach that integrates economic ambitions with security and environmental considerations.

However, as we have argued in this policy brief, for the EU to truly realise its vision of a resilient and strategically autonomous space sector, it needs to refine its procurement strategies and foster greater

[116] The Government of the Grand Duchy of Luxembourg (2020), National Action Plan 2020-2024 Space Science and Technology, p. 32 - 33.

[117] Examples of such companies are Blue Horizon (2017), Deep Space Industries Europe (2018), ISpace Europe (2016), Maana Electric, Made in Space Europe (2018) and Offworld (2016). See The Government of the Grand Duchy of Luxembourg (2020), National Action Plan 2020-2024 Space Science and Technology, p. 25 - 29.

[118] This is not limited to space mining.

[119] Luxembourg Space Agency (2023), Space Eco-system.

[120] The Government of the Grand Duchy of Luxembourg (2020), National Action Plan 2020-2024 Space Science and Technology, p. 32-33.

[121] Luxembourg Space Agency (2023), Space Eco-system.

[122] The Government of the Grand Duchy of Luxembourg (2020), National Action Plan 2020-2024 Space Science and Technology, p. 33.

[123] ESRIC (2023), Welcome to the European Space Resources Innovation Centre.

cooperation between its Member States, the European Space Agency, and the private sector. Strategic autonomy in space is vital for the EU, not only to increase its geopolitical influence, but also because critical space-based technologies and data will be increasingly important for security, novel economic activities with large spill-over effects, and necessary environmental monitoring. Entrusting the exploitation of space to a global, civilian approach and free competition no longer seems feasible. For instance, total reliance on SpaceX, as is currently the case, appears questionable in view of Musk's increasingly erratic behaviour. Furthermore, the looming re-election of an isolationist President Trump, underscores the need for the EU to develop its own space launch capabilities in order to lessen its dependence on external powers and reduce future potential for blackmail. The proposals for a European Space Launchers Alliance and the use of public procurement to stimulate innovation in the space industry are steps in the right direction but need wider support and implementation to be effective. Overcoming the traditional "fair return" approach to procurement and embracing more dynamic, competitive, and coherent models with a clear European preference principle and institutional anchor customers, will be crucial to reducing inefficiencies and stimulating the development of critical technologies, such as rocket reusability.

In addition, the EU needs clear and legally binding rules on the ownership of space resources, and transparency to secure access and avoid conflict. Firstly, the EU should work towards common international rules as, in practice, international space treaties have not yet been tested regarding rights over resources. As part of this, a binding international registry of space mining activities should be set up to avoid conflict over the same resources. An International Space Resources Authority should also be established that is responsible for sharing the benefits from space mining. Apart from this international effort, the second approach is the setting of common European rules. The EU should introduce a law using Luxembourg's corresponding legislation as a blueprint. In order to avoid fragmentation and unfair competition, the EU must provide for ownership of space resources, rather than allowing national laws to apply which vary significantly as regards ownership rules. Taken together, these measures would make the EU more competitive on a global scale – while also ensuring its long-term strategic autonomy in space.

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