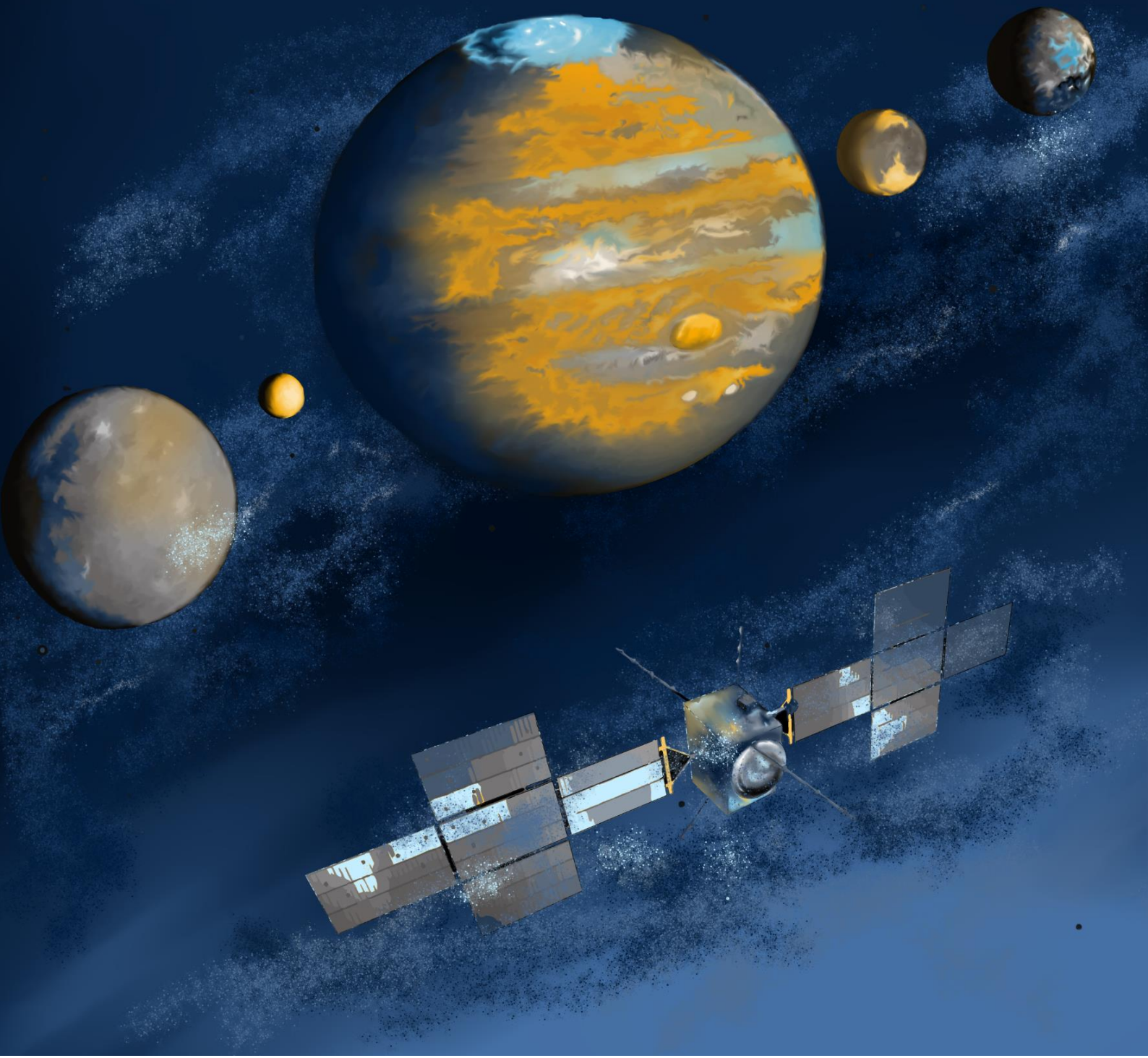
ESPI

European Space Policy Institute

ESPI Yearbook 2023

SPACE POLICIES, ISSUES AND TRENDS



Report:
Title: "ESPI Yearbook 2023 – Space policies, issues and trends"
Published: July 2024
ISSN: 2218-0931 (print) • 2076-6688 (online)

Editor and publisher:
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Cover design: ESPI
Internal layout design: www.copylot.at

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FOREWORD

Dear members of ESPI and readers in Europe and worldwide,

I am pleased to introduce to you this 2023 edition of the ESPI Yearbook. This long-established annual publication has gained a reputation over the years for being a reliable source of information and a useful tool for monitoring the development of the European space policy and programmes in a global context.

Credit: ESPI

2023 was a ground-breaking year for the space sector globally and also for ESPI: In the frame of our 20th anniversary which we celebrated in a great high-level event in the Austrian Parliament in September 2023, we launched our **ESPI 2040 Policy Vision "Space for Prosperity, Peace and Future Generations"**. ESPI 2040 proposes a vision for Europe in space, outlining how space can provide solutions to respond to unprecedented global challenges and how space can be an inspiration and catalyst to tackle its challenges. ESPI2040 defines a goal for Europe in 2040, and the ESPI Agenda to support this vision, building on Europe's achievements to engage in the space revolution, and affirm Europe's role as a strong partner to the world. ESPI2040 emphasises the policy impact of space and underlines its transformative nature, which affects all aspects of our daily lives, economies and Europe's digital future. ESPI2040 addresses policymakers and institutions, industry, economic actors and finance, academia and the scientific community, and the media: aspiring to contribute to an open debate on a bold vision, with concrete and ambitious goals and an implementation that delivers tangible results.

POLICY IMPACT

SPACE CAPABILITY & AUTONOMY

FOUNDATION

Credit: ESPI

Credit: ESPI

Moreover, ESPI stepped up with numerous actions in ESPI's 3 activity lines (1) research, (2) engagement and (3) education related to our 5 research topics "Green & Sustainable Societies", "Security & Defence", "Exploration & Science", "Industry, Innovation, Finance, Workforce" in 2023. An overview of our activities in 2023 can be read in the **ESPI Annual Report 2023** – a new ESPI publication.

With this new issue of the Yearbook for 2023, we aim to meet the expectations of our readers and we invested substantial efforts to ensure a consistent overall coverage of the 2023 space activities and related developments. The purpose we pursue with this publication is to highlight the evolving position of Europe on the international stage and put forward the trends at work that deserve to be considered in the further development of European space policy. The Yearbook is part of our mission to promote European space policy globally.

2023 was the Moon year, with the Moon race (re)surfacing after a decade-long hiatus. India stood out most notably as the rising power - being the first nation to land on the Moon's south pole with the Chadrayaan-3 mission, Russia failed to land Luna-25 on the Moon's surface, while Japan launched the lunar lander mission SLIM. Meanwhile, the U.S. and China have boosted their lunar

ambitions in a race between seeking international partners for China's ILRS project and the U.S. Artemis Accords – with several new partners joining the two initiatives in 2023.

For Europe, 2023 was marked by the launcher crisis: a further delay of Ariane 6, Ariane 5's last launch in the summer of 2023, and due to this situation, the unavailability of a European heavy-lift launcher in the second half of the year. Moreover, the Vega C launch failure at the end of 2022 was followed by an investigation resulting in the unavailability of Vega C. Moreover, Germany, France and Italy discussed a new launcher procurement and development process for Europe, which was presented at the European Space Summit in Sevilla in November 2023. Europe celebrated the inauguration of two new spaceports on Northern European territory: Esrange Space Center in Sweden and Andøya Space Center in Norway.

With regard to (human) space exploration, Europe's revived interest continues, but without much action or reaction to the recommendations of the Report of the High-Level Advisory Group on Human and Robotic Space Exploration for Europe. Concerning LEO Exploration, European states participating at the Space Summit decided to start a cargo transport competition and ESA signed an agreement with Axiom Space and Voyager Space for the involvement in the commercial LEO stations.

Moreover, two European space science missions were successfully launched in 2023: the JUICE mission to explore Jupiter's icy Moons and the Euclid deep space telescope.

In 2023, the Council of the EU gave the final approval for the regulation on the EU's secure connectivity programme for 2023-2027, the "Infrastructure for Resilience, Interconnectivity and Security by Satellite" (IRIS^2), which marked the last step in the EU decision-making process, and a consortium of European industry was formed to build the multi-orbital constellation. Moreover, ESA and the European Commission signed a contribution agreement.

The war in Ukraine, with its implications for European security and defence, and the role of space continued to be in the spotlight. In March 2023, the first ever EU Space Strategy for Security and Defence was tabled by the European Commission and the High Representative Josep Borrell. In November 2023, the Council of the EU released conclusions on the strategy.

The Yearbook is structured in 4 chapters:

- **Policy & Programmes** outlines the developments of public, governmental & institutional affairs,
- **Industry and Innovation** gathers prominent announcements related to space industry evolutions worldwide and promising progress in technology development.
- **Global Space Economy** collects indicators relevant to the global space economy.
- **Launches & Satellites** exploits ESPI databases related to launch site activities.

Beyond the monitoring of news and developments and the identification of the key trends and events of the year, we report about the major news on a monthly basis in the **ESPI Insights** and analyse selected key topics in various ESPI Publications, such as the **ESPI Director's Perspectives, ESPI Policy Briefs**, and **ESPI Reports.**

The monthly **ESPI Director's Perspectives** analyse major developments in the space sector, and relevant ESPI activities that are contributing to and boosting European ambitions as well as highlight how Europe is positioned in the international context.

With regard to developments in Policy and Programmes, 2023 has been quite remarkable with:

- **The revived Moon Race** with India, Japan and Russia have launched missions to the Moon, and India was the first nation to land in the lunar south pole region with Chandrayaan-3. Moreover, the U.S. and China progressing with and competing to find allies to join their Moon programmes Artemis and ILRS.
- **Europe's highlights in space exploration and science:** launch of JUICE mission to Jupiter and launch of deep space telescope Euclid**.**
- **The European launcher crisis and absence of European access to space:** no launch vehicles and transformation of future launcher procurement towards more European internal competition, while European spaceports progressed and were inaugurated (Esrange, Andøya).
- **Approval of the EU Secure Connectivity Programme "Infrastructure for Resilience, Interconnectivity and Security by Satellite" (IRIS^2).** A European industry Consortium was formed to build the constellation, and ESA and EU signed a contribution agreement on IRIS^2.
- **Increased European ambition to connect Space, Security & Defence –** the release of the EU Space Strategy of Security and Defence and the first steps of its implementation.
- **The UK rejoined Horizon Europe and Copernicus:** the dedicated UK-EU agreement was approved by the Council of the EU.
- **Rising Stars:** India, Gulf nations and Africa step up in space.

Regarding the space industry, 2023 has also been quite vibrant with the advent of major initiatives that will have an impact on future public and new private initiatives:

- **Developments in verticalisation of Space – space in other industry sectors:** in 2023, developments were visible mainly in the maritime, automotive and biotechnology domains, but also in energy and terrestrial transport. In particular, 2023 saw developments in in-flight connectivity, satcom for automotive and space for maritime safety and sustainability.
- **Developments in in-orbit servicing –** including in ADR, in-space refuelling, Docking & RPO, and Last Mile Delivery.
- **Developments in space cybersecurity –** including commercial space cyber security providers and quantum key distribution and post quantum cryptography. Having received a boost already in 2022 in light of Russia's cyberattack on ViaSat's KA-SAT satellite network, 2023 saw continued developments and increased efforts.
- **Developments in space-based solar power:** in Europe, ESA awarded concept studies for commercial-scale SBSP plants under SOLARIS, the UK allocated €5 million in government funding for made-in-UK SBSP technologies and European companies such as Thales Alenia Space and DCUBED progressed in SBSP. Beyond Europe, the U.S. and China especially progressed in R&D for this technology.
- **Developments in space nuclear propulsion:** the U.S. is leading the emerging space nuclear propulsion market. NASA and DARPA announced a partnership to showcase a nuclear thermal rocket engine in space, a pivotal advancement for NASA's manned missions to Mars on the DRACO programme. In Europe, ESA is investigating multiple studies of innovative applications of nuclear propulsion for deep space exploration, and on the national level, the UK is pushing for this technology. Furthermore, Russia announced that the planned nuclear-powered space tug to remove space debris is scheduled before 2030.

With regard to the Global Space Economy, the following numbers characterise 2022 and 2023:

- **The Global Space Economy** in 2022 is estimated at **$385 billion (SIA) and $546 billion Space Foundation)** and is comprised of 4 indicators: (1) Government Space Budgets, (2) Commercial Satellites and Launches, (3) Ground Stations and Equipment, (4) Space Products and Services.

- With regard to **institutional space budgets**, the dedicated section gives a global overview and evolution and lists the space budgets per country. The total governmental budget for space programmes in 2022 is estimated to be **$101.8 billion by SIA/Bryce, $118.6 billion by the Space Foundation, and $103 billion by Novaspace**.
- With regard to the **European space budget**, the dedicated section gives an overview of the consolidated European Space Budget valued at **€13,853 million in 2022** and its components, including the national space budgets, as well as the ESA, EU and the EUMETSAT ones.
- The sections include **European Space Economy Statistics**, the European space manufacturing industry, and the European GNSS and EO sector. The European space manufacturing industry's final sales decreased by 4,1% to around **€8.257 million (2022)**. The European EO sector sees data revenues of €100 million (17% global share) and value-added service revenues of €415 million (15% global share), while the GNSS sector devices revenues of €16 billion (23% global share) and services revenues of €32 billion (17% global share).
- Finally, the section analyses the **Global Private Space Investment**, including global investment dynamics, and global investment distribution (based on ESPI Space Venture 2023 Report). The Global investment in space ventures in **2023 totalled €6 billion** (a 32% decline from the previous year's peak of €8 billion).

Regarding launches, 2023 is characterised by the following numbers and launch highlights:

- **221 launches conducted in 2023** (+19% compared to 2022), thereof 10 launch failures (which makes 4,8% of all launches, 19 spacecraft)
- **2889 satellites launched** (+16% compared to 2022), 2840 of which were launched into LEO, 7 into MEO, 32 into GEO and 19 into other orbits.
- The majority of satellites launched in 2023 were telecommunication satellites (76.2% of all satellites launched, 77% of the mass launched)
- **Top 3 launch countries:** 1. U.S., 2. China, 3. Russia
- Launch highlights of 2023 include for Europe the launch of the JUICE mission and the launch of the Euclid mission, for the U.S. the two starship launch attempts, India's Moon landing, etc.

In a nutshell, and from an international perspective, 2023 kicked off the Moon race between global space powers, while marking the year of the European Launchers Crisis with no heavy-lift launcher availability in Europe. Highlights include the launches of the two space science missions JUICE and EUCLID as well as the swift developments related to the EU Secure Connectivity Programme. While most of the political and programmatic focus has been on resolving the launcher crisis, including at the Space Summit, Europe must also give more attention to the use of space, space exploration and security & defence.

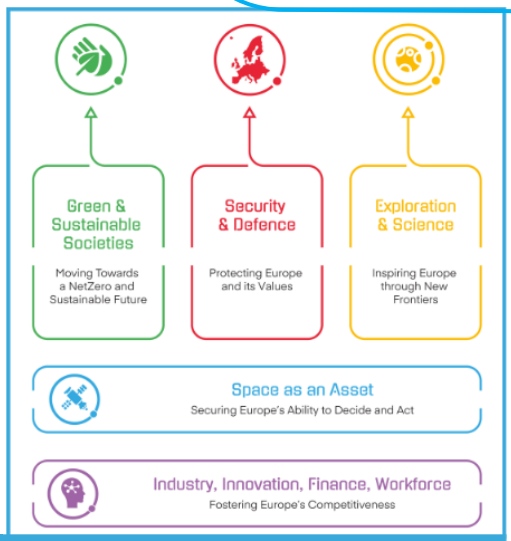
I hope you will enjoy reading this publication as much as we did preparing it. I would be more than happy to receive feedback on how we could further improve this publication to your needs.

Sincerely yours,

Hermann Ludwig Moeller
Director, European Space Policy Institute (ESPI)

1 POLICY & PROGRAMMES

2023 saw various developments in space policy and programmes, which can be broadly categorised in ESPI's 5 research themes, especially in the three vertical themes (1) Green & Sustainable Societies, (2) Security & Defence, (3) Exploration & Science, and always covering aspects related to ESPI's two transversal research themes "Space as an Asset" (which covers i.a. access to space, sustainability and safety in space and regulatory, policy and governance aspects) and "Industry, Innovation, Finance, Workforce".



Chapter Policy & Programmes	ESPI's 5 Research Themes	
Subchapters	Primary Research Theme(s)	Connected Themes
1.1 Highlights and Key Developments in Europe at the EU, ESA and National Levels		
1.2 Space Exploration & Science		
1.3 Space as an Asset: Access to Space - Launchers & Spaceports		
1.4 Space, Security & Defence		
1.5 Space as an Asset: Space Safety & Sustainability		
1.6 Space for Green & Sustainable Societies		
1.7 Developments in Space Governance, Policy & Law		
1.8 International and Bilateral Cooperation		
1.9 Rising Stars in 2023: Spacefaring Nations		

1.1 Highlights in Europe

2023 highlights in Europe include the European Space Summit, the release of the first-ever EU Space Strategy for Security and Defence, the approval of IRIS[2] at EU level.

1.1.1 "Zeitenwende" or a Revolution Postponed: focus on launcher crisis but limited attention to (human) space exploration

The Space Summit held in November 2023 in Seville has been one of the milestones for signalling European ambition in space, after ESA CM22 in November 2022. As an impulse to push **ambitions in European space exploration** and with clear recommendations for Europe, the High-Level Advisory Group (HLAG) on Human and Robotic Space Exploration for Europe released the report Revolution Space in March 2023. In response to the HLAG's recommendation to study the benefits of human space exploration in preparation for the Space Summit in Seville, ESPI and the Boston Consulting Group (BCG) worked on the study "More than a Space Programme: The Value of Space Exploration to Empower the Future of Europe" published in November 2023. While the Space Summit put more emphasis on the European launcher crisis, it also **laid the ground for the European Commercial Cargo Competition** based on one of the HLAG recommendations.

Revolution Space: Europe's mission for space exploration – recommendations for ESA towards the space summit

Credit: HLAG/ESA

On March 23rd, the Report "Revolution Space: Europe's Mission for Space Exploration" on Europe's state and future in space exploration was presented to the 315th ESA Council session in Paris and released to the public. [1][2] The report is based on the work and reflections of the High-Level Advisory Group (HLAG) on Human and Robotic Space Exploration for Europe. The HLAG, which included 12 high-level representatives from industry, government, academia, and civil society, was established in the summer of 2022 following a mandate given by the ESA Council "to provide an independent and objective assessment on the *(1) geopolitical*, *(2) economic* and *(3) societal* relevance of human and robotic space exploration for Europe". ESPI supported and accompanied the HLAG in their elaboration of key messages and recommendations for the report.[3]

The report highlights the strategic importance of independent European access to space and the absence of European independent human launch capabilities. It argues that human space exploration, and space at large, are undergoing a revolution, which Europe cannot afford to miss". The report covered human and robotic exploration: both essential for an autonomous exploration strategy. It notes that Europe's overreliance on international partners threatens its future as a credible global economic and geopolitical actor.

Therefore, the report claims that Europe needs to significantly increase its investment in exploration and develop its own human spaceflight transportation capabilities to secure and foster the benefits of a booming space economy. It argues that Europe must adopt a new procurement model, allowing industry to innovate while cutting costs. Furthermore, the report highlights the exponential

[1] Revolution Space: Europe's Mission for Space Exploration, Report of the High-Level Advisory Group on Human and Robotic Space Exploration for Europe, March 2023
[2] Independent advisory group presents report on European space revolution to ESA, ESA, March 2023
[3] Report of the High-Level Advisory Group on Human and Robotic Space Exploration for Europe, ESPI, March 2023

growth of the total value of the global space economy, stating that "the cost of inaction would far outweigh the necessary investment to establish Europe as a strong and independent space actor". This suggests that greater investment in space exploration will help attract top talent, maintain excellence, and unite Europe through a grand vision. It is argued that greater autonomy in space will make Europe a stronger and more attractive partner for international cooperation.

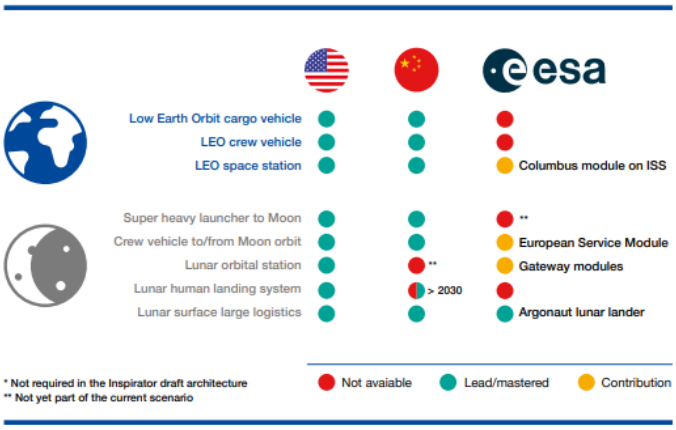


Figure 1: Where does Europe stand in space exploration - Comparative capabilities by 2030 (Source: ESA)

Credit: ESA

The Revolution Space report considers itself a "wake-up call" for European leaders to act now and not miss this opportunity.

The report culminates in a set of recommendations directed at ESA & Europe at large, calling relevant actors to act:

1. Visionary

- Establish autonomy in space capabilities.
- Extend leadership in space applications and science into exploration, with sustainability as the differentiating factor.
- Increase public investment to catch up with the global space economy by 2040.

2. Differently

- Boost entrepreneurship and intra-European competition to stimulate the transformation of the European ecosystem and ESA.
- Pursue symbiotic public-private partnerships with an increased risk and reward-sharing culture
- Integrate bottom-up industrial and academic innovation, and lead in international partnerships.

3. Now

- Need to act now, despite current challenges as postponing will increase the gap between Europe and international space powers (U.S., China).
- Address and respond to security challenges and security and safety in space.
- Ensure reflection of European values in its strategic culture for space exploration and secure Europe's role in international governance discussions.

The HLAG called on ESA to prepare for the 2023 Space Summit:

- Transformation and Invigoration Plan of the European space ecosystem and processes: including the quantification of the induced and catalytic economic impact.
- A scenario for an independent and sustainable European human landing on the Moon in the 2030s.
- Proposals for new transformative European space flagship projects for the 2030s and beyond.

To evaluate and consider the recommendations stated in the report in preparation for the Space Summit, ESA set up a Council working group to review these recommendations.

Exploring the wider benefits of space exploration towards the Space Summit: "More than a Space Programme: The Value of Space Exploration to Empower the Future of Europe"

In response to the HLAG's recommendation to study the benefits of human space exploration in preparation for the Space Summit in Seville, ESPI and the Boston Consulting Group (BCG) worked on the study **"More than a Space Programme: The Value of Space Exploration to Empower the Future of Europe"** from March until November 2023.[4] The report addresses the call in preparation for the Space Summit by the HLAG to plan for the transformation and invigoration of the European space ecosystem and processes including quantifying the induced and catalytic economic impact of space exploration and human spaceflight.

The study was funded by ESA, as an independent assessment performed by ESPI and BCG. The report provides the findings quantifying the induced and catalytic economic impact of a bold European Mission for Space Exploration. The report analysed benefits that Europe can gain from space exploration, encompassing **(1) Direct, indirect, induced, and catalytic benefits; (2) Cross-fertilisation benefits within the space industry; (3) Significant broader improvements and outcomes for the economy and society at large**. The development of core space exploration capabilities is pivotal to unlocking cross-fertilisation effects for the space industry and, therefore, enhancing value generation for the broader economy and society. The report states that space exploration has the potential to create at least ~€260 billion of cumulative GDP impact and an average of ~90,000 FTEs in Europe between 2025 and 2040. The investment in space exploration is estimated to generate a large share of total benefits (~60%) and to enable catalytic effects, accounting for the remaining proportion (~40%) of cumulative impact. Additional sizable benefits are expected after the 2040 time horizon as the emergence of future markets.

The identified benefits could only be unlocked through a significant step up in Europe's investment. Particularly, the underlying assumption is that dedicated funding for space exploration will grow from the current investment of less than €1 billion to more than €3 billion per year, with an overall commitment of ~€50 billion in the 2025-40-time horizon, leading to a multiplier effect of over 5 times the total budget. These resources would be deployed to design and implement a European Space Mission establishing an independent European presence in Earth orbit, lunar orbit, on the Moon, and beyond, including a European Commercial LEO Station, cargo and crew capabilities for the Gateway and the Moon, and sustained presence on the lunar surface.

Preparation of a new approach for the future European launchers towards the Space Summit

Meanwhile, the European launcher crisis and lessons learned for the future of European launchers received more attention and in 2023, **France, Germany and Italy worked on a concept/roadmap for Europe's future in the launcher** sector towards the Space Summit in November 2023. The work was kicked off by the signature of the Joint Statement by Germany, France and Italy on the future of launcher exploitation in Europe at ESA CM22 in November 2022. The Joint Statement grants a renewal of public funding to equilibrate the Ariane 6 and Vega C institutional and commercial exploitation and calls on ESA to review the legal framework governing the European launcher exploitation scheme.[5] Milestones of the trilateral work in 2023 towards to Space Summit include a Progress meeting at Ministerial Level from France, Germany, and Italy in May 2023, and a Status Report to the ESA Council in June 2023. This is outlined in more detail in the **subchapter 1.3 Access to Space**.

[4] More than a Space Programme: The Value of Space Exploration to Empower the Future of Europe, ESPI/BCG, November 2023
[5] Ministers from France, Germany and Italy signed a Statement on the future of launcher exploitation in Europe, November 2022

Space Summit 2023 in Seville

ESA

On November 6th, the European Space Summit 2023 took place in Seville, Spain, gathering Government ministers representing ESA's Member States, Associate States and Cooperating States resolved together to strengthen Europe's space ambitions.[6] The Summit was comprised of the ESA inter-ministerial Council Meeting and an informal EU ministerial meeting on competitiveness (space). The ESA Council Meeting was chaired by Anna Christmann, Federal Government Coordinator of German Aerospace Policy and hosted by Spain, the Council of EU Presidency.

European access to space and in particular, space transportation was a core topic of the Summit. With regard to Europe's future launcher procurement, Germany, France and Italy signed a trilateral agreement on European launchers with "fundamental points for the relaunch of the space sector", resolving long-standing disputes on the availability of launches and related sites. The defined space policy covers the financing of launchers. In particular, the agreement will provide €340 million of financing per year for the Ariane 6 launcher in exchange for a commitment to an 11% cut in cost. Ariane 6 will be awarded at least 4 missions from public institutions per year and the Vega C launcher will get at least 3 launch missions per year. Moreover, France, Germany and Italy will support the launcher programme for an additional 1,5 years. In total this results in an increase in the number of guaranteed launches for Ariane 6 by 15 to 42 by 2030.[7]

Moreover, in order to boost European space exploration and as a potential first step toward developing a crewed vehicle, ESA will start a competition between companies to develop commercial vehicles based in Europe to transport cargo to and from the ISS by 2028. The ESA commercial cargo competition is the first response to the recommendations of the HLAG. The vehicle for cargo transport to the ISS could further evolve into a crew vehicle for LEO and destinations beyond. Funding for the initial project phase has already been secured from ESA's European Exploration Envelope Programme. ESA aims to provide study contracts to 2-3 companies with a total value of €75 million. For the second and later phases, the required funding would be allocated by ESA member states and will form part of the proposals for the next ESA CM25, while private funding requirements will also be embedded.[8]

1.1.2 EU Space Strategy for Security and Defence (EU SSSD)

Announced in the 2022 Strategic Compass, the EU Space Strategy for Security and Defence (EU SSSD) was released and reviewed in 2023. While the strategy is the result of a long process, its release in March 2023 took place little more than a year after Russia's cyberattack against the KA-SAT satellite disrupted communication and connectivity in Ukraine, shortly before the start of Russia's military invasion. The cyber-attack damaged hundreds of terminals on EU soil - strongly affirming the need for prompt implementation of the strategy. ESPI published an Executive Brief "High time for an EU Space Strategy for Security and Defence" on ESPI's expectations and recommendations for the strategy.[9][10]

[6] Ministers back Europe's sustainable and competitive space ambitions, ESA, November 2023
[7] France, Germany and Italy sign agreement on launch vehicle development, Space News, November 2023
[8] ESA to start commercial cargo program, Space News, November 2023
[9] EU space strategy for security and defence: Call for evidence, European Commission, February 2023
[10] High time for an EU Space Strategy for Security and Defence, ESPI Executive Brief No. 63, ESPI, March 2023

The European Commission and the EEAS released EU Space Strategy for Security and Defence

On March 10th, the European Commission and the EU External Action Service released the EU Space Strategy for Security and Defence. The Strategy outlines counterspace capabilities and threats in space that risk space systems and their ground infrastructure and the EU's approach to dealing with these developments.

The EU SSSD has the following objectives grounded on 5 pillars:

1. Common understanding of the Space Threats Landscape

- Classified annual space threat landscape analysis, incl. evolution of counterspace capabilities

2. Resilience and protection of space systems and services

3. Responding to space threats

- Expand the space threat response mechanism to all EU space systems/services
- Mobilise EU tools to respond to space threats
- Access to SDA information to characterise unresponsible behaviours and protect assets
- Space exercises with EU MS to test and develop EU response to space threats

4. Use of space for security and defence

- Maximising the use of space for security and defence purposes
- New Copernicus EO governmental service
- Connecting space, defence and security at EU level
- Enhance cooperation between space and defence start-ups

5. Partnering for responsible behaviours in space

- Engaging within the United Nations framework
- Working with the US as strategic partners
- Developing space security dialogues with third countries
- Deepening EU-NATO cooperation

The Council of the EU approved conclusions on the EU Space Strategy for Security and Defence

On November 14th, the Council of the EU approved conclusions on the EU Space Strategy for Security and Defence. In the Council's conclusions, the Council proposed the following actions:

- Increase the EU's understanding of space threats, through a yearly classified analysis and the strengthening of military and civilian intelligence services on space security.
- Increase and strengthen the resilience and protection of space systems and services, acknowledging the plan to propose an EU space law.
- Better response to space threats through SDA information, a dedicated toolbox for EU joint responses, and the further development of exercises.

- Increase the use of space for security and defence by better integrating the space dimension into the planning and conduct of EU CSDP missions and operations, by strengthening the EU Satellite Centre and by developing space services for governmental use at EU level.
- Address challenges in space through international cooperation (incl. the creation of new space security dialogues).[11]

Credit: European Commission

ESPI published an Executive Brief, based on input submitted following the EC's public call for evidence, on ESPI's expectations and recommendations for the strategy.[12] As outlined in the ESPI brief, the EU Space Strategy for Security and Defence will be a major milestone in the future of military space activities in Europe. Concerning the implementation and next steps, the brief outlines that a key element of the implementation process will be to ensure that EU activities fit and coordinate with efforts conducted at national, multilateral and intergovernmental levels. This is to multiply the capacity of European stakeholders to act decisively in this domain and increase the continent's credibility.[13]

1.1.3 EU Secure Connectivity Programme IRIS² kicks off

EU legislative process on IRIS² finalised – EU approved IRIS²

In February 2023, the European Parliament adopted the report on the proposal for a regulation of the EP and of the Council of EU establishing the EU Secure Connectivity Programme IRIS² with a majority of 603 votes in favour (6 against and 39 abstentions).

On March 7th, the Council of the EU gave the final approval for the regulation on the EU's secure connectivity programme for 2023-2027, the "Infrastructure for Resilience, Interconnectivity and Security by Satellite" (IRIS²), which marked the last step in the decision-making process, finalised by the signature of the regulation text by President of the European Parliament and the President of the Council.[14]

Credit: EUSPA

The programme's €6 billion price tag hopes to be financed through a multitude of actors: the EU's contribution amounts to €2.4 billion stemming from the MFF 2021-2027, the remaining funds are envisaged to come directly from Member States, ESA contributions and private co-investment.[15] The European Commission announced IRIS² would be developed from 2023 onwards, with initial services to begin in 2025, and full operational capability ambitiously expected by 2027.[16]

[11] Space: Council approves conclusions on the EU space strategy for security and defence, Council of the EU, November 2023; Council Conclusions on the EU Space Strategy for Security and Defence, Council of the EU, November 2023
[12] EU space strategy for security and defence - Feedback and statistics: Call for evidence, ESPI, February 2023
[13] High time for an EU Space Strategy for Security and Defence, ESPI Executive Brief No. 63, ESPI, March 2023
[14] Secure space-based connectivity programme: Council gives its final approval, Council of the EU, March 2023
[15] Commission welcomes political agreement to launch IRIS², the Union's Secure Connectivity Programme, Press release European Commission, November 2022
[16] Regulation (EU) 2023/588 of the European Parliament and of the Council of 15 March 2023 establishing the Union Secure Connectivity Programme for the period 2023-2027, March 2023 ; Europe approves multi-orbit connectivity constellation plan, Space News, February 2023 ; IRIS²: the new EU Secure Satellite Constellation Infrastructure for Resilience, Interconnectivity and Security by Satellite, European Commission, February 2023

European industry joined forces and formed the Consortium for IRIS²

In spring 2023, a newly formed consortium of European space and telecommunications companies signed a partnership agreement to bid for the European Commission's call for tender for the European satellite constellation IRIS². The consortium is led and coordinated by Airbus D&S, Eutelsat, Hispasat, SES and Thales Alenia Space and further consists of Deutsche Telekom, OHB, Orange, Hisdesat, Telespazio, and Thales, while remaining open for other participants, encouraging start-ups and SMEs to join.[17]

IRIS² in view of ESA-EU cooperation

In September 2023, ESA DG Josef Aschbacher and Thierry Betron, EU Commissioner for EU Internal Market, European Commission, signed a 12-year ESA-EU Contribution Agreement for the secure connectivity satellite constellation IRIS². This specific agreement builds on the Financial Framework Partnership Agreement signed between the European Commission, ESA and EUSPA in 2021 for the implementation of the EU space programme.

Under this Contribution Agreement, ESA will ensure the development and in-orbit validation of elements for the multi-orbit constellation IRIS² on behalf of the European Commission. ESA will receive an additional budget of €380 million delegated from the European Commission to execute its role as the Qualification and Validation Authority of the governmental infrastructure, which aims to ensure that industry will deliver as per the established requirements and to support the Commission in defining future generation of systems.[18]

1.1.4 EU Priorities and Budget 2023-2024

Priorities of the Presidencies of the EU Council 2023-2024

In 2023, priorities were set, and developments pursued in European space policy by the Presidencies of the Council of Sweden (January-July 2023) and Spain (July-December 2023). Moreover, Belgium released the programme for its EU Presidency (January-July 2024).

EU Council Presidency		Time Period	Priorities
Sweden	sweden 2023.eu	January 1st – June 30th 2023	• Promote the work on the envisaged EU space strategy for security and defence • Promote the legislative process for IRIS² • Promote measures for a fair and sustainable use of space. [19]

[17] European Space and Telecoms Players Sign Partnership Agreement to Bid for IRIS2 Constellation, Eutelsat, May 2023
[18] ESA works with EU on secure connectivity, ESA, September 2023
[19] The Swedish Presidency Programme – Sweden2023. EU, December 2022

Spain	EU23 SPANISH PRESIDENCY COUNCIL OF THE EUROPEAN UNION	July 1st – December 31st 2023	• Adoption of the Council of the EU's Conclusions about STM • Continuation of advancing a European policy on space, defining and reinforcing the role of the EU • Preparation of the Council of EU's Conclusions on the Space Strategy for Security and Defence • Space Summit 2023: focusing on the sustainable and green use of space, on resilience and on competitive and sustainable industrialisation.[20]
Belgium	be EU belgium24.eu	January 1st– June 30th 2024	• Contribution of research and innovation as the foremost catalyst for achieving greater open strategic autonomy for Europe. • Importance of space activities as a strategic asset, particularly in domains such as security, defence, climate change mitigation, and the empowerment of New Space actors. • Facilitating the implementation of the EU space strategy for security and defence. • Advancing cybersecurity and secure connectivity to promote the safe, sustainable, and secure use of space, and ensuring the cyber resilience of space infrastructure. The Presidency will also support any action taken by the EC to enhance the resilience of space systems and services in the EU and will strive to ensure coordination between Member States.[21]

EU Commission opened a call for feedback on the mid-term evaluation of the EU Space Programme

In November, the European Commission opened a call for feedback for the EU mid-term evaluation of the EU Space Programme[22], to which ESPI submitted a contribution with recommendations in line with ESPI 2040 policy vision and recommendations.[23]

ESPI's feedback included the following key messages:

As outlined in ESPI2040: Space for Prosperity, Peace and Future Generations, Europe has all the prerequisites to develop into a full space power, by bringing together, federating and developing the excellence of its European, national and industrial capacities. However, what is missing is a clear political will and a whole-of-Europe vision beyond the perceived bounds of space systems, which would precipitate policy impact. To date, European space policy and programmatic action are mostly concerned with space capabilities, such as satellites and launchers, and less so with the policy impact of space and the foundations that enable steps towards acquiring Space Power status.

[20] Programme of Spain's Presidency of the Council of the EU – EU23 - Europe, closer, EU, June 2023
[21] The Belgian presidency programme – be EU – belgium24.eu, December 2023
[22] Mid-term evaluation of the Space Programme, European Commission, November 2023
[23] ESPI's Provision of Evidence for Mid-Term Evaluation of the EU Space Programme, ESPI, November 2023

Policy impact includes efforts to integrate space into other policy sectors, including security and defence, and climate, while the Foundation layer focuses on building the required environment for reinforced industrial competitiveness, scientific and technological excellence, innovation, talent, and financing. The EU Space Programme represents the largest EU investment in space and a considerable share (roughly 20%) of the overall European public space expenditure. The MFF evaluation is therefore an important step in calibrating the programme's impact under the current MFF envelope and preparing the next MFF, where ESPI believes the EU Space Programme should receive a further boost in funding. In this context, this contribution does not focus on existing (and planned) capabilities, but rather on key identified priorities that go beyond the current perimeter.

The capabilities addressed in ESPI's feedback include:[24]

Space for Security & Defence	Market Creation for Space Services	Space Safety & Sustainability	Directed Innovation Policy & Growth	International Relations	Europe as a Space Power

Council of the EU approved the EU annual budget for 2024

On November 20th, the Council of the EU approved the joint text on the EU's general budget for 2024, which was agreed in negotiations with the European Parliament on November 11th. For the EU's general budget, total commitments are set at €189.385 million and total payments at €142.630 million.[25] A budget of €2.3 billion is allocated for space. The budget for the space cluster includes €2.18 billion for the EU Space Programme, €270 million for EUSPA, and €190 million for secure connectivity.

Credit: Council of the EU

Moreover, €13.6 billion of the EU 2024 budget is allocated for R&I (incl. €12.9 billion for Horizon Europe) and €1.6B billion for defence (incl. €638 million to support capacity D&R under the EDF).[26] The 2024 budget was adopted by the European Parliament on November 22nd 2023.[27]

Out of the EU's full space budget, €1.82 billion is implemented via the European Space Agency.

Horizon Europe developments

Positive evolution of EU-UK relations: UK rejoined Horizon Europe and Copernicus

In July, following a meeting between UK Prime Minister Rishi Sunak with European Commission President Ursula von der Leyen, the EU and the UK agreed to a draft agreement for the UK's re-entry into the EU's Horizon Europe and Copernicus Programme, which the UK lost access to as a consequence of Brexit.[28]

[24] ESPI's Provision of Evidence for Mid-Term Evaluation of the EU Space Programme, ESPI, November 2023
[25] Council gives go-ahead to EU annual budget for 2024, Council of the EU, November 2023
[26] Commission welcomes agreement on EU Annual Budget 2024, European Commission, November 2023 ; 2024 Budgetary Procedure Conciliation Document – Joint Text, Council of the EU, November 2023
[27] MEPs adopt EU budget 2024: focus on research, youth and external challenges, European Parliament, November 2023
[28] The U.K. and EU Agree Draft Horizon Deal, Spacewatch global, July 2023

In September, it was announced that the UK would rejoin the EU's Horizon Europe research programme and the Copernicus programme. The agreement facilitates UK scientists' access to EU funding and promotes closer collaboration with their European counterparts.

The UK is expected to contribute approximately €2.34 billion annually to participate in Horizon Europe, in addition to €154 million for association with Copernicus. To address potential profit or loss disparities, both sides have established a "correction mechanism". If the UK receives more in grants than it contributes, its profits will be capped at 8% over two consecutive years. Conversely, if the UK faces a 12% deficit, it can request intervention from a UK-EU Specialised Committee, and a 16% loss would lead to adjusted future financial contributions.

In November 2023, the Council of the EU approved the agreement. The agreement allows UK researchers and organisations from January 2024 to participate in Horizon Europe (with equal rights as entities in EU Member States) and the UK will once again participate in Copernicus. The UK's participation will be subject to all the safeguards of the EU-UK Trade and Cooperation Agreement, including the payment of a participation fee into the EU budget. This decision of the Council will enable the EU to formalise the agreement in principle reached with the UK, by adopting a decision within the EU-UK Specialised Committee on Participation in EU programmes.[29]

Canada joined Horizon Europe

Moreover, at the end of 2023, it was decided that Canada would join the Horizon Europe programme as an associate member. This announcement came during a visit by EU Commission president Ursula von der Leyen and EU Council president Charles Michel in Canada. The EU and Canada confirmed that discussions about Canada's participation would only involve the second pillar, which concerns R&I collaboration on global challenges and industry competitiveness.[30]

[29] EU-UK relations: Council gives the go-ahead to UK participation in the Horizon Europe and Copernicus programmes, Council of the EU, November 2023; COUNCIL DECISION on the position to be taken on behalf of the European Union within the Specialised Committee on Participation in Union Programmes established by the Trade and Cooperation Agreement between the European Union and the European Atomic Energy Community, of the one part, and the United Kingdom of Great Britain and Northern Ireland, of the other part, as regards the adoption of Protocols I and II and the amendment of Annex 47 thereto, Council of the EU, November 2023

[30] Trudeau says Canada is joining Horizon Europe, Research Professional News, November 2023

1.2 Space Exploration & Science

From an international perspective, 2023 marked the year with several milestones related to moon exploration with India landing the Chayandraan mission, Japan launching the SLIM mission, and Russia's attempt to land Luna. The U.S. progressed with its Artemis programme, following the launch of Artemis I in late 2022, and successfully recruited new signatories for the Artemis Accords, while in parallel China progressed with its International Lunar Research Station (ILRS) plans, outlining details on the timeline, establishing the ILRS organisation and finding new ILRS partner. For Europe, 2023 saw relevant declaratory developments focused on the future European strategy in exploration, expected to materialise in the years to come as well as a first-ever commercial cargo competition announced in November 2023.

1.2.1 LEO (ISS, commercial space stations)

2023 saw various developments in shaping the future of human presence in LEO. On one end ISS partners extended the commitments to their participation in the ISS until 2030 (with the exception of Russia; 2028) at the end of 2022 and early 2023. On the other hand, commercial space stations driven by U.S. industry for the post-ISS era saw further progress through, including by bringing transatlantic partners on board. Europe, on the back of the Revolution Space report published by a High-Level Advisory Group on Human and Robotic Exploration mandated by the ESA Council, also showed signs of increased ambition in exploration, announcing a commercial LEO cargo competition, as a potential first step towards a more autonomous European footprint in LEO.

Moreover, 2023 saw progress in nationally developed space stations, including the first taikonaut mission to China's Tiangong space station and plans to add additional modules to it. Further afield, details emerged on the plans for Russia's own Russian Orbital Service Station (ROSS), while Indian Prime Minister Narendra Modi announced India's goals of setting up a space station by 2035 and sending a man to the moon by 2040.

In February 2023, JAXA selected two new astronaut candidates (for the first time again after 14 years), to join JAXA from April 1st for ISS missions and to support the NASA-led Artemis program: Makoto Suwa and Ayu Yoneda.[31]

Developments in Europe

Space Summit: competition to develop a commercial vehicle for cargo transport to the ISS

At the European Space Summit 2023 in November, launchers and space transportation were a central topic. In line with recommendations formulated in Revolution Space, ESA Member States decided to launch a competition to develop commercial vehicles based in Europe to transport cargo to and from the ISS by 2028.[32] This could become a first step towards potentially developing a European crewed vehicle. Public funding for the initial stages of the project has already been secured, with private contributions being sought in complement. ESA envisioned a first phase where study contracts are provided to two or three companies in the near term with a total value of €75 million, using existing funding from ESA's European Exploration Envelope Programme.

[31] NASA selects Axiom Space for third private astronaut mission to ISS, SpaceNews, March 2023
[32] Revolution Space: Europe's Mission for Space Exploration, Report of the High-Level Advisory Group on Human and Robotic Space Exploration for Europe, March 2023

Funding for the second phase and later phases would be allocated by ESA member states and will form part of the proposals at CM25. By taking a preliminary decision at the Space Summit, ESA could start work immediately to meet the ambitious 2028 milestone.

Developments in European-owned? capabilities include:

Credit: ESA

- **ESA's Commercial Cargo Transportation Initiative**: ESA's Commercial Cargo Transportation Initiative, first floated in May 2023, provides a partnership and support scheme, whereby private companies receive support from ESA for the development of commercial cargo transportation services to human outposts in LEO. These services should specifically target operations with the ISS and future Commercial LEO Destinations (CLD). The initiative aims to execute a demonstration mission, which will deliver at least 2 tons of pressurised cargo to the ISS and safely return at least 1 ton back to Earth before the end of 2028. The mission is free to include the provision of additional capabilities, such as the delivery of more pressurised or unpressurised cargo. If the initiative is successful, ESA plans to follow up with service contracts. ESA divided the initiative into three phases: Phase 1.1, including preliminary design and third-party funding, has a €2 million budget; Phase 1.2 will de-risk the most critical areas of design and secure additional third-party funding; while Phase 2 will be the final step towards the demonstration flight, open to all companies, regardless of Phase 1 participation.
- **Advancements in ArianeGroup's Susie upper-stage launcher development:** In October 2023, a demonstrator of ArianeGroup's reusable upper-stage SUSIE completed its first ignition in Les Mureaux (Île-de-France). The 2-metre-tall, 100 kilogrammes demonstrator is designed to develop a controlled landing system, with testing expected to continue until Q2 2025. The full-sized Susie spacecraft, measuring 12 metres tall and 5 metres wide with a payload capacity of 7 tons, is intended for a variety of roles, including crew and cargo transport. In November 2023, ArianeGroup announced that it started the testing of SUSIE's prototype.[33]
- **Airbus' design concept for the Loop Module:** In April, Airbus unveiled a 26ft-wide concept design for a future three-deck space station with living quarters, a science hub and a greenhouse. The concept design of the 'LOOP' module, a multi-purpose orbital module, is designed for a 4-person crew and hosts 3 floors (incl. a habitation deck and a science deck, a centrifuge that creates Earth-like gravitational conditions, to decrease the stress of weightlessness on the human body). In addition, the station will have a greenhouse for growing crops. The modular approach enables to adapt the deck selection to individual mission requirements and objectives. Several LOOP modules can be combined into a larger station.[34]

European cooperation with commercial space stations

Moreover, developments in European engagement for post-ISS and involvement and cooperation with commercial space stations received a boost in 2023 at the time of the European Space Summit in November 2023 in Seville. In January, Voyager chose and signed an agreement with Airbus to contribute technical design support and expertise to the Starlab project.[35] In August, Voyager Space and Airbus D&S announced an agreement for a transatlantic joint venture to develop, build, and operate Starlab - a joint venture as part of NASA's Commercial Destinations Free Flyer programme.

[33] Premier allumage réussi pour le démonstrateur du module réutilisable Susie d'ArianeGroup, L'usine nouvelle, October 2023 ; ArianeGroup begins testing prototype of multirole Susie upper stage, Space News, November 2023
[34] Airbus LOOP Multi-Purpose Orbital Module, Airbus
[35] Voyager Space and Airbus Announce International Partnership for Future Starlab Space Station, Voyager Space, January 2023

In November, at the sidelines of the European Space Summit, ESA, Airbus Defence & Space, and Voyager Space formalised their collaboration through a trilateral MoU, focusing on joint efforts for the post-ISS era's Starlab space station. The MoU outlines the parties' commitment to mutually support science and technology development and explore potential collaborations related to post-ISS LEO destinations.[36]

Developments beyond Europe

Developments related to the ISS

Following the approval of Axiom Space's second private crewed mission to the ISS Axiom Mission 2 (Ax-2), in January 2023, it was announced that Axiom Space will fly four astronauts atop SpaceX's Falcon 9 in spring 2023. The 12-day mission will be carried out by a multinational crew, including two Saudi astronauts and the first Saudi woman to embark on the ISS, Rayyanah Barnawi. The Ax-2 crew will partake in extensive scientific research on the mission and investigate cutting-edge technologies with a view to lay the groundwork for the world's first commercial space station under development by Axiom Space.[37]

Credit: Axiom Space

On March 2nd, the Crew-6 mission was launched to the ISS with SpaceX's Falcon 9, and the Crew Dragon spacecraft Endeavour, from Kennedy Space Center - after a first launch attempt on February 27th. The Crew-6 mission brought 4 astronauts, namely NASA astronauts Stephen Bowen and Warren Hoburg (mission commander and pilot), Roscosmos cosmonaut Andrey Fedyaev and UAE astronaut Sultan Alneyadi, to the ISS for an approx. 6-month stay. The four-person Crew-5 mission comprised of the NASA astronauts Nicole Mann and Josh Cassada, JAXA astronaut Koichi Wakata and Roscosmos cosmonaut Anna Kikina, returned from the ISS on March 11th.[38]

Credit: Twitter/@SpaceX

On March 14th, NASA signed a mission order with Axiom Space, approving plans by Axiom Space to fly a third private astronaut mission (Ax-3) to the ISS by January 2024. Later, on May 21st, the Ax-2 mission was launched.

Also in March, Türkiye's President Erdogan announced Türkiye's first candidates for human spaceflight. The selected candidates are Turkish Air Force pilot Alper Gezeravci who will fly to the ISS, and Tuva Cihangir Atasever who will serve as a reserve candidate.[39] Additionally, Axiom announced an agreement with the Turkish Space Agency to fly a Turkish astronaut on a future mission and a MoU with the Canadian Space Agency to investigate opportunities for future space cooperation, including Canadian astronauts on Axiom missions.[40]

On April 18th, at the Space Symposium in Colorado Springs, ESA, the Swedish National Space Agency (SNSA), and Axiom Space signed a Letter of Intent to send a Swedish ESA astronaut to the

[36] Starlab Space Station to boost European Space Agency ambitions in low-Earth orbit, Airbus, November 2023
[37] NASA, Space Station Partners Approve Ax-2, Axiom Space Private Mission Crew, Axiom Space, January 2023
[38] Crew-6 launches to space station, SpaceNews, March 2023; NASA's SpaceX Crew-5 to Discuss Mission Following Return to Earth, NASA, March 2023
[39] Erdogan announces Türkiye's first space traveller candidates, TRTWorld, March 2023
[40] Axiom space and Türkiye sign agreement to send first Turkish astronaut to space, PRNewswire, September 2022 ; Canada eyes new astronaut flights with Axiom space, Space.com, September 2022

ISS on an upcoming Axiom Space mission for a 10-day visit, focusing on scientific research and educational outreach. In September it was announced that ESA project astronaut Marcus Wandt from Sweden will travel to the ISS on the Ax-3 mission in early 2024.

ESA, as the mission's crew provider, prepares the required operational support for the flight and signed an agreement with Axiom Space for the definition and implementation of the mission jointly designed by ESA and the SNSA. The agreement marks the first commercial human spaceflight for an ESA astronaut. ESA Director General Josef Aschbacher stated that "the ESA astronaut policy was developed for exactly these opportunities, flying on commercial flights in partnership as we transition Europe's access to space and diversify the space market".[41]

On May 21st, the Ax-2 mission launched. Ax-2 has been the second mission that Axiom Space organised and operated aboard the ISS. This time, it included the first two Saudi visitors onboard the ISS, Rayyanah Barnawi –the first Saudi woman to reach space – and Ali AlQarni. Axiom Space's Ax-2 crew docked to the ISS on Monday 22nd, following a nearly 15-hour journey, undocked, and splashed down off the coast of Florida on May 30th.[42]

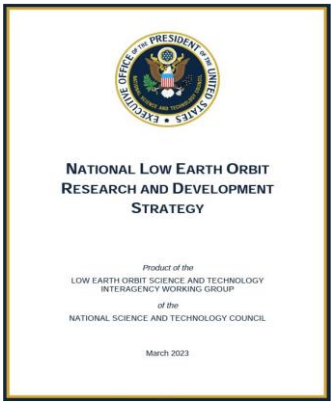
In August, Poland signed an agreement with Axiom Space, supported by ESA for a future Axiom Space mission– the agreement is similar to the one signed between Axiom Space and Sweden. Through this agreement, Poland will be the second country supported by ESA to send an astronaut. Sławosz Uznański, on a commercial human spaceflight mission with Axiom Space.[43]

In September, Axiom Space also signed a new agreement with the Saudi Space Commission (SSC) to fly two astronauts of Saudi Arabia to space on a future Axiom mission.[44]

White House Released National Low Earth Orbit (LEO) Research and Development Strategy

On March 31st, the White House Office of Science and Technology Policy released the National Low Earth Orbit Research and Development Strategy, which highlights the U.S. approach to the realisation and institutionalisation of the scientific, economic, diplomatic, and educational benefits of LEO research platforms for the future, pointing out 5 policy objectives and action items for U.S. leadership in LEO:

- Advance groundbreaking science and technology
- Strengthen U.S. government collaboration and partnerships
- Promote market opportunities, innovation, and sustainability
- Expand international cooperation
- Stimulate STEM education and workforce development.[45]



Credit: White House

National/institutional agreements with commercial space stations

2023 saw institutional (European and U.S.) support and cooperation with commercial space stations, which are briefly outlined in this section. The developments of the U.S. commercial space stations are described in more detail from a commercial/industrial perspective here and in more detail in the **chapter 2 Industry and Innovation**.

[41] Sweden intends to send ESA astronaut to the International Space Station, ESA, April 2023
[42] Ax-2 Mission Successfully Launches, Four Private Astronauts Headed to Space Station, Axiom Space, May 2023
[43] Axiom Space Sign Agreement with Poland for Future Human Spaceflight Mission, Spacewatch Global, August 2023
[44] Saudi Arabia launches Astronaut program and partners with Axiom to fly two astronauts to space, Spacewatch, September 2022
[45] National Low Earth Orbit Research and Development Strategy, NSTC White House, March 2023

Starlab Space Station

In January, Voyager Space chose Airbus to contribute technical design support and expertise to the Starlab project. In August, Voyager Space and Airbus D&S announced an agreement for a transatlantic joint venture, Starlab Space, to develop, build, and operate Starlab - as part of NASA's Commercial Destinations Free Flyer programme.

In November, the European Space Agency, Airbus Defence and Space, and Voyager Space signed a trilateral MoU, focusing on joint efforts for the post-ISS era's Starlab space station.[46]

Orbital Reef Space Station

In November, Sierra Space unveiled the Dream Chaser spaceplane "Tenacity". The vehicle hopes to serve as a commercial runway-capable spaceplane and will undergo environmental testing at NASA's Armstrong Test Facility in Ohio. Under NASA's CRS-2 contract. The inaugural mission is planned for 2024, using ULA's Vulcan Centaur rocket.[47]

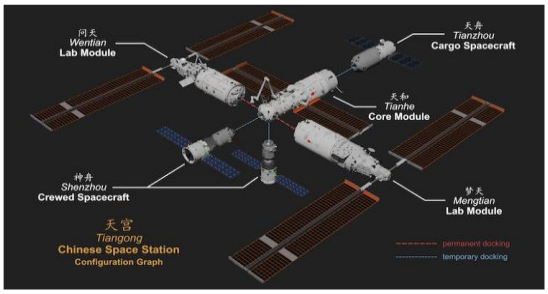
Starship-based Space Station

In 2023, there were two Starship launch attempts – with a positive tendency and an increased level of success. Beyond its initial purpose, in June, it was reported that NASA is exploring repurposing components of the SpaceX Starship system into a functional space station. In a collaborative effort with SpaceX, NASA is actively engaged in developing an "integrated LEO architecture".[48] The NASA-SpaceX collaboration is among 7 partnerships recently unveiled by NASA and U.S. companies, with the overarching goal of advancing human spaceflight and fostering the development of a commercial LEO economy in the U.S.[49]

National Space Stations

In 2023 notable milestones related to the operationalisation of China's Tiangong space station have been met and the station can now host astronauts. Further afield, Russia, with its ROSS project has revealed more plans on its plans, while India's Prime Minister Modi announced an autonomous Indian space station by 2035.

Updates on China's Tiangong Space Station



Credit: Shujianyang/Wikimedia Commons

Following the completion of China's Tiangong space station end of 2022, 2023 saw the first missions to Tiangong. In 2023 the space station became fully operational and can now host 3 astronauts for 6-month intervals and can support 6 astronauts during crew handovers. Having initiated human spaceflight training with CMSA in 2017 aiming to send ESA astronauts to Tiangong, in January 2023, ESA announced the suspension of its astronaut missions to China's space station, citing political and financial considerations.[50] Moreover, China also unveiled plans for a cargo delivery system and added additional station modules.

Furthermore, January also saw the chief designer of China's human spaceflight programme Zhou Jianping announce that China will actively encourage the private sector to carry on commercial activities and missions to Tiangong. The China Manned Space Engineering Office (CMSEO) unveiled

[46] Starlab Space Station to boost European Space Agency ambitions in low-Earth orbit, Airbus. March 2023
[47] Today Sierra Space Introduces Tenacity®, Sierra Space, November 2023
[48] NASA and SpaceX explore using Starship as space station, Institution of Mechanical Engineers, June 2023
[49] Seven US Companies Collaborate with NASA to Advance Space Capabilities, NASA, June 2023
[50] ESA is no longer planning to send astronauts to China's Tiangong space station, SpaceNews, January 2023

plans to establish a commercial, cost-effective transportation system for delivering cargo to and from Tiangong. In May, the CMSEO launched the call for proposals for a commercial, low-cost flexible transportation system to deliver cargo to and from its Tiangong space station.[51] The requirements include a plan for the launch segment, the capability of sending not less than 1.800 kilogrammes to LEO, the spacecraft's ability to stay docked in orbit for at least 3 months, the capability of controlled re-entry, and the limit of the offered price at 120M yuan ($17.2M) per 1 ton delivered. The program is similar to NASA's Commercial Resupply Services (CRS) program.[52]

On May 30th, the 3 Chinese astronauts (including the first Chinese civilian astronaut) of the Shenzhou-16 crewed mission arrived at the Tiangong space station.[53] In June, China's Tiangong Space Station achieved a new premiere by successfully installing an electric propulsion system gas cylinder in-orbit with a robotic arm for a gas exchange method.[54] On October 25th, China launched its Shenzhou-17 mission with three astronauts (Tang Hongbo, Tang Shengjie and Jiang Xinlin) to Tiangong for a six-month mission aboard the Long March 2F Yaoqiu 17 rocket. Hongbo was the mission commander, having already participated in the Shenzhou-12 mission, while both Shengjie and Xinlin flew for the first time. The Shenzhou-16 astronaut crew returned to Dongfeng Landing Site on the 31st of October.[55]

Also, announced in October during the IAC, Tiangong is set to expand from 3 modules to 6. The expansion will see a multi-functional module with six docking ports launched and docked to the core module, Tianhe. Full-size modules will then be added over the next 4 years. In addition to increasing the volume, Tiangong will also host a Hubble-class co-orbiting space telescope named Xuntian, which can dock with the station for maintenance, repairs, refuelling, and upgrades.

Moreover, according to reports in November, China plans to use Tiangong for technology testing of space-based polar power (SBSP) – particularly an on-orbit assembly of modules with robotic arms for a SBSP test system.[56]

Russia unveiled details on the progress and timeline for Russian Orbital Station (ROS)

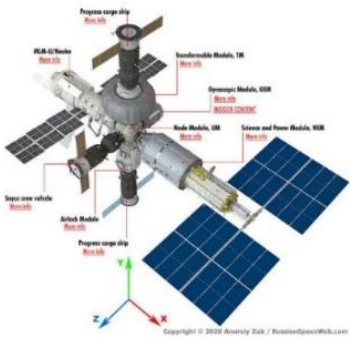
In April, Russia committed to participate in the ISS until 2028 – 2 years before the planned de-orbiting of the ISS in 2030.[57] Concerning Russia's participation in the ISS and the transition phase from ISS to ROSS, according to a statement done at the beginning of October by Roscomos Head Yury Borisov at the IAC in Baku, Russia's extension of the operation of the ISS after 2028 will depend on the technical condition of the ISS (and in particular the Roscosmos module) and on the progress of ROSS and its cosmonaut programme. He also confirmed that Russia will support ISS partners in efforts to properly de-orbit the ISS.[58]

In June, Roscosmos unveiled details on the progress and timeline of the Russian Orbital Service Station (ROSS). Roscosmos announced that it will select two cosmonauts by 2024 for the inaugural mission to ROSS, with a training programme expected to be fully developed by 2025.

In July, Russia proposed to create a joint module for ROSS to allow BRICS countries participation through conducting scientific research. Reportedly, Russia has already offered African countries the opportunity to participate in the ROS project and the creation of dedicated national modules.[59]

[51] China calls for space station commercial cargo proposals, SpaceNews, May 2023
[52] China calls for space station commercial cargo proposals, SpaceNews, May 2023
[53] Shenzhou-16 astronauts arrive at China's space station, SpaceNews, May 2023
[54] Tiangong Space Station's electric propulsion engine achieves first in-orbit gas exchange, Global Times, June 2023
[55] Shenzhou-17 Crew Launch to Tiangong Space Station, Spacewatch Global, October 2023
[56] China to use space station to test space-based solar power, SpaceNews, January 2023
[57] Roscosmos Reveals Details on the Russian Orbital Station Cosmonaut Program, Payload Space, June 2023
[58] ISS operation extension after 2028 to depend on orbital post's condition — Roscosmos chief, Tass, October 2023
[59] Russia proposes joint research module on space station for BRICS members — Roscosmos CEO, TASS, July 2023

At the beginning of October, during the IAC in Baku, Azerbaijan, Roscosmos invited the national space agencies of Brazil, Türkiye, and South Africa to participate in the ROSS project, having presented the plans for the development of the station and the continuation of Russia's human spaceflight programme in bilateral meetings.[60] At the end of October, President Putin announced that the initial phase of Russia's upcoming space station is projected to be fully operational by 2027.



Credit: RussianSpaceWeb.com

ROSS is expected to be in a sun-synchronous orbit at an altitude of 400 kilometres. Roscosmos stated that its space station would be launched in two phases. ROSS's seven-module structure includes four modules in the initial phase: NEM-1, an updated NEM, a node module, and a gateway module. The Science Power Module 1 (NEM-1), also known as the fundamental module, marks the cornerstone of ROSS**.** Originally slated for a 2024 launch to the ISS, NEM-1 is undergoing a 1.5–2-year development process to assume its role in ROSS, now aiming for completion by 2035. The second stage contemplates additional modules for spacecraft maintenance, logistics, production, and even a commercial module for space tourism.

The proposed two-stage construction plan, commencing in 2028 with the launch of the Science Power Module, underscores the ambitious timeline for ROSS's realisation. Russian state media have suggested the launch of the first stage is planned for 2025-26 and no later than 2030. Launch of the second and final stage is planned for 2030-35.

According to the head of Roscosmos, Yury Borisov, the development of ROSS until 2032 is estimated at 609 billion roubles (approx. €6 billion) and about 150 billion roubles (approx. €1.5 billion) are planned to be spent on the project between 2024-2026. Although ROSS is a national initiative, Russia signalled its openness to engage in partnerships with global counterparts and will potentially cooperate with countries such as China and Iran.

India announced plans to develop Bharatiya Antariksha Station

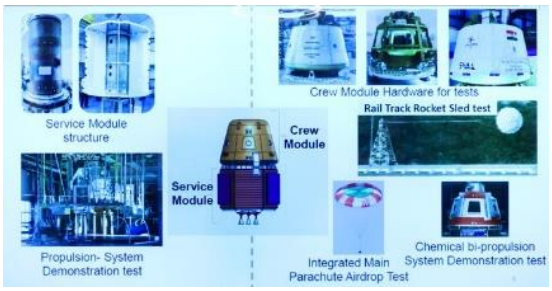
Two months after India's successful Moon landing and the launch of the Aditya Solar Observatory, India's Prime Minister Narendra Modi announced new targets for ISRO.[61] These plans include the establishment of a national LEO Space Station (Bharatiya Antariksha Station) by 2035 and the first Indian Moon landing by 2040.

Originally slated for launch in 2030, the space station project was delayed to 2035 due to setbacks related to technical issues associated with the Gaganyaan crewed spaceflight mission and the global COVID-19 pandemic. ISRO Chairman S. Somanath emphasised that the Gaganyaan programme was a crucial step toward achieving human spaceflight capabilities, paving the way for subsequent modules dedicated to space station construction. The projected timeline for the space station spans the next 20 to 25 years, with plans for human exploration, extended human spaceflight durations, and space exercises. The Department of Space has been tasked with developing a roadmap for Moon exploration, encompassing a series of Chandrayaan missions, with the next mission aimed at bringing back Moon samples. ISRO will also focus on developing a next-gen

[60] Roscosmos wants Brazil, Türkiye, South Africa in on orbital station project, Tass, October 2023
[61] PM Modi spells out ISRO goals: Space station by 2035, Indian on Moon by 2040, Indian Express, October 2023

launch vehicle, a new launch pad, and human-centric laboratories and technologies to support these missions.[62].

On October 21st, the first demonstration flight of the Crew Escape System Test Vehicle was conducted when ISRO launched an empty module from Satish Dhawan Space Centre into space and brought it safely back to Earth. This successful test flight provided the basis for the remaining qualification tests and unmanned missions.



Credit: Narendra Modi on X

1.2.2 A Moon Race? Global powers vying for influence in lunar exploration


Credit: Fotolia

2023 was the year of Moon exploration. India successfully landed the Chandrayaan-3 Lander Module on the Moon's surface in July, becoming the first nation to land on the Moon's South Pole and the fourth country in the world to achieve a soft landing on the lunar surface – joining the U.S., the former USSR, and China.

While India successfully landed Chandrayaan-3 on the Moon, Russia's Luna-25 mission failed to land. Moreover, Japan launched its Moon mission SLIM (Smart Lander for Investigating Moon). Meanwhile, the U.S. and China progressed with their lunar ambitions – the U.S. Artemis Programme and China's International Lunar Research Station (ILRS). Europe remains a junior partner to the U.S. Artemis Programme by contributing the crucial European Service Modules (ESM) for the Orion Spacecraft.

Global Space Powers in the Moon Race

India successfully landed Chandrayaan-3 on the Moon's surface

Launched from the Satish Dhawan Space Centre in Sriharikota Range on July 14th, ISRO successfully landed the Chandrayaan-3 Lander Module on the Moon's surface. India became the first nation to land on the lunar southern polar region, notwithstanding different definitions of the lunar South Pole, and the fourth in the world to achieve a soft landing on the lunar surface. After reaching lunar orbit on August 5th, the lander module separated from the propulsion module on August 17th. Subsequently, it initiated its descent to the surface.

Credit: ISRO

On August 23rd, ISRO confirmed the successful touchdown of Chandrayaan-3's lander as planned. [63] One crucial support function of the mission was provided by ESA, ensuring communication from ESA's station in Kourou, French Guiana and from the UK's Goonhilly Earth Station.[64] The achievement conveys India's rising global ambitions and comes at a time of renewed interest in lunar exploration, particularly the lunar South Pole. Following the success, Indian Prime Minister Modi announced a 2040 timeframe for India's first human-led mission to the lunar surface.

[62] Prime Minister reviews readiness of Gaganyaan Mission, Press Information Bureau Government of India, October 2023
[63] Chandrayaan-3 is on its journey to the moon, ISRO, July 2023
[64] India's Chandrayaan-3 successfully lands on the Moon, ESA, August 2023

Russia's Luna-25 mission failed to land on the lunar surface

In August, Russia's Luna-25 mission, Russia's first Moon mission in almost 50 years and its first mission to explore the lunar South Pole region reached the vicinity of the Moon. The mission was successfully launched but ended in failure as the spacecraft crashed into the Moon after encountering problems as it moved into its pre-landing orbit. The failure happened 4 days before the successful Moon landing by India. Luna-25 was originally scheduled for a landing attempt near Boguslawsky crater on August 21st, but Roscosmos confirmed that an anomaly during a manoeuvre on August 19th led to the spacecraft's impact on the lunar surface. Initially, Luna-25 was planned to launch in 2022 but was postponed due to technical issues. However, Russia announced its plan to launch a new mission to the Moon's South Pole in the 2025-2026 timeframe.[65]

Japan launched the lunar lander SLIM (Smart Lander for Investigating Moon)

On September 6th Japan launched two missions into space, including a lunar lander SLIM (Smart Lander for Investigating Moon) and a powerful X-ray space telescope XRISM (X-Ray Imaging and Spectroscopy Mission) from the Tanegashima Space Centre. SLIM is tasked with achieving Japan's first-ever soft lunar landing and carries two small probes designed to monitor the lander's status, capture landing site photos and provide an independent communication system with Earth.

U.S. progressed with Artemis Programme and commercial, CLPS-backed Moon missions

In 2023, the U.S. progressed with the Artemis Programme. Following the successful Artemis I mission in 2022, Artemis II will be the first crewed mission of the Artemis Program, building on the successful Artemis I uncrewed flight test.

On March 15th, Axiom Space unveiled the prototype spacesuit for NASA's Artemis III mission during an event at Space Centre Houston in Texas. Axiom Space was selected by NASA to deliver the mission's moonwalking system, which includes the design, development, qualification, certification, and production of flight training spacesuits (the Axiom Extravehicular Mobility Unit (AxEMU)) and support equipment. Prior to the mission, Axiom Space will test the spacesuit in a spacelike environment. The AxEMU spacesuit aims to enhance mobility and provide protection from hazards on the Moon.[66]

Credit: NASA

On April 3rd, NASA and the Canadian Space Agency (CSA) announced the 4 astronauts for the first crewed Artemis mission Artemis II, Commander Reid Wiseman (U.S.), Pilot Victor Glover (U.S.), Mission Specialist 1 Christina Hammock Koch (U.S.), and Mission Specialist 2 Jeremy Hansen (Canadian). The crew will conduct tests and demonstrations during the 10-day flight around the Moon which is planned to launch in late 2024 to prove the life-support systems of the Orion spacecraft.[67]

With regard to Artemis, NASA selected Blue Origin to develop a lunar lander, which aims to transport astronauts on the Artemis V mission as part of NASA's Sustaining Lunar Development (SDL) efforts. The SDL was announced by NASA in March 2022 to support work on a second lander, complementing SpaceX's Starship selected by NASA in April 2021 for the Human Landing System (HLS) program. Blue Origin and Dynetics, who competed with Space X and lost the bidding competition, protested the award to the Government Accountability Office – which was rejected.

[65] Abnormal situation occurs during transfer of Luna-25 probe to pre-landing orbit, Tass, August 2023; Roscosmos to consider sending new mission to Moon's south pole in 2025-26, Tass, August 2023
[66] Spacesuit for NASA's Artemis III Moon Surface Mission Debuts, NASA, March 2023
[67] NASA Names Astronauts to Next Moon Mission, First Crew Under Artemis, NASA, April 2023

SDL aimed to ensure competition in the HLS program. SpaceX was excluded from the SLD competition because of the existing HLS award in 2021. With the award under SLD, Blue Origin will lead a team, which includes Boeing, Draper and Lockheed Martin, to develop the lander designated as "Blue Moon". The $3.4 billion contract includes the development of the lander, a demonstration landing on Artemis 5 scheduled for late 2029, and an uncrewed test flight of the lander in 2028. In addition to the lander designed to carry astronauts, Blue Origin is planning a lander to transport cargo (20 metric tons). Blue Origin was one of two bidders - the competing team was led by Dynetics. In a source selection statement, the choice is justified by highlighting technical strengths and lower cost.[68]

Credit: NASA

In May, NASA announced a call for proposals to develop a next-generation Lunar Terrain Vehicle (LTV) that will enhance astronaut exploration and scientific research in the south polar region of the Moon during future Artemis missions. The selected rover will undergo testing and demonstration in the lunar environment before being employed in crewed missions, which are expected to begin in 2029. Before that, the vehicle will transport equipment, assist with cargo delivery, and expand research opportunities on the Moon. The LTV will function as a combination of an Apollo-style lunar rover and a Mars-style uncrewed rover, enabling scientific exploration even when astronauts are not present.[69]

The Artemis Accords, which serve as a complement to contributions to the Artemis Program, were signed by 12 new partner countries in 2023 – namely: Germany, Angola, the Netherlands, Iceland, Argentina, Bulgaria, India, Ecuador, Spain, Czech Republic, Rwanda, Nigeria.

Credit: NASA

Beyond developments in Artemis, in 2023, NASA changed the landing sites for commercial missions supported by NASA through the CLPS (Commercial Lunar Payload Services), such as the Peregrine mission and the Nova-C lander mission – the U.S.' first commercial Moon mission.

In February, NASA and Astrobotic changed the landing site for Astrobotic's first lunar lander mission "Peregrine". The landing site was moved from the initially targeted region "Lacus Mortis" on the north-eastern side of the near side of the moon to a scientifically more interesting region called "Gruithuisen Domes" on the western part of the Moon's near side.[70] The launch of Peregrine on the inaugural flight of ULA's Vulcan Centaur rocket took place in January 2024.

Moreover, citing scientific interests, NASA requested Intuitive Machines LLC, to shift the landing site of the company's first mission with the Nova-C lunar lander to the lunar South Pole region. The Nova-C lunar lander successfully landed on the moon in February 2024. [71]

[68] NASA selects Blue Origin to develop second Artemis lunar lander, NASA, May 2023; Selection Statement - Next Space Technologies for Exploration Partnerships-2 (NextSTEP-2) Appendix P: Human Landing system (HLS) Sustaining Lunar Development (SLD), NASA, May 2023
[69] NASA Pursues Lunar Terrain Vehicle Services for Artemis Missions, NASA, May 2023
[70] NASA changes landing site for Peregrine lunar lander, SpaceNews, February 2023
[71] NASA Redirects Intuitive Machines' First Mission to the Lunar South Pole Region, Business Wire, February 2023; Intuitive Machines lands on the moon, SpaceNews, February 2024

Furthermore, in May, NASA selected 5 research teams (out of 14 competitive proposals) to jointly study lunar science and sample analysis in support of future lunar exploration as part of NASA's Solar System Exploration Research Virtual Institute (SSERVI), supporting each team for 5 years with ca. $1.5 million per year. The research should support enabling the future human and robotic exploration of the Moon with NASA's Artemis program and Commercial Lunar Payload Services initiative.[72]

Beyond the Moon, NASA progressed in its Moon-to-Mars ambitions, opening a dedicated office and releasing a strategy, as outlined in the a later part of this chapter.

Canada's progress in contributions to Artemis and Lunar Gateway

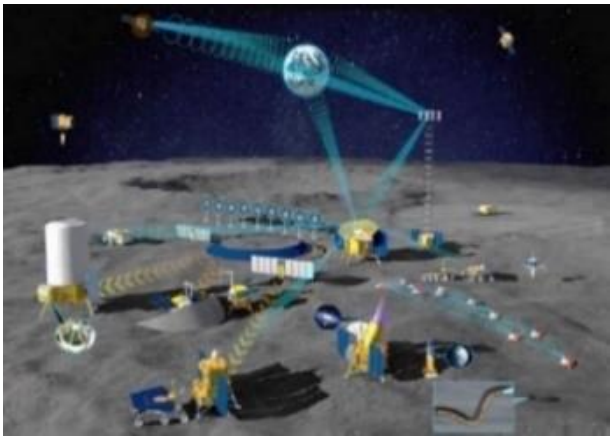
Credit: NASA& CSA

On April 3rd, NASA and the Canadian Space Agency (CSA) announced the 4 astronauts for the first crewed Artemis mission Artemis II, including the Canadian astronaut Jeremy Hansen, as Mission Specialist 2. In August, Canada allocated $1.7 million in funding to support the Canadian space industry for lunar exploration. the funding was awarded to AllSeeing Corp., MDA, the University of Alberta, Pelican MRI, Inc., the Ottawa Hospital Research Institute and Lunar Medical, to support the Canadian space industry for lunar exploration, as part of Canada's provision of Canadarm3 to the Lunar Gateway.[73] Beyond Canada's contribution to the Gateway by the provision of the Canadarm3 robotic arm system, the Canadian government announced the objective to invest $1.2 billion from 2024 over a period of 13 years, to develop a robotic lunar rover ("lunar utility vehicle").[74]

China progressed with the International Lunar Research Station (ILRS)

In April. the China National Space Administration (CNSA) announced the establishment of an organisation to manage and coordinate the China-led International Lunar Research Station (ILRS) - the International Lunar Research Station Cooperation Organization (ILRSCO).

On April 25th, the CNSA and the Asia-Pacific Space Cooperation Organization (APSCO) signed a joint statement on ILRS cooperation. In addition, CNSA signed cooperation agreements with several countries, including Russia, Argentina, Pakistan, the UAE and Brazil. Also in April, during a bilateral meeting of the Bolivarian Agency for Space Activities (ABAE)'s Executive Director Marglad Bencomo and CNSA's former Deputy Director at China's new national Deep Space Exploration Laboratory (DSEL), China invited Venezuela – as the first country – to join the China-led International Lunar Research Station (ILRS) project, whose



Credit: DSEL

[72] NASA Selects Five Teams to Study Lunar Science and Sample Analysis, NASA, May 2023
[73] More than $1.7M in funding to support the Canadian space industry in its exploration of the lunar environment, Government of Canada, August 2023
[74] Canada proposes to develop robotic lunar rover for Artemis, SpaceNews., April 2023

construction is planned to start at the beginning of the next decade. The meeting concluded with Venezuela expressing the intent to sign a MoU with China for the ILRS project.[75]

In May, China stated its goal to land astronauts on the Moon before the end of the decade and that the Moon Landing Phase of its human lunar exploration program had started. The ongoing preparatory work includes the development of the Long March 10 rocket for crewed launches, a crew spacecraft, a lunar lander, and a Moon suit, as well as the construction of a new launch site.[76] In addition, reportedly, Chinese scientists built a chamber simulating lunar conditions to support China's preparation for long-term lunar exploration.[77] As part of China's 2023 lunar roadmap, China provided and unveiled from January until May: (1) designs for its lunar lander, (2) details on its fully reusable Long March 9 rocket, (3) details on forming an international coalition for its Moon base, (4) plans for a lunar base by 2028, (5) the goal of landing a crew on the Moon by 2030.[78]

Moreover, China reportedly aims to define the task sharing for ILRS as well as approve and sign intergovernmental agreements among the ILRSCO's founding countries before the end of 2024.

Artemis Accords Signatories (2023)	ILRS Signatories (2023)
• Germany • Angola • the Netherlands • Iceland • Argentina • Bulgaria • India • Ecuador • Spain • Czech Republic • Rwanda • Nigeria	• Venezuela • Asia-Pacific Space Cooperation Organisation • Belarus • Azerbaijan • Argentina • Pakistan • Brazil • South Africa • Egypt • NanoSPACE AG (Switzerland) • ILOA (Hawaii) • NARIT (Thailand) • University of Sharjah (UAE) • University Adriatic Aerospace Association (Croatia) • PT Universal Satelit Indonesia

Other developments in China's moon ambitions include:

- In May, the Beijing Institute of Technology (BIT) received the lunar samples delivered by the Chang'e-5 mission and started studying the samples' material characteristics.[79]
- China announced the launch of the communications relay satellite "Queqiao 2" in early 2024 to the Moon – to be used to support China's robotic lunar missions Chang'e 6, 7 and 8.[80]

[75] China invites Venezuela to join moon base project, SpaceNews, April 2023
[76] China sets sights on crewed lunar landing before 2030, SpaceNews, May 2023
[77] China builds simulated moon chamber to prep for crewed lunar landings, Space.com, May 2023
[78] China to Invest Heavily in its Race to the Moon, Payload Space, May 2023
[79] China to explore Chang'e-5 lunar materials for future research station, CGTN, May 2023
[80] China to launch communications relay satellite to the moon in early 2024, Space.com, May 2023

ispace announced and unveiled details on its second moon mission HAKUTO-R Mission 2

In November, the Japanese company ispace announced its second moon mission, the HAKUTO-R Mission 2, unveiling the final design of its micro rover, which will be transported to the Moon by its lunar lander. The mission is planned to launch end of 2024.[81]

Israel advanced with the Beresheet 2 lunar mission

On February 1st, the Israel Space Agency (ISA) and NASA, represented by NASA Associate Administrator Robert D. Cabana and ISA Director General Uri Oron, signed a Statement on Intent for their cooperation in and NASA's contribution to Israel's Beresheet 2 lunar mission., planned to launch in 2025. Beresheet 2, the second lunar mission led by SpaceIL, will comprise of a three-spacecraft system. One of the two small lunar landers will land on the far side of the Moon and the other lander on the near side, while the orbiter will orbit the Moon for more than 5 years.[82]

Also in February, SpaceIL signed a cooperation agreement with the German Aerospace Center (DLR) on Beresheet 2, which includes the use of DLR's unique Crater Navigation algorithm (CNav). The algorithm is able to identify craters in lunar surface images and adds the data to an onboard database which will support navigation during the landing with accurate positioning information.[83]

Türkiye announced plan to launch the first spacecraft to the moon in 2026

In November, Türkiye announced that it aims to launch the first spacecraft to the moon in 2026. The spacecraft was developed with the Lunar Research Program (AYAP) within the National Space Programme. Thales Alenia Space signed a contract with TÜBİTAK Space Technologies Research Institute (TÜBİTAK UZAY) to provide a communication S-Band TT&C (Tracking, Telemetry and Command) Transponder for Türkiye's first lunar mission spacecraft AYAP-1.[84]

Developments in Europe

Revolution Space: Europe's Mission for Space Exploration"

In March, the High-Level Advisory Group (HLAG) on the future of human and robotic space exploration for Europe, mandated by ESA, released the Report "Revolution Space: Europe's Mission for Space Exploration" with an independent and objective assessment of the (1) geopolitical, (2) economic and (3) societal relevance of human and robotic space exploration for Europe. The report notes that Europe's overreliance on international partners is threatening its future as a credible actor on the global economic and geopolitical scene. Therefore, the report claims that Europe needs to significantly increase its investment in exploration and develop its own human spaceflight transportation capabilities to secure and foster the benefits of a booming space economy.

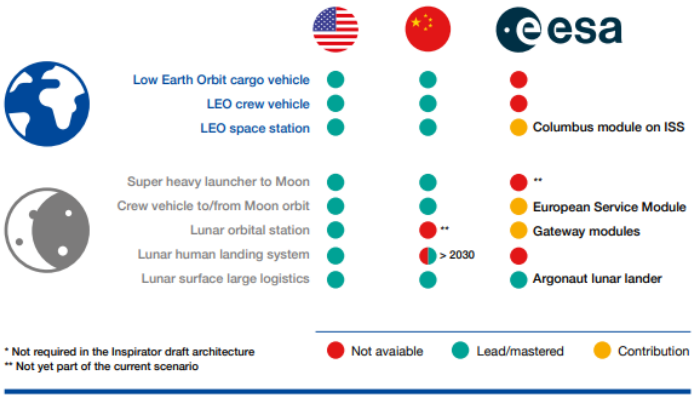


Figure 1: Where does Europe stand in space exploration - Comparative capabilities by 2030 (Source: ESA)

Credit: ESA

It is argued that greater autonomy in space will make Europe a stronger and more attractive partner for international cooperation. Concerning

[81] ispace Announces Mission 2 with Unveiling of Micro Rover Design, isce, November 2023
[82] NASA, Israel Space Agency to cooperate on Beresheet 2 lunar mission, the Jerusalem Post, February 2023
[83] SpaceIL signs agreement with German Aerospace Center, Spacewatch Global, February 2023
[84] Türkiye's 1st spacecraft to travel to moon in 2026, AA, November 2023 ; Thales Alenia Space to provide transponder for Türkiye's 1st lunar mission, Satnews, November 2023

moon exploration, the report states: "Europe should design and implement a European Space Mission to establish an independent European presence in Earth orbit, lunar orbit, on the Moon, and beyond, including a European Commercial LEO Station, Cargo and Crew Capabilities for the Gateway and the Moon, and sustained presence on the lunar surface." As a recommendation for ESA towards the Space Summit, the report called on ESA to prepare a scenario for an independent and sustainable European human landing on the Moon within 10 years.

Ready for the Moon: ESA high-level event on Europe's lunar ambition

Credit: ESPI

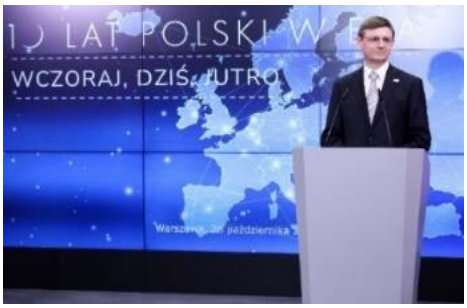
On June 2nd, a high-level conference "Ready for the Moon", organised by ESA in cooperation with the Federal Chancellery of the Republic of Austria, took place in Vienna, discussing Europe's future ambition in space exploration. The conference focused on the findings and recommendations from the final report "Revolution Space" of the High-Level Advisory Group (HLAG) on the future of human and robotic space exploration for Europe, mandated by ESA, with regard to the international, economic, and societal importance of space exploration for Europe. ESPI Director Ludwig Moeller joined the panel on the Economic Importance of Space Exploration for Europe.[85]

ESA opened a tender for Moonlight

In February, ESA opened a call for tender under its Moonlight programme, inviting private space companies in Europe and Canada to create a satellite constellation for commercial telecommunication and navigation service which will be placed around the moon to support lunar missions. ESA will serve as an anchor customer, but the involved companies are free to also sell lunar services and solutions to other agencies and commercial ventures. Ca. 100 companies covering the whole value chain expressed interest in being involved in Moonlight.

Poland plans lunar exploration mission

During the Impact'23 Congress in Poznań in June, the President of the Polish Space Agency (POLSA) Grzegorz Wrochna announced that Poland plans a national lunar exploration mission, incl. the development of a probe named "Sony"- and in the long-term also the construction of lunar bases. Previously, POLSA asked the Polish space industry, scientists and researchers to submit proposals on ideas for a lunar exploration mission.



Credit: Tomasz Gzell/PAP

The Polish space industry already demonstrated capabilities and expertise, having contributed so far to more than 80 space exploration missions by developing and providing research instruments. The "Sony" probe is planned to fly to space within this decade and to employ infrared radiation technology for scanning the lunar surface and searching for raw materials. While a prototype probe is currently undergoing testing, initial mission preparations will start later this year with Phase A.[86]

[85] ESPI at the Ready for the Moon Conference, ESPI, June 2023
[86] Polish Space Agency Plans First Moon Orbital Mission, Poland Daily 24, June 2023

UK Space Agency invests in Moon and Mars R&D projects, research on the use of nuclear power for moon base, and communication and navigation services around the moon

On March 7th, the UK Space Agency announced to invest £1.6M into projects supporting future Moon and Mars missions. The 8 projects are funded by the UK's Enabling Space Exploration Fund through remote technologies and resources found in space to sustain astronauts and will be led by universities and companies across the UK.[87]

Also, the UK government signed a £2.9M contract with Rolls-Royce to investigate how nuclear power could be used to support a future Moon base, in order to extend the future mission duration to the Moon. Specifically, Rolls-Royce plans to send a small nuclear reactor to the Moon by 2029. Rolls-Royce will jointly work on the project with UK Universities and research institutes.[88]

Finally, UKSA announced £50M funding as part of ESA's Moonlight Programme, for UK companies to develop communication and navigation services for the Moonlight satellite constellation around the Moon from 2028. This funding comes on top of the UK-led Lunar Pathfinder project expected to launch by 2025.[89]

ASI seeks commercial partners for the ORACLE project

ASI sought commercial operators for its lunar regolith oxygen extraction project known as the Oxygen Retrieval Asset by Carbothermal-reduction in Lunar Environment (ORACLE) project. The ORACLE project is allocated a budget of up to €11 million, and its timeline is set for a maximum duration of 48 months. ASI partnered with Politecnico di Milano to initiate the developmental phase. The project encompasses various phases, with the initial collaboration focusing on the technology's validation for future missions. Once this stage concludes, ASI plans to transition the project to an industrial partner to steer it through subsequent stages, leading to an eventual launch.[90]

European contributions to China's Chang'e 6 lunar lander

In 2023, French, Italian and Swedish instruments were delivered to China (CNSA) to be integrated onboard the Chang'e 6 lunar lander. The Chang'e 6 mission is slated for launch in early May 2024. CNES' DORN was delivered in August for integration on board the Chang'e 6 lunar lander. Italy's National Institute for Nuclear Physics provided an Instrument for landing-Roving laser Retroreflector Investigations (INRRI). The Swedish Institute of Space Physics contributed NILS (Negative Ions on Lunar Surface).[91]

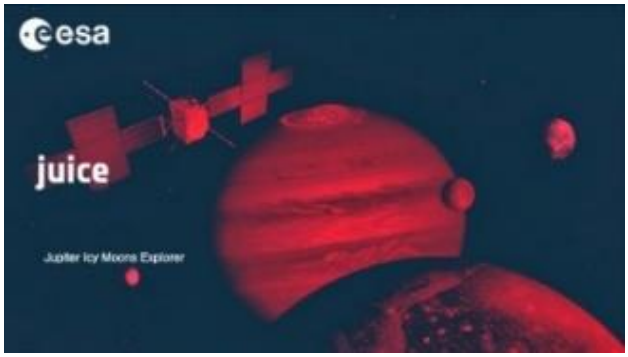
1.2.3 Mars, Jupiter, and deep space exploration and space science

In 2023, Europe's highlights in space exploration and science were the launch of the JUICE mission to study Jupiter's icy moons in April, and the launch of the Euclid deep space telescope mission. Beyond Europe, NASA progressed with its Moon-to-Mars strategies and Mars exploration, while Japan launched the X-ray space telescope XRISM, and India launched its Aditya-L1 solar observatory – only a few weeks after its successful moon landing of Chandrayaan-3.

[87] UKSA Invests Another £1.6m Into Moon And Mars Projects, Orbital Today, March 2023
[88] Government signs £2.9m Moon base nuclear power deal with Rolls-Royce, BBC, March 2023
[89] UK companies to provide services for future Moon missions, UK Government, February 2023
[90] ASI Seeks Commercial Operator for Lunar Oxygen Extraction Mission, European Spaceflight, November 2023
[91] Chang'e-6 enters lunar orbit ahead of far side landing attempt, SpaceNews, May 2024

Developments in Europe

Exploring the gas giant: ESA's Jupiter Icy Moons Explorer (JUICE) mission launches



Credit: ESA

On April 24th, ESA's Jupiter Icy Moons Explorer (JUICE) mission launched aboard an Ariane 5 rocket from Europe's spaceport in Kourou. The mission's objective is to study Jupiter and its three biggest moons Ganymede, Callisto and Europa. These are believed to harbour big liquid-water oceans beneath their icy shells, and JUICE aims to investigate whether there could be habitable environments.

The JUICE mission carries a set of 10 science, remote sensing, geophysical and in situ instruments, including an optical camera system, spectrometers, a radar sounder, a laser altimeter, a magnetometer, and particle analysis instruments. During the mission, JUICE will conduct four separate "gravity assist" planetary flybys, with the first to take place in August 2024. The second gravity assist from Venus is scheduled for August 2025. Then JUICE will swing by Earth for two more gravity assists in September 2026 and January 2029.

After this final Earth encounter, the probe will reach Jupiter in July 2031, followed by another flyby of the JUICE spacecraft to insert itself into Jupiter's orbit. Then the 3 moons will be observed over the course of 35 flybys between 2031-2034.[92]

ESA's Euclid Mission was launched and successfully deployed to study deep space

On July 1st, ESA's Euclid Space Telescope was launched with SpaceX onboard a Falcon 9 rocket from Cape Canaveral. After the launch, a trajectory correction manoeuvre was conducted by ESA mission control to guide Euclid to Lagrange Point 2 to join ESA's Gaia telescope and the JWST. The $1.4 billion Euclid astrophysics mission aims to study dark energy and matter over approximately 6 years. Euclid includes two scientific instruments (1) the visible-wavelength camera (VIS) and (2) the Near-Infrared Spectrometer and Photometer (NISP), while NASA provided the detectors for NISP.

Updates on the replacement of Russia for the ExoMars Rosalind Franklin mission

In March, following the restructuring and postponed launch of the Rosalind Franklin Rover due to the cancellation of the cooperation with Russia and the confirmation at the ESA CM22 that ESA will build its own lander, ESA gave an update on the ExoMars Rosalind Franklin mission:

- Timeline: The mission was now set to launch between October 5th and the 25th in 2028, allowing for a landing on October 28th in 2030.
- Cooperation/replacement of Russia: The European-built lander will be different from the initially planned Russian Kozachok platform, as it will limit itself to delivering Rosalind Franklin safely to the surface of Mars and will not offer any additional payload services. Moreover, ESA and NASA have been in talks to ensure that NASA provides engine elements as well as launch services and radioisotope heater units.
- Landing site: ESA selected the mission's landing site to be in Oxia Planum, which preserves remnants of the planet's wetter past.[93]

[92] ESA's Juice lifts off on quest to discover secrets of Jupiter's icy moons, ESA, April 2023
[93] ROSALIND FRANKLIN ROVER TARGETING 2028 LAUNCH TO MARS, Sky & Telsecope.Org, March 2023

In November, UKSA provided £10 million to replace a mission-crucial Russian instrument with a new instrument "Enfys", to pick out the best spots for finding life on Mars.

The new instrument Enfys is an infrared spectrometer and will be designed and built primarily by Aberystwyth University. Enfys and the mission's camera system "PanCam" will work together to identify minerals.[94]

ESA and China conduct spacecraft-rocket integration tests for the SMILE mission

In February, ESA and Chinese scientists jointly conducted spacecraft-rocket integration tests (incl. docking, satellite separation and impact tests) at ESA's ESTEC site with a prototype of the satellite for the ESA-CAS Solar wind-Magnetosphere-Ionosphere Link Explorer (SMILE) science mission.

The 3-year mission, which is planned to launch in 2025 (after being postponed due to project delays), has the objective to study solar wind and Earth's magnetosphere interaction and effects in the ionosphere. The prototype SMILE satellite was developed by the Innovation Academy for Microsatellites of the CAS (IAMCAS), while ESA developed the payload adapter for the mission's launcher Vega-C. This joint testing marked the first time that a Chinese team has conducted such tests at ESA facilities.[95]

ESA Comet Inceptor Mission Updates

In December 2022, ESA and a consortium led by OHB Italia signed a €117,5 million contract for the development of the Comet Interceptor mission. The agreement includes OHB System AG, SENER Aerospacial S.A., and OHB Sweden AB and includes the management of the space infrastructure.[96] In June, the study phase of Comet Interceptor was completed and the mission was approved for construction.[97] In October, Redwire Space BV secured a contract with OHB Italia S.p.A. to deliver the onboard computer for Comet Interceptor's Implementation Phase (Phases C/D/E1).[98] In November, TEKEVER secured a €3.2 million contract to provide satellite communications for Comet Interceptor.[99]

UK released its Space Exploration Technology Roadmap

In line with the UK National Space Strategy and within the framework of civil capabilities as part of the National Space Strategy in Action, the UK released the Space Exploration Technology Roadmap (SETR), which aims to guide the UKSA in decision-making by focusing on technologies in which the UK leads or plans to lead.[100]

Credit: UKSA

[94] Britain steps in to keep Mars rover mission rolling, the Telegraph, November 2023
[95] ESA, China conduct spacecraft-rocket integration tests but joint science mission delayed to 2025, SpaceNews, February 2023
[96] NEW CONTRACT BETWEEN ESA AND OHB ITALIA FOR THE DEEP SPACE MISSION "COMET INTERCEPTOR", OHB Italy, December 2022
[97] Comet Interceptor approved for construction, ESA, June 2023
[98] Redwire Awarded Contract to Provide Onboard Computer for ESA's Comet Interceptor Mission to Study Pristine Comet, Redwire, October 2023
[99]
[100] Space Exploration Technology Roadmap, Gov.UK, July 2023

Developments beyond Europe

NASA progresses with Moon-to-Mars ambitions

Credit: NASA

In March, NASA established a new Moon to Mars Program Office at NASA HQ in Washington D.C., which is responsible for carrying out NASA's human exploration activities on the Moon and Mars under the Exploration Systems Development Mission Directorate. The new office will lead planning and analysis for developments to support human Mars missions, focusing on hardware development, mission integration, and risk management functions to prepare for human missions to the Moon and Mars. The office is led by Deputy Associate Administrator Amit Kshatriya, former Acting Deputy Associate Administrator for Common Exploration Systems Development.[101]

During the Space Symposium in April, NASA released an updated Moon to Mars strategy "NASA'S Moon to Mars Strategy and Objectives Development - A blueprint for sustained human presence and exploration throughout the Solar System". The document describes how Artemis fits towards a set of 63 final objectives for NASA's long-term Moon to Mars human spaceflight mission plans, with a crewed Mars mission tentatively scheduled for the late 2030s/early 2040s.[102]

Objectives			
Science	**Transportation and Habitation**	**Lunar and Martian Infrastructure**	**Operations**

Benefits		
Science	**National Posture**	**Inspiration**

The revised strategy is based on the Moon to Mars Objectives published in September 2022, and a result of public consultation as part of NASA's overall Moon to Mars strategy, which seeks to develop a roadmap with U.S. and global space stakeholders' input.[103] Complementary to the revised strategy, NASA released the Moon-to-Mars Architecture Definition Document and several White Paper documents on the technical architecture of its plans, including the Architecture Concept Reviews (ACR) 2022. The ACR 2022 sets out areas of cooperation in (1) power infrastructure and distribution, (2) communication and navigation, (3) lunar environment mitigation, (3) robotics and mobility, (4) logistics, (5) utilization operations, (6) lunar sampling and curation, (7) habitation and crew health systems, (8) exploration systems and operations analog testing.[104]

Also in April, NASA selected 16 proposals from 12 U.S. companies under its 2022 ACO to advance technologies and capabilities, such as testing a lunar rover design, developing a robotically assembled power system and an electrically actuated device to join in-space propellant transfer lines, to support to NASA's Moon to Mars objectives.

[101] New Program Office Leads NASA's Path Forward for Moon, Mars, NASA, March 2023
[102] NASA'S Moon to Mars Strategy and Objectives Development - A blueprint for sustained human presence and exploration throughout the Solar System, NASA, April 2023
[103] Moon to Mars Objectives, NASA, September 2022
[104] Moon-to-Mars Architecture Definition Document (ESDMD-001), Exploration Systems Development Mission Directorate, NASA, April 2023; Moon to Mars Architecture, NASA, April 2023;

The 12 companies are Aerojet Rocketdyne (2 proposals), Blue Origin (2 proposals), Boeing, Canopy Aerospace, Lockheed Martin (3 proposals), Maxar, Phase Four, Psionic, LLC, Roccor, LLC (Redwire), Sierra Space, Stratolaunch, Venturi Astrolab. The proposals will run under an unfunded Space Act Agreement, under which NASA will provide access to its facilities and technical expertise. The agreements are supported by a general total estimated value of $14.5 million.[105]

NASA's new draft strategy for long-term robotic exploration of Mars

End of March, NASA released a draft strategy for long-term robotic exploration of Mars called "Exploring Mars Together", following committee meetings of the National Academies' Space Studies Board. The strategy outlines a plan for a series of "sustainable" low-cost missions (between $100 million and $300 million) and – these missions being competitively selected – with potential commercial partnerships.

Apart from NASA's Mars Sample Return, NASA is currently only developing the small satellite mission robotic Mars mission ESCAPADE - scheduled to be launched in late 2024. The new plan is not foreseen in NASA's FY2024 budget proposal (which only includes "Mars Future Missions", including NASA's support for ESA's ExoMars mission). In the next steps, the new plan is unveiled for feedback from scientists to refine and specify the strategy.[106]

Japan launched the X-ray space telescope XRISM

On September 6th, Japan launched two missions, SLIM (Smart Lander for Investigating Moon) and the X-ray space telescope XRISM (X-Ray Imaging and Spectroscopy Mission). XRISM (formerly known as XARM) is a JAXA-NASA mission with ESA participation which aims to investigate celestial X-ray objects in the Universe. The XRISM payload consists of two instruments: (1) Resolve, a soft X-ray spectrometer, and (2) Xtend, a soft X-ray imager.[107]

India launched its first solar mission Aditya-L1

On September 2nd, India's first solar observation mission Aditya-L1 lifted off from the launch pad at Sriharikota and reached its final destination Lagrange Point 1 (L1), from where it will continuously observe the Sun, in January 2024. The orbiter carries 7 scientific instruments which will observe and study (1) the solar corona (the outermost layer), (2) the photosphere (the Sun's surface or the Sun's part visible from the Earth) and the chromosphere (a thin layer of plasma between the photosphere and the corona).[108]

Credit: iStock

UAE announced Mission MAX ("Multiple Asteroid Exploration")

On May 28th, the UAE Space Agency announced the UAE's Mission "Max" ("Multiple Asteroid Exploration"), which will see the MBR Explorer spacecraft travel 5 billion kilometres to a region called Asteroid Belt EMA between Mars and Jupiter to study asteroids. The mission, with planning started in 2019, will take 13 years in total, 6 years for spacecraft development and 7 years travel time to the belt, including 6 asteroid fly-bys and fly-bys of Venus, Earth and Mars.[109]

[105] NASA Selects 12 Companies to Collaborate on Key Technology Development, NASA, April 2023; Space Technology Announcement of Collaboration Opportunity (ACO), NASA, 2022
[106] NASA releases draft strategy for long-term robotic Mars exploration, Space News, March 2023
[107] Japan Joins the New Moon Race, and Launches an X-Ray Telescope, Too, the New York Times, September 2023
[108] Aditya-L1: India's Sun mission reaches final destination, BBC, January 2024
[109] UAE mission to asteroid belt: Codename Max, Spacewatch Global, May 2023

1.3 Access to Space - Launchers & Spaceports

This chapter covers institutional developments in access to space, in particular with regard to launchers and spaceports. From a commercial perspective, this is addressed in **Chapter 4 Launches & Satellites** provides a table of all launches in 2023, analyses trends in the launcher sector and outlines 2023 launch highlights.

1.3.1 Europe's launcher crisis in full effect, but progresses with new spaceports and changes underway for future European solutions

2023 marked the peak of the European launcher crisis. The unavailability of Soyuz since the war in Ukraine from February 2022, the further delay of Ariane 6 (originally scheduled for a 2020 debut but postponed multiple times), the last Ariane 5 launch, and the delay of Vega C to return to flight after the launch failure of its second flight in December 2022, intensified Europe's reliance on foreign providers. In response, this re-opened a debate on the resilience of Europe's autonomous and independent access to space. In fact, with Ariane 5's last launch in June, Europe has no access to its own heavy-lift launcher at least until July 2024. Throughout the year a host of European satellites relied on American launch services, namely SpaceX's Falcon 9. In addition to scientific launches with SpaceX, such as Euclid and EarthCare, the EU was forced to initiate discussions on the launch of Galileo's next-generation satellites with SpaceX and US counterparts.

While the European launcher crisis was discussed in the frame of the broader debate on European strategic autonomy, it also opened a debate on the right approach to develop future European (heavy lift) launchers. First, with regard to launcher procurement, came the need for more Europe-internal competition. Second, was the question of launch provision with the prioritisation of institutional launches anchor customer schemes. As outlined in the ESPI Director's Perspectives November 2023 "From Djibouti and the Northern Territories to the Use of Space – an outside Perspective", a large portion of the global demand is routed in institutional and commercial markets in the U.S. and China. The 18 Ariane 6 launches for the Kuiper constellation, occupying most of the capacity of the future European launcher, cannot come as a surprise, as the economic sustainability of the launcher may increasingly depend on (foreign) commercial markets. However, a too strong dependency on foreign markets may be dangerous for any European launcher. When faced with giants, booking an impressive 80 heavy-lift launches with a portfolio of ULA, Arianespace, Blue Origin, and now SpaceX, commercial and political priorities could shift preferences and conditions of market access. Moreover, geopolitical trendstrebds can be expected to increasingly impact the above dependencies,[110] The aforementioned points were addressed at the Space Summit in November. In contrast to the launcher crisis, European spaceports progressed significantly, starting with the inauguration of the first European spaceport on European soil, Esrange, and the opening of Andøya spaceport in addition to significant progress on UK spaceports.

Beyond Europe, China is on the rise in numbers of launches. Beyond Europe, China is on the rise in number of launches. Launching from 7 locations so far, it will soon be at par and may overtake the U.S., as Chinese satellite constellations will see the light. 94.5% of the payloads on these launches are domestic, many commercial.[111]

[110] ESPI Perspectives November 2023 "From Djibouti and the Northern Territories to the Use of Space – an outside Perspective", ESPI, November 2023
[111] ESPI Perspectives November 2023 "From Djibouti and the Northern Territories to the Use of Space – an outside Perspective", ESPI, November 2023

Towards a new approach for the future of European launchers? - Launchers in the centre of discussion at the European Space Summit

Space transportation at the centre of discussions during the Space Summit

Following the Joint Statement of ESA CM22, France, Germany and Italy worked throughout 2023 on a roadmap for Europe's future in the launcher sector towards the Space Summit in November.[112] The roadmap aims to change European launcher procurement to create more competition while ensuring the availability of launchers for institutional demands. Milestones of the trilateral work towards the Space Summit included a progress meeting at the Ministerial Level between France, Germany, and Italy in May, and a Status Report to ESA Council in June,

At the Space Summit in November, European access to space was a core topic. With regard to Europe's future launcher procurement, Germany, France and Italy signed a trilateral agreement on European launchers with "fundamental points for the relaunch of the space sector", resolving long-standing disputes on the availability of launches and related sites. The document covers the financing of launchers. In particular, the agreement will provide €340 million of financing per year for the exploitation of Ariane 6 in exchange for a commitment to an 11% cut in cost and Ariane 6 will be awarded at least 4 missions from public institutions per year. The Vega C launcher will get at least 3 launch missions per year. Moreover, the three countries will support the launcher programme for an additional 1,5 years. In total this results in an increase in the number of guaranteed launches for Ariane 6 by 15 to 42 by 2030.[113]

During the Space Summit, ESA member states granted Avio independence in marketing and managing Vega C launches, ending its association with Arianespace. Avio is set to become the Launch Service Operator for Vega C by mid-2024, managing flight operations and commercialisation rights.

Updates on European launchers

Absence of Europe's access to space with heavy-lift launchers: Last Ariane 5 launch and further delay of Ariane 6

On July 5th, Ariane 5 made its 117th and final flight, concluding nearly three decades of launches with a track record of 115 successful missions and only two outright failures. The final launch, designated VA261, carried two communications satellites destined for GEO. The first payload deployed was the German Heinrich Hertz-Satellite, designed to test advanced communications technologies, the second payload was the French military satellite Syracuse 4B, intended for use by the French military.[114]

As outlined in the introduction above, 2023 was the year of Europe's launcher crisis peak, as following the last flight of Ariane 5 in the second half of 2023, Europe had no access to space with heavy-lift launchers – with Ariane 6's first launch further delayed and pushed into mid-2024.

[112] Ministers from France, Germany and Italy signed a Statement on the future of launcher exploitation in Europe, November 2022
[113] France, Germany and Italy sign agreement on launch vehicle development, Space News, November 2023
[114] A France-German Success for the finale Ariane 5 mission, Arianespace, July 2023

In May, the inaugural flight of Ariane 6 was pushed into early 2024. This update contrasted previous predictions, which anticipated a potential maiden flight by the end of 2023.[115] In August, ESA confirmed a further delay of Ariane 6's first flight to take place in mid-2024.[116] In light of this situation, the Ariane 6 Launcher Task Force outlined the key milestones leading up to the inaugural flight:

Credit: ESA/D. Ducros

- May: Flight software qualification tests.
- May: Ground combined tests sequence at Europe's Spaceport.
- Completion of outstanding qualification reviews of products and sub-systems.
- Late June: Overall launch system qualification review.
- Early July: Upper stage additional test at DLR Lampoldshausen.
- Starting November: Launch vehicle assembly and inaugural flight launch campaign.[117]

On September 1st, the upper stage of the Ariane 6 launcher underwent a comprehensive hot-firing test at DLR in Lampoldshausen. This test, lasting for approximately 22 hours, recreated the conditions the upper stage will encounter during its inaugural mission. This collaborative effort between the DLR and ArianeGroup took place at the ESA P5.2 test stand and involved two ignitions of the Vinci engine and two of the APU, offering an intricate simulation of operational scenarios.

The successful outcome of this test brought Europe a step closer to deploying Ariane 6.[118] The next stage involved combined tests of the entire launch system at the European spaceport in Kourou, French Guiana. Following the successful initial test, the long-duration hot fire test set for October, simulating the entire flight phase of the core stage, was postponed due to an anomaly affecting its thrust vector control system, which maintains altitude during flight by adjusting the Vulcain 2.1 engine's position.[119]

After the Space Summit in November, a 6-week launch window of Ariane 6's launch debut was set and announced by ESA, CNES and ArianeGroup: June 15th-July 31st, 2024.[120]

Key milestones, including successful tests of the core and upper stages bolstered confidence in the launch. Indeed, on November 23rd, ESA successfully conducted a 7-minute full firing test of the Ariane 6's Vulcain 2.1 engine. Despite a minor delay due to a transient threshold pressure anomaly, the static-fire test simulated a complete burn of the core stage. The combined loading tests focused on system robustness, with particular attention to cooler ambient temperatures during night operations.[121]

In December, the upper-stage Ariane 6 test was conducted at the DLR facility in Germany. The upper stage experienced an early abort just two minutes into the test. The purpose of this test was to demonstrate the performance of the rocket's upper stage in degraded conditions, following a successful full-duration test firing on September 1st. Despite the setback, Toni Tolker Nielsen, ESA Acting Director of Space Transportation, stated that the early abort would not impact the aforementioned June 15th and July 31st, 2024 launch window.

In a subsequent statement on December 19th, ESA reported the successful completion of a

[115] Ariane 6 first launch slips to late 2023, SpaceNews, October 2022
[116] ESA confirms Ariane 6 debut to slip to 2024, SpaceNews, August 2023
[117] Ariane 6 joint update report, 12 May 2023, ESA, May 2023
[118] Hot-firing test for Ariane 6 upper stage prepares way for first launch, DLR, September 2023
[119] Ariane 6 Development Suffers Another Setback, European Spaceflight, October 2023
[120] Europe's new Ariane 6 rocket to launch June 15-July 31, 2024, Reuters, November 2023
[121] Successful Ariane 6 core stage long-duration hot-fire test, Arianegroup, November 2023

combined test loading (CTLO3) for an Ariane 6 prototype at the spaceport in Kourou. The core and upper stages' CTLO3 test demonstrated extreme ignition conditions and degraded liftoff modes, concluding with a successful four-second firing of the core stage's Vulcain 2.1 engine.

Also in December, ArianeGroup awarded the Irish-owned Réaltra Space Systems Engineering a contract valued at close to €1 million. The contract entailed the development and delivery of a GNSS telemetry system for the maiden flight of Ariane 6.

Vega-C: Investigation of a launch failure with political implications, while new contracts prove trust in the success of Vega C's comeback shifted from end of 2023 to end of 2024

Credit: ESA/CNES/Arianespace

Following the launch failure of Vega C's second flight in December 2022, 2023 started with the investigation of the cause behind it. In January 2023, Arianespace and ESA established an independent inquiry commission to identify the cause of the launch failure and identify the required steps to return the Vega C to flight.[122]

Despite the uncertain situation due to Vega C's launch failure, also in February. South Korea selected Arianespace's Vega C rocket to launch its EO (SAR) satellite KOMPSAT-6 - following a competitive process of international bidding. In December 2022, South Korea formally revoked a Russian contract for the launch of KOMPSAT-6 from the Plesetsk Cosmodrome aboard the Angara initially planned for the end of 2022.[123]

In March, the independent inquiry commission investigating the December Vega C launch failure identified the cause of the failure: a flaw in the carbon-carbon material utilised for the throat insert of the Zefiro 40 second-stage nozzle. The Zefiro 40's nozzle material will need to be replaced with another carbon-carbon material. Following this result of the investigation, Vega C was not expected to return to flight again before the end of 2023.[124] In the meantime, intending to limit disruptions to the vehicle's launch manifest, Arianespace decided to reassign a Vega C mission to one of its two remaining Vega launchers.

The announcement of the investigation results turned into a political affair. The component at the cause of the failure was manufactured by the Ukrainian company Yuzhnoye. The Ukrainian government responded to ESA's investigation results and stated that the investigation committee was "premature" in concluding that a component from a Ukrainian company was the root of the failure. The State Space Agency of Ukraine released a statement on March 6th, stating that the investigation results "cast a shadow over the reputation of the space industry of Ukraine" and argued that the issue may still require further investigation to identify if there could be additional factors.[125] On March 7th, ESA DG Josef Aschbacher reacted with a statement, clarifying that the conclusions were not meant "to place blame on Ukraine or on the integrity of the Ukrainian space industry, an industry that has been gaining much-deserved clout in recent years".[126]

The results of March concluded that the carbon-carbon material from the Ukrainian company Yuzhnoye did not meet specifications. In consequence, ArianeGroup was selected to supply the insert, replacing Yuzhnoye.

[122] Independent panel to investigate Vega C launch failure, SpaceNews, December 2022
[123] South Korea picks Vega C to launch satellite grounded by Russian sanctions, SpaceNews, February 2023
[124] Vega C Will Not Return to Flight Until Late 2023, European Spaceflight, March 2023
[125] Ukrainian government criticizes Vega C investigation, SpaceNews, March 2023; Information about the situation with Vega C LV launch, State Space Agency of Ukraine, March 2023
[126] Statement by Josef Aschbacher on Twitter, Twitter, March 2023

Causing further delay, in June, Vega C's Zefiro 40 second-stage malfunctioned during a static-fire rehearsal – a test that was one of the key steps in the effort to return the Vega C to flight. ESA and Avio were then tasked with conducting two static-fire tests to ensure the issue was resolved, with tests to be conducted in the second quarter of 2024, with a return to flight planned for the end of 2024.

During the ESA Council meeting in June, ESA DG Josef Aschbacher stated that following the recommendation from ESA's inspector general, ESA plans to shift the 2024 launch of the ESA-JAXA Earth science mission EarthCARE's spacecraft from Vega C to SpaceX's Falcon 9.[127]

Credit: ESA

In October, ESA officially closed the investigation, concluding that a rocket motor nozzle needs to be redesigned, stating that Vega C will return to flight at the end of 2024.[128] The launch failure of Vega C and the ongoing work to return it to flight until Q4 2024 resulted in the return of its ancestor: Before Vega C returns to flight, two launches of the original version of Vega, which does not use the Zefiro 40 engine, will take place.

So, in October, Vega launched 12 satellites taking off from Kourou. The two main payloads were THEOS-2 ("Thailand Earth Observation System-2") used by the government of Thailand and FormoSat-7R/Triton, which was developed by Taiwan's space agency.[129]

End of October, the Italian Government officially submitted a request to ESA to separate the activities of Avio from those of Arianespace. The division between Arianespace and Avio was set to be subject to ESA member states approval and was addressed at the ESA Space Summit in November. To date, Arianespace is responsible for managing the commercialisation of Avio's launch vehicles and oversees launches from Kourou.

Moreover, in October, AVIO extended its contract with Telespazio to maintain and provide operational support for the Vega launch pad at the Guiana Space Centre. The 3-year contract, worth €2.7 million, will continue until 2025. Telespazio serves as the prime contractor, working in conjunction with its subsidiaries in France and French Guiana, which will act as subcontractors to ensure excellent service delivery.[130]

With regard to Vega-C's return to flight, according to ESA statements in October, the cost of the additional work to return the Vega C to flight will be funded within existing budgets, with full return-to-flight costs estimated at €25–30 million.

After Vega C's return to flight end of 2024, according to statements made in October, there are 4 expected Vega C flights in 2025 - with the ambition of increasing the launch rate to 5-6 launches a year.[131] Therefore, as confirmed at the Space Summit, Vega C will get at least 3 European institutional launch missions per year. Avio independence in marketing and managing Vega C launches from Arianespace, designates it as the Launch Service Operator for Vega C by mid-2024, managing flight operations and commercialisation rights.

[127] Vega C suffers setback in return to flight effort, SpaceNews,, June 2023
[128] ESA delays Vega C return to flight to late 2024, SpaceNews, October 2023
[129] Arianespace's Vega rocket launches 12 satellites to orbit, Space.com, October 2023
[130] Telespazio renews contract with AVIO for maintenance and operational support of the VEGA launch pad, Telespazio, October 2023
[131] ESA delays Vega C return to flight to late 2024, SpaceNews, October 2023

The Kourou Space Centre will allocate infrastructure to Vega C and Vega E, enhancing launch frequency. The allocation of facilities at the Guiana Space Centre ensures the future of Vega, positioning it for continued success.[132]

In December, ESA postponed the second and last launch of the original Vega rocket from spring to September 2024 due to missing tanks for the rocket's Avum upper stage. Two tanks intended for the final Avum upper stage were reported missing from an Italian factory used by Avio during facility renovations. The Acting Director of Space Transportation at ESA, Toni Tolker-Nielsen, confirmed the tank issue, stating that the tanks were later discovered in a landfill, and rendered unusable. The September launch date relies on a workaround solution, considering two options. One involves using tanks built for Vega qualification over a decade ago, allowing a July launch, but deemed risky. The preferred solution is adapting tanks from the larger Avum+ stage for the Vega C rocket, with structural modifications to the Avum inner structure.[133]

Europe's strategic autonomy and sovereignty challenged: the Galileo case

EU investigates agreement to launch Galileo satellites from U.S. territory

In September, it was reported that the EU has been discussing and approaching an agreement that will allow the launch of the Galileo satellites from U.S. territory in early 2024. The Council of the EU has been revising the proposal and was expected to likely pass a decision "authorising the opening of negotiations" with the U.S. "laying down security procedures for the launch of Galileo satellites from United States' territory". The final decision came later in the spring of 2024.

Due to the loss of Soyuz and the delay of Ariane 6, a U.S. launch is necessary to keep the constellation in service as it is estimated that the current constellation is not planned to ensure the continuation of full service after mid-2024. Initially, the latest batch of Galileo satellites was planned to be launched in the spring of 2022. The agreement, aimed at protecting the integrity and safety of the satellites and the information (incl. EU classified information) contained, would protect the exchange of provision of classified information between the EU and the U.S. and would require the U.S. to establish measures to protect the space assets upon arrival on U.S. territory until the satellites were launched.[134]

Initiatives for the future of European space transportation

ESA aims to create a European launch service provider pool

Credit: European Spaceflight

In October, ESA unveiled that it aims to create a "European launch service providers pool", opening a call for European launch provider startups and companies, managed under the ESA's Boost! programme. The call aims to support companies by providing the opportunity to secure the first ESA launch contracts. In particular, ESA aims to create a pool of European launch service providers which will be used to launch in-orbit demonstration and validation (IOD/IOV) missions of the European Commission. The call is the third call under the Boost! Initiative (Boost!3), which aims to support the development and deployment of new European commercial space transportation services. At ESA CM22 in November 2022, ESA member states committed €31.2 million for the Boost!3 call and agreed to open ESA's launch procurement to competition.

[132] ESA Ministerial Council: Important Decisions regarding Ariane 6, Vega C and Vega E, Avio, November 2023
[133] Final Vega launch delayed because of upper stage tank problem, SpaceNews, December 2023
[134] EU nears agreement to launch satellites from US territory, EURACTIV, September 2023

Developments in R&D for Europe's future launchers

In May, the 10th DLR Industrial Days on the future of European space transport at the DLR site in Lampoldshausen brought together stakeholders from space agencies, space industry and research. The main topic was the future of European access to space and space transportation, and how launch facilities need to be prepared for the future. Central discussion points were the increasing demands and new opportunities of European space transportation, the relevance of strategic test infrastructure for current and future space transport systems, test stands for space propulsion, and the potential of small launch vehicles.[135]

On May 29th, ESA signed 4 contracts with ArianeGroup, Avio, Sener, and The Exploration Company to conduct studies to explore solutions for the preparation of the future for the European launcher sector. These focused on reusable launch systems - covering the full range of micro-mini, medium and heavy launchers and including human space transportation as part of the technical vision exercise "Vision 2030+".[136]

Credit: ESA

Moreover, ESA started the new "PROTEIN" investigation study (as part of the ESA Future Launchers Preparatory Programme (ESA-FLPP)) about European reusable, sustainable and cost-effective heavy lift transport towards developing a European Heavy Lift Launcher (EHLL). The study will investigate the feasibility and identify technologies necessary to develop such a system. ArianeGroup and Rocket Factory Augsburg have been chosen by ESA to carry out a Phase 0/A investigation of the PROTEIN study.

The aim is to enable access to LEO and beyond, offering substantial payload capacities (at least 10,000 tons per year), a high launch frequency, cost-effectiveness in construction and operation, and minimised environmental impact in alignment with the European Green Deal. It is engineered to be more efficient than current launchers, with optimised capabilities for deploying extensive infrastructures, including as part of the ASCEND and SOLARIS studies, and supporting deep space missions beyond 2035, alongside In-Space Transportation Vehicles (ISTV).[137]

DLR successfully completed the first flight test of its new Red Kite Solid Rocket Motor. Red Kite can be used in a one- or two-stage rocket configuration. The Single Stage Operational Assessment of Red Kite (SOAR) mission carried scientific payloads of two DLR institutes. The first operational flight of a rocket equipped with Red Kite was planned for February 2024 from Esrange.[138]

[135] Strategies for test infrastructure and launch sites – competitive, flexible and sustainable, DLR, May 2023
[136] Signature of industrial contracts for the consolidation of the common building blocks for future European reusable launch systems, ESA, May 2023
[137] Protein – the new European Heavy Lift Launcher Study, ESA, May 2023
[138] DLR Successfully Tests its New Red Kite Solid Rocket Motor, European Spaceflight, November 2023

Successful European year for spaceports contrasts with the 2023 launcher crisis

Inauguration of the orbital launch facilities at Esrange

Credit: SSC

With Sweden having taken over the EU Presidency from January until July, on January 13th, the inauguration of the new launch facility at the Esrange Space Center in Kiruna took place, attended i.a. by the Swedish head of state, King Carl XVI Gustaf, President of the EC Ursula von der Leyen, and ESA DG Josef Aschbacher. Esrange is the first European spaceport that enables vertical orbital launches for small satellites from European soil. Since 1966, Esrange has hosted suborbital launches of sounding rockets and high-altitude balloons. Now, small satellites can be launched from Esrange into polar orbits in LEO. Moreover, the new facility enables testing for reusable rockets. ArianeGroup will conduct initial testing of its Themis reusable booster demonstrator. In addition, Isar Aerospace has been and will continue conducting tests at Esrange for their microlaunchers.[139]

Official Inauguration of Andøya Spaceport and aim to attract non-European demand

In September, Andøya Spaceport, which has been in the final stages towards its official inauguration, announced the aim to attract foreign demand, having appointed Vincent Ciccarelli as its Commercial Director of North America and Asia. On November 2nd, Andøya Spaceport was officially inaugurated by H.R.H Crown Prince Haakon of Norway. The Spaceport, located at Nordmela, on the island of Andøya within the Arctic Circle, provides multiple launchpads. Due to its location, the Spaceport aims to focus on being a launch site for sun-synchronous and polar orbits and currently focuses on small to medium-sized launch vehicles. Isar Aerospace will have access to the first launch pad and is expected to carry out final testing of its Spectrum two-stage launch vehicle. The agreement for the launch pad was signed in 2022 to last for 20 years. In addition to the launch pad, the spaceport's infrastructure will include payload integration facilities and a mission control centre.[140]

Germany's North Sea offshore launch platform to see first suborbital test launch in spring 2024

Credit: GOSA

In September, at the time when Germany released its national space strategy, announced to work on a national space law and signed the Artemis Accords, the German government committed €2 million to support the development of an offshore launch infrastructure in the North Sea. The North Sea offshore spaceport idea and initiative was pushed by the German Offshore Spaceport Alliance (GOSA) formed by Tractebel DOC Offshore, MediaMobil, OHB, and Harren Shipping Services and is supported by European launch companies, German HyImpulse and Rocket Factory Augsburg (RFA), the UK-based Skyrora, and the Dutch T-Minus through MoUs expressing their interest.

GOSA aims to primarily rely on private funding to realise the offshore launch platform, valued at €22-30 million over 6 years of development. Nevertheless, the €2M funding is seen as a significant political signal of the German Government.[141] Following the €2 million commitment of the German Government for the planned German Offshore Spaceport in the North Sea, in October, the German Offshore Spaceport Alliance (GOSA) announced that a first launch is planned in April 2024 as a suborbital test launch.

[139] The world watched the inauguration of Spaceport Esrange, SSC Space, January 2023
[140] Andøya Spaceport officially opened, Andøya Space, November 2023
[141] Germany Commits €2M to Fund Offshore Launch Infrastructure, European Spaceflight, September 2023

UK spaceports saw progress in 2023

While for the UK 2023 started with the launch failure of the horizontal air launch with Virgin Orbit from Spaceport Cornwall, the year saw progress in the UK's spaceports.

In January, the first launch from UK soil, Virgin Orbit-operated "Start Me Up" mission, lifting off the LauncherOne rocket and its payload of 9 satellites from Spaceport Cornwall, failed during the second stage. Although the rocket reached space, the system malfunctioned preventing the spacecraft from being inserted into orbit. Among the payloads were several satellites commissioned by the UK Ministry of Defence as well as the first Omani satellite.[142]

In January, initiating a multi-year agreement and substantial investment, Rocket Factory Augsburg (RFA) obtained exclusive rights to SaxaVord's Launch Pad Fredo. This move allows RFA's RFA ONE launch vehicle to conduct polar and sun-synchronous orbit missions from SaxaVord. In November, RFA UK secured £3.5 million from the UK Space Agency under ESA's Boost! Programme to further its initiatives at SaxaVord Spaceport, targeting RFA ONE system launches from Q2 2024.[143]

In May, according to Science Minister George Freeman, JAXA expressed interest in utilising British spaceports for launches, with SaxaVord being a prime candidate. Additionally, Skyrora and Lockheed Martin are set to conduct launches at SaxaVord ahead of JAXA.[144]

The UK Space Agency is contributing £3.5M to support the UK-based subsidiary of Rocket Factory Augsburg (RFA) in preparing for its inaugural launch from the SaxaVord Spaceport in Scotland's Shetland Islands, scheduled for 2024. This funding - also granted through ESA's Boost! Programme - will benefit RFA UK, a subsidiary of the rocket developer tasked with building infrastructure and test equipment for the mission. Lockheed Martin also received funds from UKSA to set up launch operations at SaxaVord Spaceport in collaboration with Californian rocket startup ABL Space Systems.

In November, SaxaVord Spaceport announced a collaboration with HyImpulse Technologies to facilitate orbital rocket launches starting in late 2025. Following extensive engine testing in Shetland over three years, HyImpulse aims for two suborbital launches from Unst beginning August 2024, paving the way for full commercial operations by 2030.[145] In December, the UK Civil Aviation Authority granted a spaceport licence to SaxaVord spaceport. The licence allows Saxavord spaceport to commence launches in 2024 and authorises up to 30 yearly launches.[146]

In May, the Scottish launch startup Orbex announced the commencement of construction at Sutherland Spaceport, the first vertical launch facility on the UK mainland. Situated on the northern coast of Scotland, this spaceport will serve as the primary base for Orbex, enabling to launch of up to 12 orbital rockets annually for satellite deployment. In December, Orbex secured £3.3 million funding from the UK Space Agency's ESA Boost! initiative for the Ultra-Green Launch Complex at the spaceport.[147]

[142] LauncherOne: Virgin Orbit reveals why UK's first rocket launch failed as it plans further attempts, SkyNews, January 2023
[143] UK Space Agency supports RFA UK through BOOST!, Rocket Factory Augsburg AG, October 2023
[144] Japanese space agency to launch from Shetland in major boost to Britain, The Telegraph, May 2023
[145] SaxaVord and HyImpulse announce launch plans, SaxaVord, November 2023

[147] Contruction Begins at Sutherland, the UK Mainland's First Vertical Launch Spaceport, Orbex Space, May 2023
Orbex Awarded £3.3 Million as Part of European Space Agency's Boost! Initiative, Orbex Space, December 2023

1.3.2 International developments

International developments – launch highlights

U.S. and China both launch classified spaceplanes

On December 28th, the X-37B Orbital Test Vehicle, operated by the Space Force, embarked on its seventh mission to space: this time aboard a SpaceX Falcon Heavy rocket from the Kennedy Space Center. While specific details about the X-37B are limited, the Space Force has confirmed that the mission aims to explore new orbital patterns, trial space domain awareness technologies, and study the effects of radiation on NASA materials. Notably, each of the spacecraft's missions has seen an increase in its duration in orbit, setting a record of 908 days during its previous return in November 2022. X-37B was launched shortly after China's spaceplane, named Shenlong, was sent to orbit on December 14th[148] on a Long March 2F for a third flight. Shenlong was observed to releasing six classified objects into orbit, some of which were transmitting signals. The US Space Force had initially scheduled the X-37B's launch for December 7, ahead of Shenlong's deployment, but faced multiple delays.[149]

Responsive space mission "Victus Nox" launched on a Firefly rocket

The U.S. Space Force has confirmed the successful launch of a Millennium Space small satellite on September 14th by Firefly Aerospace using their Firefly Alpha rocket. This mission called "Victus Nox" was specifically designed to showcase the ability to launch on a significantly shorter timeline than what is typically required for national security missions.[150]

United Launch Alliances new Vulcan rocket launches

The Vulcan Centaur rocket, developed by United Launch Alliance (ULA), successfully embarked on its inaugural flight on January 8th.[151] Mounted on the rocket was the Peregrine Moon lander by Astrobotic.

First successful launch of India's SSLV rocket

After the failed launch of India's new Small Satellite Launch Vehicle (SSLV) on August 7th, 2022, the second attempt on February 10th, was successful. The first payload to test the SSLV's launching capabilities and its responsiveness was the small Earth observation satellite EOS 07, developed by ISRO. The other two satellites are AzaadiSAT 2, and Janus 1. Compared to India's GSLV and PSLV rockets, SSLV is designed to provide more affordable and flexible access to space.[152]

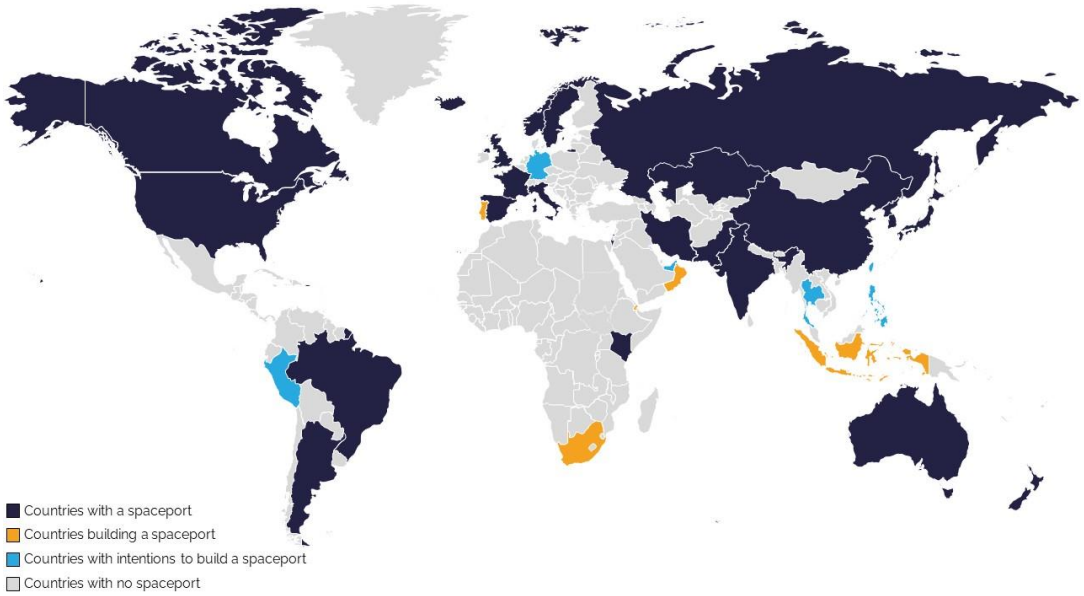
China crushes national launch record twice

On June 15th, 41 small satellites were successfully deployed into orbit by a Long March 2D rocket lifted off from Taiyuan, primarily expanding Changguang Satellite's Jilin-1 commercial remote sensing constellation. This launch surpasses the previous Chinese record of 26 satellites on a single mission, which was achieved only a few days earlier, on June 7th, by CAS Space's Lijian 1 rocket. The payloads for the Lijian 1 launch mostly consisted of undisclosed technology demonstration satellites. The current record for the most satellites deployed in a single mission is 143, set by SpaceX's Transporter-1 rideshare mission in January 2021.[153]

[148] China launches mystery reusable spaceplane for third time, SpaceNews, December 2023
[149] X-37 and Chinese Space Plane Both Launch: 'Two of the Most Watched Objects on Orbit', AirandSpaceForces.com, January 2024
[150] Firefly launches Space Force 'Victus Nox' mission, SpaceNews, September 2023
[151] ULA's Vulcan rocket launches private US moon lander, 1st since Apollo, and human remains in debut flight, Space.com, January 2024
[152] India's SSLV rocket succeeds in second try, SpaceNews.com, February 2023
[153] China launches national-record 41 satellites on single rocket, Space.com, June 2023

Developments in Spaceports

With a projected exponential growth in space launches, spaceports have a critical role in the growing global commercial space transportation industry. In 2023, a noticeable trend was the development of spaceports in Africa, the Middle East and South America.



U.S. Senators introduce Spaceport Act to enhance spaceport activities

U.S. Senators introduced the bipartisan Spaceport Project Opportunities for Resilient Transportation (SPACEPORT) Act. The Spaceport Act aims to encourage the development of commercial spaceports through the modernisation of the Space Transportation Infrastructure Matching (STIM) grant program of the Federal Aviation Administration (FAA).[154]

U.S. ensures launch opportunities beyond U.S. territory

- **The U.S. and Australia signed a Technology Safeguards Agreement for space launch:** The TSA provides a legal and technical framework for launching U.S. commercial space launch vehicles from Australia's territory. The TSA aims to protect sensitive U.S. launch technology and data in Australia and to create the potential for commercial opportunities in the space sector. The TSA is expected to support and boost the Australian launch sector and the several initiatives underway including Equatorial Launch spaceport, Southern Launch, and Gilmour Space.[155]
- **The U.S. and Peru are considering construction of a national spaceport in Peru:** The partnership is based on the agreement between Peru's National Commission for Aerospace Research and Development (Conida) and the U.S. Space Command from April.[156] In August, the Peruvian Air Force (FAP), along with the National Commission for Aerospace Research and Development (Conida) and the U.S. Space Command, discussed plans to construct a spaceport and launch sites for space vehicles in Peru, with the Paita desert in Piura as a potential location. Its abundance of resources and proximity to a major port make it attractive. Spanning 1,000 square kilometres and near the equator, Paita promises reduced launch costs and enhanced operational efficiency.[157]

[154] A BILL To amend chapter 511 of title 51, United States Code, to modify the authority for space transportation infrastructure modernization grants, and for other purposes, Hickenlooper.Senate.Gov, June 2023
[155] US and Australia Sign Space Launch Agreement, Satellite Today, October 2023
[156] Peru announced Air Security Pact with the United States after extended Pause, U.S. News, August 2023
[157] Peru's Air Force and the U.S. pave the way for a national spaceport in Peru, The Rio Times, August 2023
Peru's Paita Desert Could Become the Largest Spaceport in South America, BNN, September 2023

Equatorial Launch Australia unveiled final plans for its spaceport

With regard to spaceports in Australia, three NASA rockets were launched from the Arnhem Space Centre Advanced Launch Pads (ASCALP) in 2023, marking Australia's first commercial space launches. Moreover, Equatorial Launch Australia (ELA) revealed its final plans for the Arnhem Space Centre Advanced Launch Pads (ASCALP), designed to accommodate multiple rocket companies with minimal changes. ELA aims to host up to seven rocket companies at its Northern Territory spaceport, addressing the demand for satellite launches. ELA has been and is working with the Australian Space Agency to obtain a launch permit.[158]

Developments related to the Chinese launch sector

The Republic of Djibouti signed a MoU with a Hong Kong based Holding for the development of an international commercial spaceport, a $1 billion project, which will include 7 satellite launch pads. Djibouti will provide the land with at least a 35-year lease. The contract was planned to be signed in March but is still facing legal hurdles.

On December 29th, the first launch pad at the Chinese Hainan Commercial Launch Site was completed, the initial of two planned. Designed for liquid propellant launch vehicles, this development supported the nation's increasing space missions, including national and commercial launches. Constructed by the China Aerospace Science and Technology Corporation (CASC), the launch station is slated for completion in 2024. It will feature service structures and essential equipment to facilitate regular commercial missions.[159]

[158] ELA unveils launch pad design for spaceport, Space Connect, December 2023
[159] New Chinese commercial spaceport to host first launch next year, SpaceNews, February 2023

1.4 Space, Security & Defence

1.4.1 Developments in Europe

New Strategies, Policies and Governance and Budgets Changes

EU Space Strategy for Security and Defence released in 2023

On March 10th, the European Commission and the EEAS released the EU Space Strategy for Security and Defence (EU SSSD). The Strategy outlines counterspace capabilities and threats in space that pose risks to space systems and their ground infrastructure and the EU's approach to dealing with these developments. The EU SSSD has the following objectives grounded on 5 pillars:

Credit: European Commission

1. Common understanding of the Space Threats Landscape

- Classified annual space threat landscape analysis, incl. evolution of counterspace capabilities

2. Resilience and protection of space systems and services

- Potential EU Space Law
- EU Space Information Sharing and Analysis Centre (as from 2024)
- Developing technologies and capabilities to increase resilience

3. Responding to space threats

- Expand the space threat response mechanism to all EU space systems/services
- Mobilise EU tools to respond to space threats
- Access to SDA information to characterise unresponsible behaviours and protect assets
- Space exercises with EU MS to test and develop EU response to space threats

4. Use of space for security and defence

- Maximising the use of space for security and defence purposes
- New Copernicus EO governmental service
- Connecting space, defence and security at EU level
- Enhance cooperation between space and defence start-ups

5. Partnering for responsible behaviours in space

- Engaging within the United Nations framework
- Working with the US as strategic partners
- Developing space security dialogues with third countries
- Deepening EU-NATO cooperation[160]

[160] EU Space Strategy for Security and Defence for a stronger and more resilient European Union, European Commission, March 2023

ESPI published an Executive Brief, based on input submitted following the EC's public call for evidence, on ESPI's expectations and recommendations for the strategy.[161]

As outlined in the ESPI brief, the EU Space Strategy for Security and Defence will be a major milestone in the future of military space activities in Europe. The process leading to the elaboration of this Strategy has raised the awareness of all states on the relevance of space security and defence and encouraged Member States to scale their investments. With regard to the implementation and next steps, the brief outlines that a key element of the implementation process will be to ensure that EU activities fit and coordinate with efforts conducted at national, multilateral and intergovernmental levels, in order to multiply the capacity of European stakeholders to act decisively in this domain and increase the continent's credibility.[162]

EU Defence Ministers approved 2023 EU Capability Development Priorities

In November, EDA's Steering Board, the 27 EU Ministers of Defence, approved the 2023 EU Capability Development Priorities, a basis for EU-wide defence planning and defence-related initiatives, such as the Coordinated Annual Review on Defence (CARD), the Permanent Structured Cooperation (PESCO), the European Defence Fund (EDF). It sets out 22 priorities focusing equally on short, medium, and long-term planning.

Credit: EDA

The priorities are broadly categorised in:

- Land Based Precision Engagement
- Integrated Air and Missile Defence
- Underwater/Seabed Warfare
- Sustainable and Agile Logistics
- Cohesive and Well-Trained Militaries

With regards to space, two of these priorities include space: (1) Integrated Air and Missile Defence, incl. developing systems with space-based early warning, and (2) Cohesive and Well-Trained Militaries: military training, ability to adapt to an ever-changing environment, and to operate in new military domains, such as space and cyber.

Space is divided into two areas (1) Space Operations and (2) Space Services, each encompassing three key areas:

Space Operations – Key areas:		
Space Situational Awareness	**Access to Space**	**Protection of Space Systems**

Space Services – Key areas:		
Space-based EO Capabilities	**Positioning, Navigation & Timing**	**SatCom**

[161] EU space strategy for security and defence - Feedback and statistics: Call for evidence, ESPI, February 2023
[162] High time for an EU Space Strategy for Security and Defence, ESPI Executive Brief No. 63, ESPI, March 2023

European Defence Fund €1.2 billion Work Programme for 2023 allocates €125 million to space

Credit: EDF

On March 30th, the 2023 European Defence Fund (EDF) work programme was released, which will provide €1.2 billion for defence research, development and innovation through its annual calls for proposals, open from June 15th until November 22nd. The programme is structured in 7 calls (4 thematic calls + 3 calls for SMEs and disruptive topics) in 17 topic areas and 34 topics.

Space is one of the 17 topic areas and was allocated a €125 million budget, which makes it the second highest funded area (after Naval Combat with €154 million). The two topics within space are: (1) Threat surveillance and protection of space-based assets (R) and (2) Initial operational capacity for SSA C2 and sensors (D).[163]

Space-related security and defence projects funded through the EDF

In June, the European Commission selected proposals for two space-related EDF projects from the EDF 2022 Work Programme. REACTS (Responsive European Architecture for Space) and ODIN´S EYE II. The European Commission announced the allocation of €19.2 million for the research project REACTS. The project aims to develop a framework for a resilient and scalable Network of Responsive Space Systems (RSS) for Europe. REACTS will define the architecture, concept of operations (CONOPS), roadmap, interface standards, and software-based configuration for the RSS Network. The goal is to launch/replace satellites and deliver data within 72 hours. ESPI contributes to the work of the DLR-led REACTS Consortium, comprised of 35 (mainly industry) partners.[164]

The OHB system AG-led Consortium won the bid for the ODIN´S EYE II EDF project. In collaboration with 38 European companies from 14 EU Member States, the consortium received a €90 million grant from the European Commission to design and study a space-based missile early warning system - developing a common response to current and future threats.[165]

The French MoD allocates €6 billion of the LPM for military space budget for 2024-2030

France's 7-year Military Programme Law (LPM) published on April 4th with a €413 billion military programme budget, allocates €6 billion for military space programmes between 2024 and 2030. This encompasses previously announced investment in ground- and space-based technologies to defend and protect from approaches to French military space assets.[166]

[163] European Defence Fund: €1.2 billion to boost EU defence capabilities and new measures for defence innovation, European Commission, March 2023
[164] REACTS Factsheet, EDF, European Commission, June 2023
[165] European Defence Fund: OHB System lead the ODIN'S EYE II project, Defence Industry Europe, June 2023 ; ODIN'S EYE II Factsheet, EDF, European Commission, June 2023
[166] French Defense Ministry proposes $6.5-billion military space budget for 2024-30, Space Intel Report, April 2023

New Security strategies referring to space

- **Security Strategy for the Kingdom of the Netherlands:** in April, the Netherlands published the "Security Strategy for the Kingdom of the Netherlands", which is divided in 3 main parts: (1) Threats to national security", (2) Strategic Course, (3) Control over national security. In one of 10 defined priorities for 2023-2029, the strategy declares space as a key sector.[167]
- **Germany's new national security strategy:** Germany released its new national security strategy "Wehrhaft. Resilient. Nachhaltig. Integrierte Sicherheit für Deutschland". The strategy revolves around 3 main pillars: (1) Defence (2) Resilience, (3) Sustainability. Space is addressed within the pillars (1) Defence and (2) Resilience.[168]

Space and Cybersecurity

The EU conducted the Space Threat Response Architecture (STRA) 2023 exercise

From March 6th to 10th, the EU conducted the Space Threat Response Architecture (STRA) 2023 exercise at the EEAS HQ. Organised by the EEAS in coordination with EU Member States, EUSPA and DG DEFIS, it simulated the EU's space threat response mechanism that would be triggered in the event of a cybersecurity incident affecting Galileo. On March 15th, the Political and Security Committee (PSC) explored the potential EU response and activation of the EU mutual assistance clause [Article 42(7) TEU] for a space incident.[169]

ESA & Thales Alenia Space conducted a demonstration satellite hack on OPS-SAT

As part of the third edition of the CYSAT Conference, a cybersecurity exercise to test satellite safety and resilience against cyberattacks was conducted. A team of cybersecurity researchers from Thales Alenia Space jointly with the Group's Information Technology Security Evaluation Facility (ITSEF) was tasked to take control of the OPS-SAT demonstration nanosatellite and its system as part of an ethical satellite hacking exercise. The team gained access to the satellite's onboard system and exploited several vulnerabilities, highlighting the need for high cyber resilience in space operations. Thales employs over 3,500 cybersecurity specialists to enhance the security of national and European space programmes, including Galileo.[170]

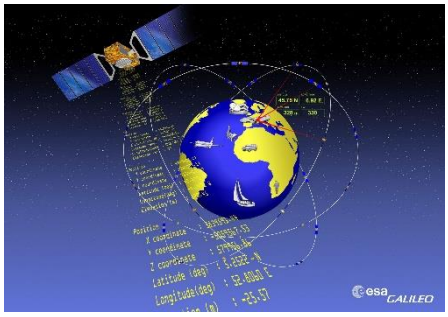
Space for Security & Defence

EU investigated agreement to launch Galileo satellites from U.S. territory with SpaceX

In 2023, the EU has been discussing and approaching an agreement that will allow the launch of the Galileo satellites from U.S. territory with SpaceX in early 2024. Due to the loss of the Russian Soyuz and the delay of Ariane 6, the launch from the U.S. is a necessary move to keep the constellation in service - as it is estimated that the current constellation will no longer be able to ensure the continuation of service after mid-2024. Initially, the latest batch of Galileo satellites was planned to be launched and deployed in space in the spring of 2022. The agreement is urgent and sensitive at the same time. The agreement aims at protecting the integrity and safety of the satellites and the information (incl. EU classified information) contained, would protect the exchange of provision of classified information between the EU and the U.S., and it would require the U.S. to establish measures to protect the space assets upon arrival on U.S. territory until the satellites are launched into space and deployed in orbit.[171]

[167] The Security Strategy for the Kingdom of the Netherlands, Government of the Netherlands, April 2023
[168] Wehrhaft. Resilient. Nachhaltig. Integrierte Sicherheit für Deutschland. Nationale Sicherheitsstrategie, BMVg, June 2023
[169] Space: EU tests its response mechanism to threats, EEAS, March 2023
[170] Hackers Hack a Government Satellite and Take Control, Expat Guide Türkiye, May 2023

Galileo Second Generation entered the full development phase



Credit: ESA

In June, the Galileo Second Generation (G2G) entered the full development phase. The system is now ready for its In Orbit Validation development phase.

The contracts for building the 12 satellites were awarded in May 2021 to Thales Alenia Space and Airbus Defence & Space and contracts for developing the ultra-precise atomic clocks carried onboard the satellites were awarded to Safran Electronics & Defence and Leonardo.[172]

EUSPA extended cooperation with CNES for the delivery of the Galileo Search and Rescue Service

In January, EUSPA extended its cooperation with CNES for the delivery of the Galileo Search and Rescue Service. The new Contract will further expand the cooperation between EUSPA and CNES in SAR activities.[173]

French Ministry of Armed Forces to deploy a new generation military observation satellite

In May, the French Ministry of the Armed Forces announced its plans to deploy a new generation military observation satellite "Iris" before 2030. The Iris programme will take over from CSO and is comprised of two satellites. Currently, two French CSO ISR satellites are in orbit (CSO-1 and -2), while the third CSO-3, initially planned to be launched by Soyuz rocket at the end of 2022, is now rescheduled for an envisaged launch in 2024 with Ariane 6. The Ministry submitted a government amendment to the military programming law (LPM), which aims to enable the registration of an additional Iris satellite even before 2030-2035.[174]

Italian Ministry of Defence registered a multi-orbit large constellation at the ITU

In September, the Italian Ministry of Defence registered a satellite constellation "ITA-LEO", comprised of 19.708 satellites in LEO and MEO orbits in 899 orbital planes carrying S-, X-, and military-Ka brand frequencies, at the ITU. The constellation not only aims at enhancing Italy's national defence and security capabilities but is also part of (and Italy's national contribution to) the GOVSATCOM Programme and the governmental pillar of IRIS^2.[175]

Italy seeking new GEO and LEO satellites

Under the Multiannual Programmatic Document (Documento Programmatico Pluriennale) 2023–2025, published on October 16th, the Italian Ministry of Defence is seeking new GEO and LEO satellites to increase the resilience of its armed forces. In particular, for the LEO constellation of high-performance communications and data relay satellites a €900 million budget over 5 years is planned (so far only €5 million approved). The LEO constellation should increase the resilience of communications networks and provide telecommunications services to the armed forces. In addition, a data exchange network between government satellites will be established to support tactical missions. Concerning GEO, the MoD intends to procure a GEO telecommunications satellite "SICRAL R1" (to replace the SICRAL 1B satellite, which has reached its EoL in 2022) with a planned budget of €300 million over two 3-year periods (2023–25 and 2026–28) – but needs to be approved.

[172] Galileo Second Generation enters full development phase, Spacewatch Global, June 2023
[173] EUSPA extends cooperation with CNES for delivery of the Galileo Search and Rescue Service, EUSPA, January 2023
[174] Paris will add an observation satellite in its military programming, the Limited Times, May 2023
[175] Italian Defense Ministry registers at ITU a constellation of 19,708 satellites in LEO and MEO orbits, Spaceintelreport, September 2023

To fill the gap between the SICRAL satellites, €18 million are envisaged for a 2-year "satcom orbital gap filler project". Last month, the Italian MoD registered a LEO and MEO constellation of 19,708 satellites at the ITU.[176]

2nd ESA Security Conference took place, co-organised by ESPI

On May 16th-17th, the 2nd ESA Security Conference took place in Brussels, co-organised by ESA and ESPI with the support of BELSPO. The conference highlighted 3 key aspects: (1) the major change of paradigm triggered by the war in Ukraine, resulting in increased urgency for space actors to prioritize security (2) the underlying need to foster a competitive and resilient space industry as a key pillar of European security, (3) the relevance of better involving users in the development of space programmes.[177]

ESA selected ICEYE as the first partner under its new Civil Security from Space Programme (CSS)

In October, ESA selected the Finnish EO company as a partner to participate in the new ESA's Civil Security from Space Programme (CSS) in the frame of the "Disaster Management from Space" project. The 3-year cooperation in the project aims to "revolutionise disaster and crisis management" by boosting the use of EO data and imagery and to develop advanced natural catastrophe monitoring services. This marks the first partnership under the CSS programme.[178]

European Commission selected ICEYE and Euroconsult for AEGIS^2

In response to a request of the European Commission, Euroconsult and ICEYE were selected by the EC to lead the European Earth Observation Consortium AEGIS^2 ("Advanced European Governmental Innovative ISR Secured Service") Consortium, which is comprised of 15 members from 8 European countries, to conduct a 1-year feasibility study for the future of European Earth Observation. In particular, the study aims to explore the best approach to implement EO services for governmental users in the EU and its member states, investigating innovative, secure, and sustainable solutions – resulting in recommendations for the European Commission.[179]

Planetek supports INTERPOL under ESA's EO for Civil Security Applications initiative

Planetek Hellas reached a collaboration phase with ESA through a newly signed contract under ESA's EO for Civil Security Applications initiative. Valued at €500.000, this 12-month initiative aims to outline EO solutions for security and law enforcement, demonstrating innovative approaches for global authorities combating terrorism and organised crime. Led by Planetek Hellas, the consortium includes Janes (UK) and the Center for Security Studies (Greece). The project seeks to enhance operational efficiency by integrating EO services into INTERPOL's Counter Terrorism operations.[180]

ASI and the Italian State Police signed an agreement to tackle cybercrimes

ASI and the Italian State Police signed an agreement to tackle cybercrimes. The prevention and fight against cyber crimes involves networks and information systems that aim at supporting the institutional functions of the State Police. The agreement develops a structured cooperation between the State Police and ASI in this field.[181]

[176] Italy seeks new GEO and LEO satellites in latest defence budget, Janes, October 2023
[177] 2nd ESA Security Conference with major ESPI involvement, ESPI, May 2023 ; 2nd ESA Security Conference, ESPI, May 2023
[178] ESA Taps ICEYE For First Civil Security From Space Partnership To Revolutionize Disaster Management, ICEYE, October 2023
[179] Euroconsult and ICEYE to Lead AEGIS^2 Consortium for the Future of European Earth Observation, ICEYE, October 2023
[180] Planetek Hellas signs new contract with ESA to support the INTERPOL's Counterterrorism Unit, Planetek, November 2023
[181] Polizia di Stato e Agenzia Spazile Italiana Siglano l'accordo sulla prevenzione e contrasto dei crimini informaciti, ASI, April 2023

Planetary Defence

ESA and GomSpace progressed on Juventas CubeSat for Hera asteroid mission

ESA and the Danish company GomSpace finalised a Contract Change Notice (CCN) worth €1.5 million for the Juventas CubeSat project, an integral part of the HERA mission. Juventas is aimed at enhancing mission robustness through system-level adaptations. The 6U nanosatellite Juventas will conduct radar and radio-science experiments targeting the binary asteroid's moon, Dimorphos. The mission is also part of the international Asteroid Impact and Deflection Assessment (AIDA) collaboration, which aims to demonstrate asteroid deflection technology for planetary defence.[182]

1.4.2 Developments Beyond Europe

New Strategies, Policies and Governance and Budgets Changes

EU and NATO released Joint Declaration

On January 10th, the EU and NATO released the third joint EU-NATO Declaration. Space is included in paragraph 12, which declares that the EU and NATO will strengthen cooperation "[…] to address in particular the growing geostrategic competition, resilience issues, protection of critical infrastructures, emerging and disruptive technologies, space, the security implications of climate change, as well as foreign information manipulation and interference".[183]

NATO Innovation Fund was fully established in 2023

At the NATO Vilnius Summit in July, the NATO Innovation Fund (NIF), priorly launched at the 2022 Madrid NATO Summit, was fully established. NIF is a €1 billion VC fund, supporting founders developing emerging/disruptive technologies. The areas funded under NIF include AI, Autonomy, Quantum, Biotech, Hypersonic Systems, Space, Novel Materials & Manufacturing, Energy & propulsion, and Communication. The fund's investment management arm is in the Netherlands.[184]

Signing Ceremony for the operational MoU of the NATO Space Centre of Excellence

The signing ceremony for the Operational MoU of the NATO Space Centre of Excellence (a joint effort led by 15 sponsoring nations) took place at the French MoD in Paris. The Centre aims to provide knowledge and analysis in the 3 operational functions (1) Space Domain Awareness (SDA), (2) Operational Space Support, and (3) Space Domain Coordination, and will bridge between NATO and national and international space organisations from defence, civil, industry, and research.[185]

Space Force to release guidelines for commercial satellite use

In Autumn, the U.S. Space Force announced the upcoming release of a commercial space strategy. It lays out guidelines for the military use of commercial satellite service and its integration into military services in order to "achieve competitive advantage through commercial augmentation".[186] Saltzman sent the Space Force's draft Commercial Space Strategy back to the drawing board, claiming to move the strategy draft from "aspirational to actionable".[187]

[182] GomSpace and ESA sign Contract Change Notice for €1.500.000 for the Juventas CubeSat implementation, Gomspace, August 2023
[183] Joint Declaration on EU-NATO Cooperation by the President of the European Council and the Secretary General of NATO, Consilium Europe, January 2023
[184] Vilnius Summit Communiqué, NATO, July 2023 ; NATO Innovation Fund (NIF), NIF Fund
[185] One More Step for NATO's Space Centre of Excellence, NATO Allied Command Transformation (ACT), January 2023
[186] Space Force to release guidelines for the use of commercial satellite services, SpaceNews, September 2023
[187] As DoD readies new commercial space strategies, industry frets funding gap, Breaking Defense, September 2023 ; 'Not enough': Space Force pauses commercial strategy to flesh out 'actionable' plans with industry, Breaking Defense, September 2023

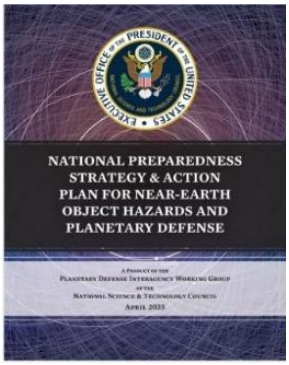
U.S. DoD unveiled updated guidance on responsible behaviours in space

On March 3rd, the U.S. DoD published updated guidelines for responsible behaviours in space, targeting military (not civilian/commercial) space operations and activities. The updated guidelines are based on the memo on five tenets of responsible behaviour in space that was first published in July 2021. These are:

- Operate in, from, to, and through space with due regard to others and in a professional manner
- Limit the generation of long-lived debris
- Avoid the creation of harmful interference
- Maintain safe separation and safe trajectory
- Communicate and make notifications to enhance the safety and stability of the domain.

The guidelines have the objective of providing "transparency about U.S. military space activities in order to reduce the risk of misunderstanding and miscalculation".[188]

The White House published a new Planetary Defence Strategy



Credit: White House

In April, the White House Office of Science and Technology Policy released the National Preparedness Strategy and Action Plan for Near-Earth Object Hazards and Planetary Defence 2023. The new strategy is an updated version of the first U.S. comprehensive Near-Earth Object Preparedness Strategy and Action Plan from 2018.

The new strategy outlines 6 key goals for the next decade:

- Enhancing NEO detection, tracking, and characterisation capabilities;
- Improving NEO modelling, prediction, and information integration;
- Developing technologies for NEO reconnaissance, deflection, and disruption missions;
- Increasing international cooperation on NEO preparedness;
- Strengthening and routinely exercising NEO impact emergency procedures and action protocols;
- Improving the U.S.' management of planetary defence through enhanced interagency collaboration.[189]

Japan adopted a space security policy

Based on the National Security Strategy updated in December 2022, Japan adopted its first space security policy, which aims to enable Japan to enhance the utilisation of space for defence over the next decade. Japan's Prime Minister Fumio Kishida stated: "For the sake of national security, we will dramatically scale up the use of space systems and ensure the safe and stable utilisation of the domain".

In particular, the policy:

- outlines a roadmap to strengthen information-gathering systems to increase counterstrike effectiveness/capabilities, i.a. through the acceleration of information transmission by combining multiple small satellites and through improving their visual data interpretation technologies by using AI.

[188] DoD releases updated guidance on 'responsible behaviors in space', SpaceNews, March 2023
[189] National Preparedness Strategy and Action Plan for Near-Earth Object Hazards and Planetary Defense 2023, NSTC, April 2023

- commits to advance Japan's national defence projects, through the use of private-sector space technologies, as part of Japan's attempt to accelerate the integration of its defence and civilian sectors – referring to U.S.' and Europe's use of data from commercial satellites to support Ukraine's defence and military operations. To achieve this, Japan aims to increase the internal cooperation between the Defence Ministry and JAXA.
- Envisages increased international cooperation for the protection of satellites with the U.S. and other allies.[190]

Bipartisan House Bill to create Space National Guard (SNG)

In January, Rep. Jason Crow, D-Colo., and Rep. Doug Lamborn, R-Colo., introduced a bipartisan House legislation the Space National Guard Establishment Act (H.R. 3048) which aims at creating a Space National Guard (SNG) under the Space Force. In the 117th Congress, lawmakers considered the proposal, and it passed the House. The act, however, was never voted in the Senate. Since the establishment of the Space Force in 2019, the creation of the SNG has been discussed, but the Biden administration rejected the proposal (with costs estimated at $500 million annually) in 2021 due to cost concerns.[191]

U.S. Space Force launched a new unit to bridge SpOC and SSC

During the Space & Cyber Conference on September 12th, Saltzman unveiled that the Space Force will change its organisational structure, launching a new type of unit, which aims to bridge the gaps among operations, engineering, and capability development specialists and bring them under one roof in order to increase the speed of delivery of maintenance and upgrades to important systems. To date, the Space Operations Command (SpOC) comprises operators in the space, cyber, and intelligence fields while the Space Systems Command (SSC) comprises engineers and program managers - a separation that delays the rate at which operators provide feedback to developers - and therefore slows down the processes to maintain and improve systems and decreases the Space Force' s readiness.[192]

U.S. Space Force Commercial Services Office (COSMO) opened its new facility

The U.S. Space Force Commercial Services Office (COSMO) opened a new facility in Virginia. COSMO's new facility aims to oversee the procurement of commercial satellite-based services and absorb other organisations that cooperate with the industry (incl. i.a. SpaceWERX, the SDA data marketplace, and the SSC Front Door initiative). As part of the new facility, a commercial collaboration centre will be kicked off during an industry day on June 7th.[193]

Developments in military space programmes

NATO members launched APSS initiative with Aquila virtual constellation

16 NATO members, including Belgium, Bulgaria, Canada, France, Greece, Hungary, Italy, Luxembourg, Netherlands, Norway, Poland, Romania, Spain, Türkiye, the UK and the U.S., together with the aspiring members Finland and Sweden, launched a new initiative the "Alliance Persistent Surveillance from Space" (APSS), which aims to transform the approach how NATO receives and uses space data, to improve NATO's surveillance and intelligence as well as to support military operations.

Credit: NATO

[190] Japan adopts space security policy and vows to expand defense use, The Japan Times, June 2023
[191] The Space National Guard Establishment Act (H.R. 3048), January 2023
[192] Saltzman Reveals New Space Units That Put Operations and Sustainment Under One Roof, Air & Space Forces Magazine, September 2023
[193] Space Force commercial office to open new facility in Virginia, Space News, May 2023

This multi-year initiative of civil-military cooperation will include the creation of the virtual constellation "Aquila" of national and commercial space assets. The initiative aims to generate cost savings and support streamlining collection, sharing and analysis of data among allies and the NATO command structure. The APSS initiative aims to:

- achieve 'persistent surveillance' - enabling NATO to collect data on any location at any time.
- increase sharing of space-based intelligence among NATO allies - for more comprehensive cross-domain intelligence to inform political decision-making and military operations.
- improve NATO's intelligence - through a more effective use of government-owned and commercial space-based assets, technologies and data.
- increase the speed at which space-based data is collected and delivered – through new technologies, such as AI and ML.
- ensure the usability of data for NATO decision-makers and military commanders.
- build a community of practice among NATO nations for better data management efficiency and enhance national and collective resilience - through training, education and cooperation.

The initiative is backed by Luxembourg with the groundwork enabled through its early 16.5M contribution. The participating countries contribute to Aquila through national assets, data, and funds, while the initiative will also remain open to other allies. In addition to national contributions, industry will support APSS through the provision of data and services.[194]

U.S. advanced in Responsive Space Capabilities

2023, and in particular, August and September, saw significant developments and progress in the U.S. in demonstrating Responsive Space Capabilities. The Space Force pushes efforts in tactically responsive space, which is the quick replacement of destroyed satellites in times of war or national emergency. In March, for the first time, the U.S. Space Force requested a budget from the U.S. Congress, proposing a $60 million budget for responsive space. In August, Space Force budget documents confirmed plans to spend $60 million over the next 2 years on tactically responsive space demonstrations. Moreover, the Space Force launched a Small Business Innovation Research program focused on tactically responsive space. In a solicitation, DIU asked companies to submit proposals by September 7th for the US Space Force and DIU-funded project Victus Haze.[195]

Credit: Space Force

On September 14th, the U.S. Space Force launched a Millennium Space small satellite in the responsive space mission "Victus Nox" by Firefly Aerospace aboard its Firefly Alpha rocket. Firefly Aerospace demonstrated its capability to prepare a satellite for the Victus Nox mission within a 24-hour window. "Victus Nox" was specifically designed to showcase both responsive space capabilities, and the ability to launch on a significantly shorter timeline than what is typically required for national security missions. On August 30th, both companies announced they were on standby, ready to receive an alert notification from the Space Force. Upon receiving the alert, they had a 60-hour window to transport the payload to Firefly's launch site at the Vandenberg Space Force Base, complete fuelling procedures and integrate it with the Alpha rocket's payload adapter.[196]

[194] 16 Allies, Finland and Sweden launch largest space project in NATO's history, NATO February 2023 ; Alliance Persistent Surveillance from Space (APSS), NATO, February 2023
[195] Defense Innovation Unit to sponsor a rapid response space mission, SpaceNews, August 2023
[196] Firefly launches Space Force 'Victus Nox' mission, SpaceNews, September 2023

On August 8th, the U.S. National Reconnaissance Office announced a contract with Firefly Aerospace and Xtenti for a responsive space mission scheduled to launch on a Firefly Alpha launcher in 2024. The mission aims to demonstrate responsive space capabilities through various on-orbit deployments of commercial rideshare payloads with Firefly's Elytra orbital vehicle and Xtenti's Fantm-Ride small satellite dispenser. After the deployment, Elytra will perform an on-orbit manoeuvre, after which Elytra will remain in orbit on standby, ready and prepared to deploy U.S. government payloads on-demand.[197]

Terran Orbital announced the launch of its Responsive Space Initiative in Q4 2024, which aims to enable Terran Orbital to provide military, civil, and commercial customers with satellite buses within 30 days and complete satellite systems with integrated payloads within 60 days. The initiative aims to reduce the time for satellite delivery for critical missions from years to days.[198]

U.S. Space Force expanded national in-orbit and ground station missile warning capabilities

As highlighted in a report by Aerospace Center for Space Policy and Strategy issued in June, recent changes in the U.S. Space Force budget for fiscal year (FY) 2024 reflect the department's push toward more spacecraft in lower and medium orbits and reinforce the growing consensus in the administration and Congress to accelerate the uptake of commercial solutions in military systems. Satellite-based missile warning systems are no exception.

In this respect, the Space Force awarded L3Harris Technologies a $29 million contract to design a sensor payload to track hypersonic missiles from MEO. The recent contract adds up to two previously selected deals that see Millenium Space Systems and Raytheon Technologies designing sensors for the MTC Epoch 1 (missile warning, missile tracking, and missile track custody) Program, and a contract awarded to Parsons to develop the ground system. The planned constellation of at least six satellites is to be deployed in MEO in late 2026. Similarly, a ground station for missile warning satellites being developed by Northrop Grumman has recently passed a preliminary design review. The Relay Ground Station-Asia (RGS-A) terminal counts six antennas, it was initiated by the U.S. Naval Information Warfare Center (NIWC) Pacific under a five-year $99.6 million contract and aims to facilitate communications between different satellite networks that detect missile launches.

SpaceX restricted military use of Starlink by the Ukraine

SpaceX moved towards restricting the Ukrainian military using its satellite internet service Starlink after claims that the Ukrainian forces were relying on the constellation to control drones. According to SpaceX President Shotwell, the service was "never meant to be weaponised" and "Ukrainians have leveraged it in ways that were unintentional and not part of any agreement".[199]

The Space Development Agency (SDA) started the deployment of its constellation

The Space Development Agency (SDA) announced the successful initial launch of Tranche 0 (T0) of the Proliferated Warfighter Space Architecture (PWSA) on April 2nd. The Transport and Tracking Layer satellites, launched on a SpaceX Falcon 9, are designed to demonstrate low-latency communication links for warfighters. This will include tracking advanced missile threats from LEO. SDA plans to launch a second Tranche 0 satellite mission in June.[200]

[197] NRO to conduct responsive space mission with Firefly and Xtenti, SpaceNews, August 2023
[198] Terran Orbital Launches Responsive Space Initiative, Spacewatch Global, September 2023
[199] SpaceX curbed Ukraine's use of Starlink internet for drones -company president, Reuters, February 2023
[200] SpaceX launches initial satellites for Space Development Agency, NASA Spaceflight.com, April 2023

USSF Space Systems Command awarded Kratos a $579 million 8-year contract extension

The USSF Space Systems Command awarded Kratos Defense & Security Solutions an 8-year contract extension for technical services supporting U.S. military communications satellites' ground systems. The indefinite-delivery/indefinite-quantity contract, valued at up to $579 million, extends through November 2031. Operating under the Command-and-Control System-Consolidated Sustainment and Resiliency (CSAR) programme, Kratos will maintain and enhance satellite ground systems for the USSF and U.S. Space Command.

Tasked with providing planning, processing, and information assurance measures, Kratos will also facilitate information technology infrastructure upgrades as new satellite constellations are deployed. The contract supports command-and-control operations for 26 military communication satellites across four constellations, as well as the integration of future satellites and constellations.[201]

U.S. Space Systems Command launched TAP Accelerator Program

In October, the Space Systems Command kicked off its Space Domain Awareness Technology, Applications, and Process (TAP) Lab Accelerator Program, which was developed to boost innovation and cooperation between industry, the DoD, and academia to boost commercial SDA prototype technologies. The projects are related to the areas: space domain awareness, threat warning and assessment, and space battle management.[202]

U.S., UK and Australia sign agreement to operate deep space radar network

In December, the U.S., UK and Australia signed an agreement to jointly develop, host and operate a network of three space-tracking radars for deep space, the "Deep Space Advanced Radar Capability (DARC)", with 3 sites to be set up in Australia, in the UK and the U.S. by 2030 - as part of the trilateral security partnership and pact AUKUS. DARC will enhance the three countries' SDA capabilities, providing 24/7 all-weather capabilities to track, identify and characterise objects deep in space. The radar sensors are funded by the U.S. Space Force and are currently developed by Northrop Grumman.[203]

North Korea deployed spy satellite

According to reports from North Korean state media, the country has asserted the successful placement of its inaugural reconnaissance satellite, Malligyong-1, into LEO on November 21st. This launch would signify North Korea's third attempt to deploy its initial spy satellite into orbit on its Chollima-1 launcher. The U.S. and South Korea have criticized the launch, citing concerns that the technology employed supports North Korea's intercontinental ballistic missile program. North Korean sources have indicated plans for more launches involving further surveillance satellites.[204]

Roscosmos planned to recruit soldiers to support Russian armed forces in the War in Ukraine

According to a report in the Financial Times, Roscosmos started in June to recruit and train a militia, the "Uran battalion", to be comprised of employees of Roscosmos and state-owned subsidiaries in the aerospace sector, to support Russia's military forces in the war in Ukraine. Reportedly, the recruits will receive a 100k rouble ($1.200) sign-up bonus and a monthly frontline duty salary of 270k roubles – which, reportedly, far exceeds the wages paid at Roscosmos.[205]

[201] Space Force extends Kratos' contract for satellite ground systems, SpaceNews, November 2023
[202] TAP Accelerator Program launched by Space Systems Command, Spacewatch Global, November 2023
[203] U.S., U.K., Australia sign agreement to jointly operate deep space radar network, SpaceNews, December 2023
[204] North Korea claims it sent a spy satellite to orbit for 1st time: report, Space.com, November 2023
[205] Russia's latest space agency mission: raising a militia for the war in Ukraine, Financial Times, June 2023 ; It appears that Roscosmos really is recruiting soldiers for the Ukraine War, Arstechnica, June 2023

Russia unveils advanced SSA/SDA capabilities for tracking objects in space

In June, Russia stated that it enhanced its defence capability for tracking objects in space (SDA/SSA) which enables Russia to detect foreign spacecraft and determine/understand the spacecraft's purpose/intention more quickly. According to Russia's MoD, the new system has "unique capabilities for automatic search, detection and control of small space objects (as small as 10cm) in near-Earth space". The new system would be able to detect spacecraft post-launch four times faster and determine their purpose twice as fast by 2027.[206]

US and China both launch classified spaceplanes in December 2023

On December 28th, the X-37B Orbital Test Vehicle, operated by the Space Force, embarked on its seventh mission to space, this time aboard a SpaceX Falcon Heavy rocket from the Kennedy Space Center. While specific details about the X-37B are limited, the Space Force has confirmed that the mission aims to explore new orbital patterns, trial space domain awareness technologies, and study the effects of radiation on NASA materials. Additional payloads carried by the X-37B are classified. Notably, each of the spacecraft's missions has seen an increase in its duration in orbit, setting a record of 908 days during its previous return in November 2022. X-37B was launched shortly after China's spaceplane (named Shenlong) was sent to orbit on December 14th on a Long March 2F for a third flight. Shenlong was observed to release six classified objects into orbit, some of which were transmitting signals. The US Space Force had initially scheduled the X-37B's launch for December 7, ahead of Shenlong's deployment, but faced multiple delays.[207]

International cooperation in space for civil security

EO Space sector supported Turkish and Syrian relief efforts with satellite images

Credit: ESA

EO satellites have become of strategic importance in security crises, notably throughout the ongoing war in Ukraine, as well as during natural disasters. The February earthquake that struck southeastern Türkiye and Syria highlighted the value of satellite imagery for disaster management, including search and rescue operations, recovery and damage assessment.

Therefore, Turkish authorities, the UN and the International Federation of the Red Cross & Red Crescent Societies activated the International Charter "Space and Major Disasters". By combining EO data and images from various space agencies, the Charter provides coverage of affected regions, illustrating the extent of the disaster and supporting local rescue teams with search and rescue efforts. Moreover, the charter activated the Copernicus Emergency Mapping Service (CEMS). The result was the delivery of 350 images from 17 space agencies including, ESA, ASI, and DLR.[208]

[206] Russia says it has improved defence capability to track objects in space, Reuters, June 2023
[207] X-37 and Chinese Space Plane Both Launch: 'Two of the Most Watched Objects on Orbit, Air & Space Forces Magazine, January 2024 ; China launches mystery reusable spaceplane for third time, SpaceNews, December 2023
[208] The International Charter Space and Major Disasters ; Satellites support impact assessment after Türkiye–Syria earthquakes, ESA, February 2023 ; DLR supports emergency responders in Türkiye, DLR, February 2023 ; ASI Assists Türkiye and Syria Relief Efforts with Satellite Images, Spacewatch Global, February 2023

EUMETSAT and CSA lead International Charter for Space & Major Disasters

EUMETSAT and the Canadian Space Agency (CSA) assumed joint leadership of the International Charter Space and Major Disasters. This global consortium, comprising 17 member agencies with support from various organisations and satellite data contributors, offers vital satellite data to aid disaster responses worldwide. EUMETSAT and CSA will serve as co-leaders for six months, managing and coordinating the Charter's operations.

The Charter enables authorised disaster management authorities to trigger support from satellite agencies through a centralised system, accessible to any country. In collaboration with Sentinel Asia and the United Nations, the Charter streamlines the process of marshalling resources and expertise for rapid disaster response, sometimes delivering satellite imagery within hours.[209]

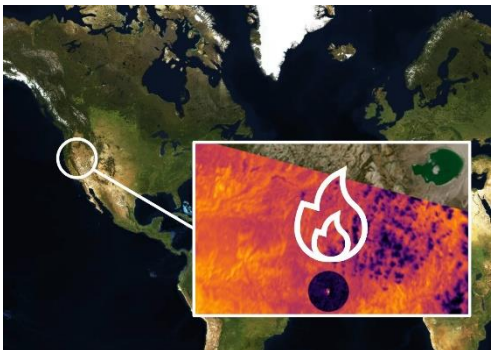
ESA partnered with UEFA to support safety of football fans with space services

In March, ESA partnered with UEFA to support the safety of football fans with space services. The services include EO satellites to monitor crowds in and around football stadiums to assist police forces, and telecommunications satellites to fill gaps due to overloaded terrestrial communications networks. Moreover, the agreement includes supporting the sustainability of football and exploring how space can contribute to promoting football.[210]

Australia collaborated with OroraTech and ICEYE for wildfire management

OroraTech is expanding its partnership with the Forestry Corporation of New South Wales (FCNSW) to enhance wildfire management in Australia. This collaboration improves early fire detection capabilities, providing FCNSW with bushfire detection and precise fire perimeter locations across its vast estate.

In parallel, ICEYE entered a partnership agreement with the Federal Government of Australia, to provide flood and bushfire hazard data. This collaboration enhances disaster assessment and response strategies, improves resource allocation, and strengthens coordination between national and local entities. ICEYE's Flood and Bushfire Insights leverages SAR imagery from its satellite constellation and enables real-time information delivery. Flood Insights offers structure-level flood extent and depth data within 24 hours of flooding peaks, while Bushfire Insights provides rapid property damage assessments during bushfire events.



Credit: Ororatech

[209] EUMETSAT, Canadian Space Agency to lead disaster response initiative, EUMETSAT, October 2023
[210] How space will help football fans to celebrate sport, ESA, May 2023

Space as an Asset

1.5 Space Safety & Sustainability

In 2023, significant advancements in space safety and sustainability were marked by collaborative international efforts and regulatory initiatives.

Key developments included the Council of the EU's Conclusions on 'Fair and sustainable use of space'. ESA launched the Zero Debris Charter process, seeking commitments for deorbiting of satellites post-mission and debris other mitigation measures. Additionally, new regulatory frameworks such as the EU Space Law began development to enhance the safety, resilience, and sustainability of space activities. These European initiatives reflect a global trend towards improving space traffic management and debris mitigation.

1.5.1 Developments in Europe

Council of the EU adopted conclusions on Fair and Sustainable Use of Space

On May 23rd, the Council of the EU adopted Council conclusions on "Fair and sustainable use of space", calling for a European approach to space traffic management (STM). In particular, the conclusions call for measures to monitor and manage space debris and to reduce space debris in the future, proposing to reinforce capabilities through the contribution of the EU Space Surveillance and Tracking (EU SST) jointly with EUSPA, to progress towards an EU approach to STM. Moreover, the conclusions call on EU Member States and the European Commission to continue the implementation of the 21 UN long-term sustainability of outer space activities (LTS) guidelines.[211]

ESA launched the Zero Debris Charter initiative

Credit: ESA

At the 2023 Paris Air Show Le Bourget, ESA launched the Zero Debris Charter initiative, joined by Airbus Defence and Space, OHB SE, and Thales Alenia Space at this early stage. The initiative aims to establish a global community committed to the safety and long-term sustainability of space operations. As part of this effort, ESA is revising its internal space debris mitigation standards, advocating and seeking commitments for a proactive "zero debris" policy across Europe. This aligns with assertions made by ESA Director General Josef Aschbacher at the World Economic Forum in Davos. This policy, expected to be implemented within the next few years, mandates that satellites be deorbited immediately after their missions end to prevent space debris. ESA's Zero Debris approach, building on a decade of standards and technology development, aims to eliminate the generation of debris in Earth and Lunar orbits by 2030. The approach was highlighted during the Space Summit in Seville, marking the beginning of a period for public and private entities to register their intent to sign the Charter. More than 40 organisations have contributed to the development of this Charter, setting space debris mitigation and remediation targets for 2030.[212]

EU opened stakeholder consultation on the EU Space Law

Following the presentation of the initiative for an EU Space Law (EUSL), the European Commission launched a targeted stakeholder consultation which was open until November 2nd on the EU legislative initiative on safety, resilience and sustainability of space activities, the EU Space Law - for which the European Commission hoped to table a legislative proposal beginning of 2024.

[211] The Council calls for a European approach on space traffic management, Council of the EU, May 2023
[212] The Zero Debris Charter, ESA, July 2023

The EU Space Law envisages setting a framework for common EU rules addressing the safety, resilience, and sustainability of space activities/operations.[213]

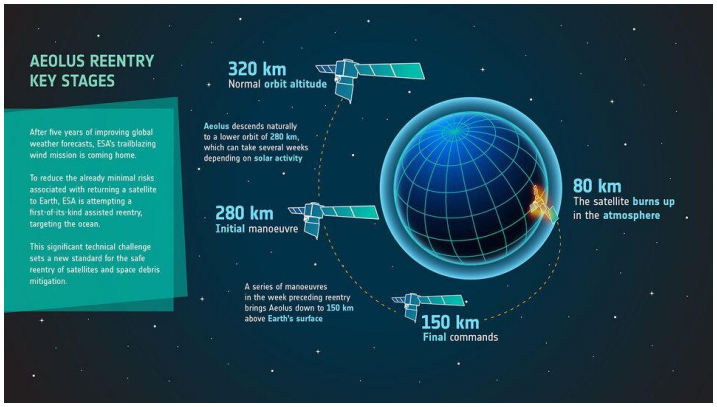
EUSPA started operating the SST Front Desk

On July 1st, the European Union Agency for the Space Programme (EUSPA) began managing the Space Surveillance and Tracking (SST) Front Desk. EUSPA's Executive Director, Rodrigo da Costa, emphasised the role of EUSST in supporting the competitiveness and sustainability of the EU space industry in 2023. The EU SST Partnership provides critical services like collision avoidance and debris analysis to improve the safety of space operations.[214]

King Charles unveiled the Astra Carta seal for Space Sustainability

At the UK's Space Sustainability Reception held at Buckingham Palace, King Charles, accompanied by notable figures including astronauts and scientists, unveiled the "Astra Carta" seal. This marked the launch of the Sustainable Markets Initiative' s Astra Carta framework, a project first announced in 2022. The Astra Carta aims to galvanise the private space sector towards embedding sustainability in its core practices globally. It acknowledges the critical role of space in fostering a sustainable future on Earth and emphasises the space industry's responsibility to consider its environmental impacts. The event followed a Space Sustainability Symposium at the Royal Society, hosted by MP George Freeman, then Minister of State for Science, Innovation, and Technology.[215]

ESA conducted first-of-its-kind "assisted re-entry" of Aeolus spacecraft



Credit: ESA

On July 28th, ESA conducted an assisted re-entry – the first-of-its-kind – for the Aeolus spacecraft, after the completion of its 5-years scientific EO mission. Aeolus is the fifth of ESA's Earth Explorer missions, studying wind patterns, and was launched in 2018, exceeding its mission lifetime by two years. Initially built to burn up in the Earth's atmosphere naturally at the end of its life, Aeolus was directed through an assisted re-entry into the Earth's atmosphere with the remaining propellant. 80% of the Aeolus spacecraft burned up in re-entry.[216]

European space debris removal ClearSpace-1 mission passed programme review

In February, the ClearSpace-1 mission passed the first program review. ClearSpace-1 is an active debris removal (ADR) mission that will use an innovative four-armed capture system to remove large debris objects. The review confirmed the mission's ability to meet the required technology specifications. At the ESA CM22 in November 2022, Member States reconfirmed their support for the ADR mission by providing full funding for its next phase. The next milestone entails the delivery of a detailed spacecraft design, and the procurement of satellite equipment, and manufacturing. The launch is expected to take place no earlier than 2026.[217]

[213] Targeted stakeholder consultation on EU legislative initiative on safety, resilience and sustainability of space activities ("EU Space Law"), European Commission, September 2023
[214] EUSPA Grows Further to Support EU Space Traffic Management, Spacewatch Global, July 2023
[215] The King unveils the Astra Carta seal at a Space Sustainability Reception at Buckingham Palace, Royal UK, June 2023
[216] 'Responsible way to act': Europe's space agency attempts an assisted re-entry for retiring satellite, Euronews, July 2023
[217] Debris Removal Mission Advances to Next Phase, Clearspace Today, February 2023

CNES signed a contract with Astroscale for active debris removal study

Astroscale Holdings Inc. has announced the creation of Astroscale France SAS in Paris and a significant partnership with the French space agency, CNES, to enhance space sustainability through active debris removal. The collaboration, formalised at the Paris Air Show on June 20th, includes a CNES-funded study focusing on the removal of French space debris. This partnership underscores France's commitment to leading in sustainable space practices and leverages Astroscale's expertise.[218]

ESPI committed to Space Sustainability and joined International Debates

The European Space Policy Institute (ESPI) has taken significant steps toward promoting the sustainable use of outer space. Joining the Paris Peace Forum's Net Zero Space Initiative, ESPI is part of a collaborative effort to ensure the sustainable use of space by 2030.[219] Additionally, ESPI has become an Academia Member of the International Telecommunications Union (ITU). Through this membership, ESPI aims to actively contribute to discussions on space and spectrum regulation challenges, bringing together experts from various countries and organisations to enrich the debate on space sustainability and regulatory issues.[220]

1.5.2 Developments Beyond Europe

Developments at the multilateral level

At COPUOS, discussions ventured into the potential for drafting new guidelines on space sustainability and the possibility of developing a new binding treaty based on these guidelines. Following the Guidelines on the Long-Term Sustainability of Outer Space Activities adopted in 2019, a new Working Group, "LTS 2.0," was established. It aims to integrate and evolve the LTS Guidelines into existing and new programmes, addressing emerging challenges in space operations. The focus is on maintaining a balanced, consensus-based approach while identifying areas for possible new guidelines. This approach ensures that discussions on guideline implementation and potential new areas are informed by shared challenges and experiences reported by all space-faring nations.[221]

Developments in the U.S. ISAM Ecosystem

NASA announced the formation of the Consortium for Space Mobility and ISAM Capabilities (COSMIC) to integrate in-space servicing, assembly, and manufacturing (ISAM) within space missions routinely. COSMIC, led by The Aerospace Corporation and scheduled for kick-off in fall 2023, will promote a robust and sustainable space ecosystem through capabilities like spacecraft repair, refuelling, and 3D printing in space. Supported by NASA's Space Technology Mission Directorate (STMD), the consortium seeks to establish the U.S. as a global leader in ISAM, aligning with the ISAM National Strategy and Implementation Plan of 2022.[222]

New Space Actors, New Space Laws

In 2023, both the United Arab Emirates and Azerbaijan took significant steps to enhance space safety and sustainability through revised space laws. The UAE, under the direction of Salem Butti Salem Al Qubaisi, announced an updated National Space Law set for early 2024, focusing on refining regulatory frameworks, improving licensing and inspections, and segregating regulatory articles to boost responsiveness.

[218] Astroscale Contracts Share My Space for Space Risk Identification, Spacewatch Global, June 2023
[219] ESPI joins the Net Zero Space Initiative, ESPI, April 2023
[220] ESPI has become a Member of the ITU, ESPI, April 2023
[221] Report of the Committee on the Peaceful Uses of Outer Space Sixty-sixth session (31 May–9 June 2023), UNGA, June 2023
[222] NASA Creates In-Space Servicing, Assembly, Manufacturing Consortium, NASA, February 2023

Concurrently, Azerbaijan passed the "On Space Activities" law, emphasising the peaceful use of space, safety, and minimising environmental impacts from space debris. These laws reflect a global shift towards ensuring sustainable and safe space operations, highlighting the need for robust national frameworks and international cooperation in the space sector.

Bahrain's Space Science Agency unveiled a system to track small space debris

At the International Space Operations Conference in the UAE, hosted by the Mohammed Bin Rashid Space Centre, Bahrain's National Space Science Agency presented a planned AI-driven nanosatellite system for monitoring small-sized space debris. Aerospace engineer Reem Senan presented this system, which uses nanosatellites equipped with optical sensors and AI algorithms to achieve 92% accuracy in tracking space debris. The conference, a significant event in the Middle East and North Africa, drew over 1,200 participants and featured more than 560 research papers.[223]

New Zealand released an Operational Policy for Active Debris Removal (ADR) policy

New Zealand has launched a new regulatory policy to support safe and transparent active debris removal and on-orbit servicing operations, enhancing orbital safety and sustainability. The policy provides transparent guidance for conducting satellite servicing and debris removal that aligns with UN space treaties and emphasises clear communication about these activities. Additionally, New Zealand partnered with Astroscale to further space safety and sustainability initiatives. Together, a feasibility study on using a single satellite to remove multiple debris objects in one mission was conducted with Astroscale, Rocket Lab, and Te Pūnaha Ātea–Auckland Space Institute.[224]

Office of Space Commerce progressed on civil space traffic coordination system

Richard DalBello, Director of the U.S. Office of Space Commerce, announced progress on the Traffic Coordination System for Space (TraCSS), set to start services in Q4 of 2024. This new system, supported by a mix of commercial and government data, aims to take over civil space safety duties from the Department of Defense, in line with Space Policy Directive 3 in 2018.

DalBello highlighted advancements in staffing and funding, with a $70 million budget for 2023 allowing for strategic investments in commercial services and SSA. The system will benefit from enhanced data contributions from the Space Force and ongoing R&D support from NASA. The project exemplifies a growing collaboration between the government and private sector to enhance space safety.[225]

WEF released Orbital Debris Mitigation Guidelines with Broad Industry Support

The World Economic Forum has introduced new guidelines aimed at reducing orbital debris, backed by several key satellite operators. Released on June 13th, the Space Industry Debris Mitigation Recommendations encourage measures such as limiting satellites' operational life post-mission and enhancing coordination among operators to prevent collisions. The guidelines suggest a 95% to 99% success rate for satellite disposal within five years post-mission, tightening the current 25-year international standard. Despite lacking endorsement from some major players like SpaceX and Amazon, the initiative has gained support from 27 companies, highlighting industry efforts to enhance space sustainability and operational safety.[226]

[223] System to track space debris is showcased, GDN Online, April 2023
[224] Active Debris Removal and On-Orbit Servicing Missions: Operational Policy, New Zealand Space Agency, May 2023v
[225] Office of Space Commerce touts progress on civil space traffic coordination system, SpaceNews, September 2023
[226] Space Industry Debris Mitigation Recommendations, World Economic Forum & ESA, June 2023

1.6 Space for Green & Sustainable Societies

This chapter provides an overview of space activities focused on supporting the green transition and climate objectives in 2023.

Space plays a crucial role in the green transition by providing essential data and technologies that enable more effective environmental monitoring, disaster management, and sustainable resource management. National Earth Observation constellations (i.a. for climate) are outlined in this chapter, while the topic is addressed from the industry/commercial perspective in the **chapter 2 Industry and Innovation**. Using satellite technology, we can track changes in the Earth's climate, monitor greenhouse gas emissions, and assess the health of ecosystems in real time, leading to more informed and timely decision-making.

1.6.1 Multilateral developments

COP28 on Space for Climate Action

The COP28 UN Climate Change Conference took place from November 30th to December 13th in Dubai, UAE. COP28 was the biggest of its kind to date, counting more than 85,000 participants, including more than 150 Heads of State and Government. Space also played a role in COP28 with several agreements signed and announcements made. In addition to the COP28 Space Pavilion, the UAE Space Agency organised the first Summit of Heads of Space Agencies to enhance cooperation to accelerate space-based climate initiatives. The summit included senior officials such as Senator Bill Nelson, NASA Administrator; Teodoro Valente, ASI President; Hiroshi Yamakawa, JAXA President; Dr. Sang-Ryool Lee, KARI President; Salem Butti Al Qubaisi, UAE Space Agency Director-General; Dr. Mohammed Al Aseeri, NSSA Bahrain CEO; Josef Aschbacher, ESA Director General; and Dr. Mohammed Al Tamimi, Saudi Space Agency CEO. Representatives from other space agencies and institutions also attended. Space-related highlights from COP28 include:

ESA and UNEP signed an MoU for the use of space for green

During the Earth Information Day at COP28, ESA and the United Nations Environment Programme (UNEP) signed a MoU that commits to increasing the use of space technology and data for environmental conservation, nature and biodiversity protection and restoration.[227] At COP28 in Dubai, ESA hosted several events at their booth, including sessions on cross-checking national greenhouse gas inventories from space and transitioning from climate science to climate services. These events aimed to increase the use of global satellite-based Earth observation data for decision-making, supporting the UNFCCC and the Paris Agreement. Key discussions included the role of regional climate reports, the use of satellite observations to improve national GHG inventories, and the value of Earth observations in supporting the Paris Agreement's goals.

ESA awarded Airbus contract for the next phase of the TRUTHS satellite mission

ESA awarded a contract to Airbus to start the next development phase of the TRUTHS satellites mission, which aims to provide solar radiation and radiation reflected from Earth back into space to enrich climate models. The next development phase particularly aims at analysing the instruments' performance and creating simulations and system modelling.[228]

[227] ESA and UNEP collaborate for a greener future, ESA, December 2023
[228] TRUTHS contract signature at COP28, ESA, December 2023

Space Climate Observatory (SCO) Charter signed by two new members

The Saudi Space Agency (SSA) and Expertise France, a subsidiary of French Development Agency (AFD), signed the SCO Charter. With the two new signatories, the SCO grew to 47 members spread across 25 countries.[229]

NASA showcased Earth Science Data

NASA presented Earth Science Data from the international Surface Water and Ocean Topography (SWOT) satellite and other EO satellites at COP28, to showcase how satellite data can be used to accelerate climate action globally.[230] .

1.6.2 Developments in Europe

ESA and European Commission sign agreement for EO cooperation for climate

Under the umbrella of the "Space for a Green Future" Accelerator, during the Space Summit in November, ESA and the European Commission (DG CLIMA) signed an agreement for cooperation to use EO data to address climate change. ESA and the EC aim to enhance knowledge and provide data for climate adaptation and mitigation policies supporting the European Green Deal and the EU's climate goals. The focus of the cooperation is on GHG emissions monitoring, deforestation, methane leak detection, and renewable energy site location identification.[231]

ESA and European Commission signed agreement for Copernicus Data Centre in the Philippines

In January, the European Commission signed a contribution agreement with ESA to develop a national Copernicus data centre in the Philippines using €10 million of funding from the EU bilateral cooperation budget. The EU will support the uptake of Copernicus to support the Philippines with data on natural disasters and climate adaptation.[232]

2023 Global Space Conference on Climate Change (GLOC 2023) took place in Oslo

Credit: GLOC 2023

From May 23rd until May 25th, the 2023 Global Space Conference on Climate Change (GLOC 2023) with the theme „Fire and Ice – Space for Climate Action", jointly organised by the International Astronautical Federation (IAF) and the Norwegian Space Agency (NOSA), took place in Oslo. GLOC 2023 aimed to contribute to the global efforts to understand and fight climate change through the use of space-based services and applications and to encourage the exchange and sharing of programmatic, technical and policy information.

Key takeaways include (1) the need to make data more accessible, (2) improving the usability of data, and (3) the need for the industry to shape up a more convincing communication strategy.[233]

[229] A look back at SCO at COP28, SCO, December 2023
[230] NASA to Showcase Earth Science Data at COP28, NASA, November 2023
[231] ESA and EC to unite on climate action from space, ESA, November 2023
[232] Global Gateway: European Space Agency and the Commission join forces on earth observation for the Philippines, European Commission, January 2023
[233] The global space conference on climate change 2023 - Fire and Ice – Space for Climate Action, IAF, May 2023

ESPI presented the paper "Using Effective Science Communication to Increase the uptake of EO Data in Climate Policymaking" at GLOC 2023.[234]

ESA's Earth Explorer missions extended to 2025 while Biomass passed crucial tests

In March, ESA's second, third and fourth Earth Explorer missions "Soil Moisture and Ocean Salinity" (SMOS) mission, the Ice Mission CryoSat and the Swarm mission were extended to at least the end of 2025. The data of the missions are used in weather forecasting and climate reporting.[235]

Also in March, ESA's Earth Explorer Biomass satellite successfully passed testing to check the ability to liftoff and deploy its solar array. The Biomass mission aims to deliver new information on forests and their carbon storage. As a next step, tests to prove the satellite's resilience to the space environment will be conducted. The Biomass satellite is planned to be launched in 2024.[236]

ESA announced that HydroGNSS mission will be comprised of two identical satellites

Also in March, ESA announced that the HydroGNSS mission will have two satellites in order to reduce revisit time. HydroGNSS is one of the new Scout missions being developed within ESA's FutureEO programme, and it produces data on soil moisture and other essential climate variables. Complementing ESA's larger Earth Explorer research missions, Scouts are developed to demonstrate value to Earth science and practical applications, while having the potential to be scaled up to bigger satellite missions. [237]

New Copernicus satellite data service kicked off and became operational

In January, the new Copernicus satellite data service was kicked off. In December 2022, ESA and a consortium led by T-Systems International, which is composed of CloudFerro, Sinergise, VITO, ACRI-ST, DLR and RHEA signed a €150 million contract for a new Copernicus data access service which has a period of 6 years and can be extended up to 10 years. The new service aims at improving the exploitation of the satellite data and entered in full operation in July. The data will be made immediately available through industry-led standard interfaces.[238]

EUSPA selected OHB Digital Services to lead EUSPA-funded Copernicus demonstrators project

EUSPA selected OHB Digital Services, a subsidiary of OHB SE, to lead the "Copernicus Demonstrators - Mobility, Emergency, and Infrastructures" project, with a €1.7 million budget from EUSPA. The initiative aims to harness data from the Copernicus satellite constellation efficiently. The project will demonstrate innovative proof of concepts in areas such as measuring aircraft emissions, emergency preparedness, optimising shipping routes, smart mobility, and monitoring infrastructure. It will be executed in two phases, focusing on technical feasibility and implementation. The collaboration includes partners like Euroconsult (France), TechHub (Germany), LuxSpace (Luxemburg), Waterjade (Italy), and S[&]T (The Netherlands).[239]

[234] Global Space Conference on Climate Change 2023, ESPI, May 2023
[235] ESA's excellent Earth Explorer missions extended to 2025, ESA, March 2023
[236] ESA's Biomass satellite robust for launch, Spacewatch Global, March 2023
[237] HydroGNSS twice as good, ESA, March 2023
[238] New Copernicus Data Access Service to Support the Ecosystem for Earth Observation, December 2022
[239] Smart use of satellite data: OHB DIGITAL wins the "Copernicus Demonstrators - Mobility, Emergency and Infrastructures" project funded by EUSPA with EUR 1.7 million, OHB, October 2023

ESA signed an agreement with Spain for the Atlantic EO satellite constellation in cooperation with Portugal - also UK joined the partnership

In September, ESA and Spain signed an agreement for Spain's national €80 million Atlantic Constellation ("Constelación Atlántica"). The constellation which will be comprised of 16 EO small satellites (8 developed in Spain and 8 developed in Portugal, both each contributing €40 million will focus on monitoring the effects of climate change, The constellation will complement Copernicus and will - once operational - provide observations every 3 hours. In November, the UK announced the joining of the Atlantic Constellation.

In addition to Spain's and Portugal's each €40 million contributions, the UK committed more than £3M contribution for the constellation (with additional co-funding by Open Cosmos) to contribute a pathfinder satellite (built by Open Cosmos), which will be launched with the same orbital plane as the three satellites from Portugal and will have the same design. These four satellites will constitute the first batch of the constellation.[240]

ESA signed contract with Thales Alenia Space for Italy's EO constellation IRIDE

In March, ESA awarded a €112 million contract to Thales Alenia Space to build a constellation of six SAR satellites called IRIDE, with an option to build four additional satellites for €75 million, and another €30 million contract for an optical satellite. IRIDE is a national project funded by Italy's National Recovery and Resilience Plan and managed by ESA and ASI. It will provide environmental data to Italian governmental agencies on fires and coastal areas as well as weather data.[241]

ESA signed a contract with Poland for EO constellation Camila

ESA signed a contract with the Polish Space Agency (POLSA) for the Polish EO constellation called Camila. ESA will have a supervisory role and Polish companies will implement the project. The constellation is expected to support the agricultural, land management, and emergency response domains. 4 satellites will be developed, including three optoelectronics satellites and one radar satellite, which are expected to be launched in 2027.[242]

ASI and NASA agreed to partner on Air Pollution Mission "MAIA"

In January, ASI and NASA announced a partnership to build and launch the Multi-Angle Imager for Aerosols (MAIA) mission, an effort to investigate the health impacts of tiny airborne particles. Set to launch before the end of 2024, the MAIA observatory will consist of a satellite known as PLATiNO-2 provided by ASI and a science instrument built at NASA JPL. The mission will collect and analyse data from the satellite, sensors on the ground, and atmospheric models.[243]

UK Space Agency allocates £4 million to space R&D projects including for NASA's SWOT mission

In November, the UK Space Agency announced £4 million in government funding for several space R&D projects, including the allocation of £206.000 to the University of Bristol to use NASA' s UK-backed Surface Water and Ocean Topography (SWOT) mission to advance global flood modelling accuracy.[244]

[240] The UK to Contribute More Than £3M to the Atlantic Constellation, European Spaceflight, November 2023
[241] Thales to Build 6 Satellites for Italy's IRIDE Constellation, ViaSatellite, March 2023
[242] 2023: POLSA's year in space, POLSA, January 2023
[243] NASA and Italian Space Agency Join Forces on Air Pollution Mission, NASA, March 2023
[244] New UK funding for space technology projects, Gov UK, November 2023

1.6.3 Development beyond Europe

UAE Space Agency announced phase 2 of its SAS Programme to address climate change

During the UAE Climate Tech Event which took place from May 10th to 11th in Abu Dhabi, the UAE Space Agency announced phase 2 of its Space Analytics and Solutions (SAS) Programme to combat climate change. The second phase of the programme will include 3 new challenges that will offer entrepreneurs and researchers support to develop space applications to address climate change: (1) the Air Quality challenge to monitor and control air pollution, (2) the Infrastructure challenge to foster infrastructure monitoring, maintenance, and operations solutions, and (3) the Losses and Damages challenge to use satellite data to investigate the losses and damages caused by climate change.[245]

Azercosmos joined the UN Global Compact initiative

United Nations Global Compact

Credit: UN

Azerbaijan's space agency Azercosmos joined the UN Global Compact initiative. This shows the willingness of Azercosmos to implement sustainable development in the country's space activities and experience sharing. As a UN Global Compact participant, Azercosmos will align its activities with Azerbaijan's sustainable development priorities and the 2021-2025 "Cooperation Framework for Sustainable Development," leveraging the Compact's expertise on the 17 sustainable development goals.. Azercosmos and the UN also plan to discuss the Azercosmos Report on the Assessment of the Impacts of Global Climate Change.[246]

NASA released its Climate Strategy

NASA published the Advancing NASA's Climate Strategy document which declares NASA's "continued commitment to lead on climate and assesses NASA's climate portfolio, including science and exploration efforts, and beyond NASA mission directorates and facilities. The strategy outlines 4 key priorities: (1) Innovate, (2) Inform; (3) Inspire; (4) Partner.

Credit: NASA

In 2023, new missions were put to observe air pollution (TEMPO), the Earth's water to improve climate models (SWOT), and storm intensity (TROPICS).[247] Moreover, NASA started a new air pollution monitoring initiative through a joint project with the agency and the Center for Disease Control and Prevention and the National Institutes of Health.[248]

NASA select ICEYE for Earth science mission

NASA awarded ICEYE US Inc. the company's first Task Order under a Blanket Purchase Agreement (BPA). The agreement funded by NASA's Earth Science Division of the Science Mission Directorate, opens access to NASA to acquire ICEYE's SAR data to evaluate it in NASA's Earth Science Research, Analysis, and Applications portfolios - which will help NASA to advance its Earth Science research objectives. ICEYE sensors provide research information for geology, topography, and climate change.[249]

[245] UAE Space Agency showcases contributions to sustainability at the UAE Climate Tech, Zawya, March 2023
[246] Azercosmos joins UN Global Compact initiative, Azer News November 2023
[247] NASA Releases Agency Climate Strategy, NASA, March 2023
[248] NASA Is Now Tracking Air Pollution From Space, Jalopnik, April 2023

Thales Alenia Space to provide Thailand with SAR solutions

Thales Alenia Space will provide Thailand with SAR solutions, partnering with App Works to enable the detection of distress signals from COSPAR-SARSAT beacons, mainly using the Galileo satellite positioning system. The system will be enhanced by Thales's innovative Medium Earth Orbit Local User Terminal (MEOLUT) Next product.[250]

Canada allocates $1 billion for Earth Observation

The Canadian government allocated $1 billion to the Canadian Space Agency to support the RADARSAT+ initiative ensuring the continuity of satellite Earth observation data provision to relevant federal authorities and organisations. In particular, the funding will be used to design and develop a replacement satellite for the RADARSAT Constellation Mission (RCM) launched in 2019, and to design a next-generation satellite system to succeed the RCM.[251]

China started construction of the Very Low Earth Orbit (VLEO) EO satellite constellation

According to the China Aerospace Science and Industry Corporation, China started the construction of the Very Low Earth Orbit (VLEO) EO satellite constellation, which will consist of 300 satellites. Reportedly, the lower orbital altitude enables "near observation" instead of "remote sensing", which lowers cost, provides higher resolution, and shorter transmission delays with a planned global fast response capability within 15 minutes.[252]

Russia opened Sfera project for international cooperation

According to Roscosmos, in July, Russia is seeking communications partners to join the Sfera project. Sfera aims to create a satellite constellation system for EO, planned to consist of 5 communication satellites and 5 EO satellites. The programme's first satellite Skif-D was already launched in October 2022.[253]

ISRO and MRIC sign MoU to construct Mauritius' EO Satellite

ISRO and the Mauritius Research and Innovation Council (MRIC) signed a MoU for ISRO to design, build, launch, and operate the first EO satellite for Mauritius. The agreement laid out a 15-month partnership for the respective roles of each nation. The satellite will be operated by both ISRO and MRIC at the MRIC's ground station. MRIC engineers will be trained by ISRO to develop the satellite's platform, systems and primary payload. Both agencies will also collaborate towards registering the satellite with UNOOSA's space objects registry and its frequencies with the ITU.[254]

ICAO adopted international standards for the use of Galileo for aircraft

The Council of the International Civil Aviation Organisation (ICAO) adopted international standards for Galileo and future satellite-based augmentation systems, which enables Galileo to provide advanced navigation capabilities for aviation to further enhance the services' availability, resilience and reliability as well as to decrease the risk of signal loss or the risk of interference. In addition, the evolution to EGNOS v3 augmenting Galileo will further enhance vertical guidance to enable a precision approach and landing capabilities for aircraft in Europe. These international standards were defined jointly by the European Commission DG DEFIS and DG-MOVE, EUSPA, EASA and ESA.[255]

[250] Thales Alenia to Provide Thailand with Search and Rescue Solution, Spacewatch Global, January 2023
[251] RADARSAT+: over $1 billion for the future of satellite Earth observation, Government of Canada, October 2023
[252] China Begins Construction of VLEO Satellite Constellation, Spacewatch Global, July 2023
[253] Russia's Sfera project open for international cooperation — Roscosmos chief, TASS, July 2023
[254] ISRO Signs MoU with MRIC to Construct Mauritius's EO Satellite, Space in Africa, November 2023
[255] New achievement for Galileo and civil aviation, EUSPA, March 2023

France and Mongolia sign partnership agreement to provide internet in Mongolia's rural areas

In October, France and Mongolia signed a partnership agreement to construct a Mongolian national satellite telecommunications system in order to provide rural areas with connectivity/internet. The partnership agreement between Thales Alenia Space, a major European satellite specialist, and the Mongolia Ministry of Digital Development and Communications was signed in the presence of the President of Mongolia, H.E. Mr Ukhnaagiin Khürelsükh and the President of France, Mr Emmanuel Macron, during the Mongolian President's state visit to France.[256]

A number of other missions and partnerships dedicated to the Green Transition in 2023

- In January, NASA announced that the Surface Water and Ocean Topography (SWOT) satellite started commissioning activities, entailing the activation of scientific instruments before the official start of the mission. In late January, the Ka-band Radar Interferometer (KaRIn) was activated but later shut down. It was restored to operational conditions in March and started to provide data on water surfaces.[257]
- Also in March, NASA's Global Ecosystem Dynamics Investigation (GEDI) mission, with an instrument on board the ISS, was put in hibernation for 13 to 18 months, four years after its launch. GEDI will restart operations in the period 2024 to 2030. The instrument is used to measure forests in 3D, including forest canopy height and the distribution of branches and leaves.[258]
- In April, NASA successfully launched its Tropospheric Emissions Monitoring of Pollution (TEMPO) instrument attached to a commercial communications GEO satellite launched by Intelsat. The instrument will provide data with a four-square-mile resolution on air pollution in North America such as rush-hour traffic to pollution from forest fires and volcanoes.[259]
- In April, Dubai's Electricity and Water Authority successfully launched its second EO nanosatellite Dewa Sat-2. The satellite, jointly built by the Emirati company DEWA and the Lithuanian company NanoAvionics, is equipped with a high-resolution camera and infrared equipment to monitor GHG emissions. The primary aim of Dewa Sat 2 is to provide data to improve the operations, maintenance and planning of electricity and water systems.[260]
- China and Brazil signed an agreement to develop and launch the Cbers-6 satellites, planned for launch in 2028. Cbers-6 satellites are expected to be equipped with radar instruments to monitor the Amazon and more broadly Brazilian and Chinese territories to support natural resource monitoring.[261]
- In November, China launched the Haiyang 3 ocean observation SAR satellite. The satellite provides data on water colour, water temperature, and sea ice.[262]
- In December, China successfully launched Egypt's MisrSat2 remote sensing satellite from the Jiuquan Satellite Launch Center. The satellite was developed as part of a technology transfer project between Egypt and China. MisrSat2 will provide data for land and resource management, water protection, agricultural productivity, and coastal change monitoring.[263]

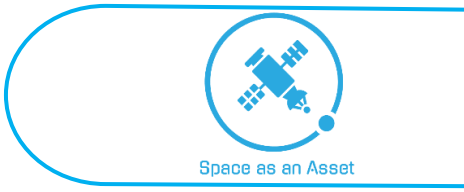
[256] New satellite agreement to strengthen strategic partnership between France and Mongolia, Thales Alenia Space, October 2023
[257] Engineers Check SWOT Science Instrument During Commissioning Activities, NASA, February 2023
[258] Global Ecosystem Dynamics Investigation (GEDI), Earth Data NASA, 2023
[259] NASA's High-Resolution Air Quality Control Instrument Launches, NASA, April 2023
[260] DEWA successfully gets its second nanosatellite in space, Arabian Business, April 2023
[261] Cbers-6: Novo satélite de parceria entre Brasil e China deve custar mais de 100 milhões de dólares e entrar em órbita em 2028, G1, April 2023
[262] China launches new-gen Haiyang ocean monitoring satellite, SpaceNews, November 2023
[263] China's expertise elevates Egypt's space ambitions with MisrSat 2 launch, SpaceDaily, December 2023

Development and launch of first sovereign EO satellites by new spacefaring nations

2023 saw several spacefaring nations launching their first satellites, including:

Country	Month	Satellite
Kuwait	January	Kuwait Sat-1
Kenya	April	Taifa-1
Oman	November	Aman-1
Djibouti	November	Djibouti 1A

1.7 Space Governance, Policy & Law



1.7.1 New space policies, laws, and strategies

In 2023, several countries went through major updates concerning national policies, organisational frameworks or laws related to space activities. 2023 saw the launch of many general national space strategies and domain-specific space strategies: ranging from space security and defence strategies to strategies related to exploration or sustainability – those strategies are covered in the dedicated chapters.

Developments in Europe

Germany releases new national space strategy

On September 27th, the German Federal Cabinet approved the Federal Government's new national space strategy. The new space strategy, replacing the national space strategy from 2010, takes into account the increasing importance of space for our society and focuses on current and future challenges. The particular focus is on advancing private sector initiatives in space (New Space), the use of space applications to combat climate change and responsible and sustainable action in connection with space.

The strategy identifies 9 areas of action for the federal government:

- European and international cooperation
- Space as a growth market - high-tech and New Space
- Climate change, resources and environmental protection
- Digitalisation, data and downstream
- Security, strategic ability to act and global stability
- Sustainable use of space
- Space exploration and science
- International space exploration
- Space in dialogue and attracting talent

The implementation of goals and measures as well as short and medium-term key projects should begin after this cabinet decision. Concrete measures include the creation of Space Innovation Hubs and the establishment of a national space law.[264]

Slovenia's Government adopted first National Space Strategy

In November, Slovenia's government adopted Slovenia's first National Space Strategy "2030 Slovenia - Small on Earth, Big in Space", alongside the decision to apply for full membership of ESA – Slovenia is currently an Associate Member of ESA, and the current Association Agreement expires at the end of 2024. The strategy outlines activities to increase the competitiveness of the Slovenian space industry and establish leadership in selected areas. Based on the development objectives announced in the Slovenian Development Strategy 2030, the space strategy underlines space for sustainability and development goals. The strategy outlines long-term objectives under strategic pillars (three pillars

[264] The German Federal Government's Space Strategy, German Federal Ministry for Economic Affairs and Climate Action, September 2023

for the programme areas and two pillars for the foundation of the sector's development) based on optional ESA programmes:

- Develop space technologies and R&D, incl. exploiting new capabilities in satcom;
- Strengthen participation in responsible international space exploration and research, and further develop technologies for human and robotic exploration;
- Foster the development and uptake of space applications through strengthening the commercial sector, leveraging next-generation innovative technologies;
- Promote STEM education among future generations;
- Stimulate entrepreneurship and university spinoffs through dedicated innovation programmes.[265]

The Swiss Federal Council adopted its 2023 Space Policy

In April, the Swiss Federal Council adopted the Swiss Space Policy 2023 - an updated version of a policy last revised in 2008. The published Space Policy document provides a general framework for Switzerland's commitment to space, considering various strategic documents, and will benefit Swiss society, science, and businesses.

The policy aims to boost innovation competitiveness. Its prioritised topics and applications are environmental monitoring, meteorology, PNT, communications, and space science and exploration. The policy defines the Federal Council's role and responsibilities in the space sector. Various federal departments will submit a progress report on the policy implementation by the end of June 2027 to the Federal Council.

The policy outlines 3 strategic priorities and subordinated for each priority 2 areas of activity:

- Access and Resiliency (Securing access; Strengthening security; Promoting sustainability)
- Competitiveness and Relevance (Promoting excellence in science; Strengthening competitiveness; Intensifying cooperation)
- Partnerships and Reliability (Strengthening international law and global governance; Contributing to shaping European space governance; Developing the national ecosystem).[266]

UK unveiled Space Strategy in Action

In July, the UK released the National Space Strategy in Action (based on the UK National Space Strategy published in 2021) which outlines further direction on the UK's priorities and strategic goals for civil space capabilities. The policy document describes concrete policy steps required to realise ambitions set out in the National Space Strategy in the short term over the next 18 months, moving from the "ignition phase" into the "thrust phase". In particular, it sets out the next steps in implementing the National Space Strategy across each of its 4 pillars: (1) unlocking growth, (2) collaborating internationally, (3) growing as a science superpower, and (4) developing resilient capabilities.

The National Space Strategy in Action policy paper sets out a 10 10-point plan:

- Capture the European market in commercial small satellite launch
- Fight climate change with space technology
- Unleash innovation across the space sector
- Expand our horizons with space science and exploration
- Develop our world-class space clusters

[265] Slovenian Space Strategy 2030, Government of the Republic of Slovenia, November 2023.
[266] Swiss Space Policy 2023, Swiss Federal Council,

- Lead the global effort to make space more sustainable
- Improve public services with space technology
- Deliver the UK Defence Space Portfolio
- Upskill and inspire our future space workforce
- Use space to modernise and transform our transport system.[267]

EU opened stakeholder consultation on EU Space Law

In September. the European Commission launched a targeted stakeholder consultation open until November on the EU legislative initiative on safety, resilience and sustainability of space activities, the EU Space Law - for which the European Commission planned to adopt a legislative proposal start of 2024. The EU Space Law envisages setting a framework for common EU rules addressing the safety, resilience, and sustainability of space activities/operations.[268]

Developments beyond Europe

Beyond Europe, there were developments in terms of new plans, strategies, roadmaps or other policy documents related to space, especially in the U.S., Japan, New Zealand, India and Azerbaijan.

New Zealand released Aotearoa Aerospace Strategy and National Space Policy

On May 31st, New Zealand released a space policy, which provides an overview of New Zealand's values and goals to guide future policies and regulation related to space, outlining the increasing space-related geopolitical risks and the importance and need to cooperate with allies and partners to secure New Zealand' s national security. The policy outlines 4 key values for New Zealand in space: (1) Stewardship; (2) Innovation; (3) Responsibility; and (4) Partnership. The space policy sets 5 objectives:

- Growing an innovative and inclusive space sector
- Protecting and advancing national security and economic interests
- Regulating to ensure space safety and security of activities
- Promoting the responsible use of space at the international level
- Modelling sustainable space and Earth environments.[269]

In July, New Zealand launched the Aotearoa New Zealand Aerospace Strategy which manifests the country's objective to establish a distinct New Zealand approach to aerospace, combining both aviation and space, and comprises 3 pillars to underpin its aerospace sector's success: (1) Unlocking aerospace potential; (2) Future-facing Government; (3) Aerospace nation. The 3 pillars aim to enable the country to achieve 5 goals for the domestic aerospace sector until 2030, of which 3 are related to space:

- Be at the forefront of sustainable space activities
- Actively support exploration in space
- Enhance decision-making using space-enabled data

The required work to achieve these goals is outlined in stages in an action plan. Moreover, the government allocated up to $12 million in funding to support the implementation of the strategy - in addition to the $15.7 million funding already announced in 2022.[270] Moreover, New Zealand

[267] National Space Strategy in Action, Gov.UK, July 2023
[268] Targeted stakeholder consultation on EU legislative initiative on safety, resilience and sustainability of space activities ('EU Space Law'), European Commission, September 2023
[269] National Space Policy, New Zealand Space Agency and Ministry of Business, Innovation and Employment, May 2023
[270] Aotearoa New Zealand Aerospace Strategy 2023-2030, Ministry of Business, Innovation and Employment, July 2023

published an Operational Policy for ADR and On-Orbit Servicing[271], which is described in detail in the **subchapter 1.5 Space Safety & Sustainability.**

U.S. Department of State released the first-ever Strategic Framework for Space Diplomacy

The U.S. Department of State released its first-ever Strategic Framework for Space Diplomacy. Through this Framework, the U.S. plans to expand international cooperation in space activities, including through the Artemis Accords, promote commitments against destructive anti-satellite missile tests, such as the U.S.-led self-imposed ASAT moratorium, and foster a conducive environment for responsible behaviour in outer space. Moreover, the new framework aims to strengthen the understanding and support for U.S. national space policies to promote the international use of U.S. space capabilities.

The framework document outlines 3 objectives:

- Diplomacy for Space - Advancing space policy for the benefit of future generations:
  advancing U.S. space policy and programs at the international level through bilateral and multilateral cooperation in order to advance U.S. leadership in safe and responsible space activities, while strengthening U.S. and allied capabilities and reducing the potential for conflict.
- Space for Diplomacy – Leveraging space activities for wider diplomatic goals:
  Pursuing increased international cooperation in the use of satellite applications to support solving societal challenges and achieve objectives of U.S. foreign policy.
- Empowering the Department Workforce on Space Diplomacy:
  Providing diplomatic posts and the DoS workforce with the modernised skill set of tools needed to pursue space policy and programmatic goals through bilateral and multilateral fora.[272]

U.S. released National Spectrum Strategy

The Biden administration released a National Spectrum Strategy, aimed at ensuring that federal operators and private companies can have adequate access to spectrum. The strategy adapts U.S. policy to address new demands raised by innovations such as 5G networks, precision farming, UAVs etc. Alongside the strategy's publication, President Biden released a presidential memorandum on spectrum, establishing an Interagency Spectrum Advisory Council to advise the National Telecommunications and Information Administration on spectrum issues.

The strategy is divided into 4 pillars:

- Ensuring U.S. leadership in spectrum management and utilisation (incl. studying 2,786 MHz of spectrum that could potentially be repurposed)
- Developing a transparent plan for spectrum allocation with input from a wide variety of stakeholders and routinely updating the national spectrum strategy
- Boosting spectrum R&D (incl. creating "sandboxes" specifically intended for spectrum research), developing a national spectrum R&D plan, and encouraging private research on spectrum
- Growing and supporting a spectrum workforce, incl. drafting a National Spectrum Workforce plan and educating policymakers about the importance of recruiting talent.[273]

[271] Active Debris Removal and On-Orbit Servicing Missions: Operational Policy, New Zealand Space Agency, May 2023v
[272] A Strategic Framework for Space Diplomacy, U.S. Department of State, May 2023
[273] National Spectrum Strategy, White House, November 2023 ; White House Releases Spectrum Strategy, Payload Space, November 2023

India approved 2023 space policy

In April, the Indian Cabinet Committee on Security and the Central Government of India approved the Indian Space Policy 2023, which aims to provide a framework for India's space sector, and boost research, academia, start-ups, and industry. About India's space governance, the policy aims to enhance the role of the Department of Space, boost ISRO's activities and delineate the roles and responsibilities of (1) the Indian Space Research Organisation (ISRO), (2) the public sector undertaking/commercial arm of the Department of Space NewSpace India Limited (NSIL), and (3) the public-private mediator the Indian National Space Promotion and Authorization Center (IN-SPACe). The policy aims to further open up the Indian space sector to private players by facilitating private investment in the Indian space sector.[274]

Azerbaijan approved National Law on Space Activities

On August 4th, Azerbaijan's President Ilham Aliyev adopted the Law on Space Activities to further develop its national space legislature. The Law on Space Activities regulates the national legal, economic and organisational bases of space activity. It will provide the legal basis for maintaining the registry of space objects at the national and international levels as well as for the certification of space systems, for radio spectrum management and for ensuring environmental protection and space safety.[275]

Japan adopted a space security policy

Based on the National Security Strategy updated in December 2022, in June, Japan adopted its first space security policy, which aims to enable Japan to enhance the utilisation of space for defence over the next decade, in order to be prepared and in response to China's and Russia's increasing use of space for military purposes. Japan's Prime Minister Fumio Kishida stated: "for the sake of national security, we will dramatically scale up the use of space systems and ensure the safe and stable utilisation of the domain". In particular, the policy:

- Outlines a roadmap to strengthen information-gathering systems with the aim to increase counterstrike effectiveness/capabilities, i.a. through the acceleration of information transmission by combining multiple small satellites and through improving their visual data interpretation technologies by using AI.
- Commits to advance Japan's national defence projects, using private-sector space technologies, as part of Japan's attempt to accelerate the integration of its defence and civilian sectors. To achieve this, Japan aims to increase the internal cooperation between the Defence Ministry and JAXA.
- Envisages increased international cooperation for the protection of satellites with the U.S. and other allies.[276]

[274] Indian Space Policy – 2023, ISRO Gov, April 2023
[275] Azerbaijan Adopts Primary Space Legislation, Spacewatch Global, August 2023
[276] Japan adopts space security policy and vows to expand defense use, the Japan Times, June 2023

Overview of Space Strategies, Policies and Laws from 2023

Name	Type	Country	Month	Domain
Space Security Policy of Japan[277]	Policy	Japan	June	Security & Defence
Operational Policy for ADR and On-Orbit Servicing	Strategy	New Zealand	May	Space as an Asset
Spaceport Project Opportunities for Resilient Transportation (SPACEPORT) Act[278]	Law	U.S.	June	Space as an Asset
National Low Earth Orbit (LEO) Research and Development Strategy[279]	Strategy	U.S.	March	Exploration & Science
NASA'S Moon to Mars Strategy and Objectives Development[280]	Strategy	U.S.	April	Exploration & Science
Draft strategy for long-term robotic exploration of Mars "Exploring Mars Together"[281]	Strategy	U.S.	March	Exploration & Science
Planetary Defense Strategy[282]	U.S.	Strategy	April	Security & Defence

[277] Japan adopts space security policy and vows to expand defense use, the Japan Times, June 2023
[278] Spaceport Project Opportunities for Resilient Transportation (SPACEPORT) Act, Senate of the U.S., June 2023
[279] National Low Earth Orbit Research and Development Strategy, White House Office of Science and Technology Policy, March 2023
[280] NASA's Moon-to-Mars Exploration Strategy and Objectives Development, NASA, April 2023
[281] NASA releases draft strategy for long-term robotic Mars exploration, Space News, March 2023
[282] National Preparedness Strategy and Action Plan for Near-Earth Object Hazards and Planetary Defense 2023, NSTC, April 2023

NASA's Climate Strategy	U.S.,	Strategy	March	Green & Sustainable Societies
Azerbaijan's National Law on Space Activities[283]	Azerbaijan	Law	August	Space as an Asset
India's 2023 Space Policy[284]	India	Policy	April	Space as an Asset
National Spectrum Strategy[285]	U.S.	Strategy	November	Space as an Asset
The German Federal Government's Space Strategy[286]	Germany	Strategy	September	Space as an Asset
Slovenia's National Space Strategy[287]	Slovenia	Strategy	November	Space as an Asset
UK National Space Strategy in Action[288]	UK	Strategy	July	Space as an Asset
Swiss Space Policy 2023[289]	Switzerland	Policy	April	Space as an Asset

[283] Azerbaijan Adopts Primary Space Legislation, Spacewatch Global, August 2023
[284] Indian Space Policy – 2023, ISRO Gov, April 2023
[285] National Spectrum Strategy, White House, November 2023 ; White House Releases Spectrum Strategy, Payload Space, November 2023
[286] The German Federal Government's Space Strategy, German Federal Ministry for Economic Affairs and Climate Action, September 2023
[287] Slovenian Space Strategy 2030, Government of the Republic of Slovenia, November 2023.
[288] National Space Strategy in Action, Gov.UK, July 2023
[289] Swiss Space Policy 2023, Swiss Federal Council,

Aotearoa Aerospace Strategy[290]	New Zealand	Strategy	July	Space as an Asset
New Zealand's National Space Policy	New Zealand	Policy	May	Space as an Asset
Strategic Framework for Space Diplomacy[291]	U.S.	Strategy	May	Space as an Asset

Table 2: Space Strategies, Policies and Laws

1.7.2 Governance changes, new appointments and budget allocations

Developments in Europe

Spain's National Space Agency was formally established

On March 7th, Spain's Council of Ministers approved Royal Decree 158/2023, in turn approving the statute of the Spanish Space Agency (Agencia Espacial Español - EEA). The EEA is a public agency located in Seville under the supervision of the Spanish Ministry of Science and Innovation and the Ministry of Defence. Miguel Belló Mora was the provisional Head of the Agency.

The EEA has a €700 million budget in 2023, and 40 staff, to be increased to 75. The EEA's objective is to coordinate and centralise Spain's space policy and will be responsible for managing Spain's strategic space direction. In particular, the EEA's mandate covers technological development and the use of space for application areas such as security, EO, connectivity, and PNT services.[292]

Moreover, Spain will increase the public contribution to the PERTE programme from €2.2 billion to €2.71 billion, of which €70 million will be used to finance Spain's national Space Technology Plan.[293]

EU, ESA and EDA transform Joint Task Force towards powering strategic autonomy in space

The European Commission, ESA and EDA initiated the evolution of their Joint Task Force (JFT), founded in 2008, to strengthen their cooperation for powering strategic autonomy in space. The 2023 JTF cycle started in May and will be completed by early 2024. The evolution of the JFT envisages new activities to address the increasing technological dependencies of the EU in space research, including the development of common JTF roadmaps, institutional synergies, and increased cooperation. The JTF will enable and envisage (1) a greater political focus and a streamlined top-down approach, (2) a greater focus on closing technological gaps, which includes identifying critical dependencies, and leading joint technological roadmaps and implementation plans, (3) increased and coordinated interaction with EU Member States and industry.[294]

[290] Aotearoa New Zealand Aerospace Strategy 2023-2030, Ministry of Business, Innovation and Employment, July 2023
[291] A Strategic Framework for Space Diplomacy, U.S. Department of State, May 2023
[292] Spain Greenlights National Space Agency, Payload Space, March 2023
[293] Spain Partner with ESA to Build €80M Atlantic Constellation, European Spaceflight, September 2023
[294] Joint Task Force – JTF Evolution: powering strategic autonomy in space, European Commission, May 2023

The French MoD allocated €6 billion of the LPM for military space budget for 2024-2030

France's 7-year Military Program Law (LPM) published on April 4th with a €413 billion military programme budget, allocates €6 billion on military space programmes between 2024 and 2030.[295] More details are provided in the **subchapter 1.4 Space, Security & Defence**

EUSPA signed agreement with Czechia for a new EUSPA HQ in Nová Palmovka in 2025

In February, the EUSPA signed an agreement with the Czech government for a new HQ in Nová Palmovka in 2025. Due to the growth in Prague, EUSPA needs to be relocated to new premises. The new facility in Nová Palmovka provides more security, and more capacity and enables innovative data infrastructures to be integrated into the site.[296]

ESA inaugurated new Telemetry, Tracking, and Control (TT&C) facility for Galileo

In July, ESA inaugurated a new Telemetry, Tracking, and Control (TT&C) facility for Galileo. The new facility is based in the Guiana Space Centre in Kourou beside the TTCF-2 facility and aims at enhancing the ground segment capabilities to support the Galileo satellite constellation.[297]

Kick-off of DLR_Startup Factory

In May, DLR celebrates the kick-off for the DLR_Startup Factory in Berlin. The DLR_Startup Factory aims to strengthen the transfer from science to the economy and society and monitor and support start-ups and spin-offs in a multi-stage process. During the event, 10 DLR teams presented their ideas and technologies and had the opportunity to network and meet potential investors.[298]

Austria increases contribution to ESA from €231 million up to €261M

At the 100th General Assembly meeting of Austrospace, Austria's Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology, Leonore Gewessler announced that Austria will increase its financial commitments to ESA from €231 million up to €261 million between 2023 and 2026.[299]

Poland increased contribution to ESA from €132 million to €295 million

In July, Poland (POLSA) increased its contribution to ESA to €295 million. Initially, at ESA CM22, Poland's contribution for 2023-2025 was set at €132 million (€81 million for basic subscription + €51 million for optional programmes). The increase to 295€ includes a contribution to optional programmes of €200 million and bilateral agreements worth €95 million.

The increase in funding will be allocated to 5 areas: (1) PL-ESA bilateral programme for building observational satellites, (2) PL-ESA bilateral programme for technology development, (3) participation in ESA programmes, (4) access to research on the ISS, (5) Internship for Poles at ESA. Poland plans to focus on the following programs: Earth Observation, Exploration, Satellite Construction and Space Safety.[300]

[295] French Defense Ministry proposes $6.5-billion military space budget for 2024-30, Space Intel Report, April 2023
[296] EUSPA signs agreement with Czech government for new headquarters, Spacewatch global, February 2023
[297] New Galileo station goes on duty, ESA, July 2023
[298] Kickoff für die DLR_Startup Factory, DLR, May 2023
[299] Österreichs Beitrag zum ESA-Budget steigt auf 261 Millionen Euro, Austria in Space, November 2023
[300] Poland signals stellar ambitions as it increases its contribution to the European Space Agency, Scienec Business, September 2023, Poland increased its contribution to the European Space Agency, Trade Gov, June 2024

Developments beyond Europe

Japan establishes new ¥1T space fund to develop space industry

The Japanese government plans to establish a new ¥1T ($6.6 billion) Space Strategy Fund over a 10-year period to support JAXA and develop Japan's space industry. The Japanese government approved the bill on November 20th to support domestic startups, the private sector, and universities. The fund aims to support emerging technologies and projects that uphold national security and strategy.[301]

U.S. Federal Communications Commission (FCC) launched a Space Bureau

The U.S. FCC split its International Bureau into two bureaus: the Space Bureau and the Office of International Affairs (OIA) to better handle the FCC's increasing workload with regard to satellite filings. The Space Bureau is led by Julie Kearney.[302]

Nigeria's NASRDA joined the Group on Earth Observations (GEO)

In July, Nigeria's National Space Research and Development Agency (NASRDA) joined the Group on Earth Observations (GEO). Nigeria is the second African nation (after South Africa) to become part of the GEO initiative. The GEO Initiative is an intergovernmental organisation comprised of 100 national governments that aims at improving the availability, access and use of EO data and supports decisions and actions based on EO data.[303]

UAE adopted National Space Fund

The UAE adopted National Space Fund. The fund is managed and supervised by the UAE Space Agency and aims to develop national capabilities and infrastructure supporting the space industry. The fund is part of a drive to diversify the national economy and strengthen the position of the UAE in the space sector and aims at adopting governance systems.[304]

South Korea unveiled 5-year plan for space and to establish a national space agency

In February, South Korea released its plans for space for the next five years, which call for doubling the government's budget for space by 2027 and establishing a new national space agency. Moreover, plans include launching its next-gen SAR and imagery satellites to be deployed from 2024 on, a lunar landing by 2032 and a Mars landing in 2045, The establishment of South Korea's national space agency KASA which was planned to be set up since March, was delayed and shifted to 2024 due to legislative hurdles.[305]

South Korea supports space start-ups by launching $39 million fund

In March, South Korea's government announced the plan to establish a $39 million fund to support startups involved in the space industry. The fund, expected to reach 50 billion won (approx. $38.5 million) by 2027, will be managed by the Korea Venture Investment Corp and will exclusively invest in private space enterprises. In April interested parties had the chance to submit their applications to become potential asset operators for the fund.

[301] Japan to create ¥1 trillion fund to develop outer space industry, the Japan Times, November 2023 ; Japan to set up $6.7B JAXA fund to develop space industry, Nikkei Asia, November 2023
[302] FCC launches space-focused bureau, Space News, April 2023
[303] Nigeria Joins the Group on Earth Observations, Space in Africa, May 2023
[304] UAE foreign trade achieved AED2.233 trillion in 2022 with growth rate of 17%: Mohammed bin Rashid, WAM, February 2023
[305] South Korea Releases Space Economy Roadmap, Payload Space, November 2023

The goal is to raise a fund-of-funds worth 10B won this year, with an initial investment of 5 billion won. The initiative aims to stimulate the growth of Korea's space industry, focusing on private enterprises.[306]

African Union Commission inaugurated the African Space Agency (AfSA)

The African Union Commission inaugurated the African Space Agency (AfSA) based in Egypt. AfSA aims to serve as a platform for space research and innovation and to strengthen space missions in Africa. It also coordinates Africa's collaboration with international partners..[307]

Senegal plans launch a national space agency

Senegal plans to launch a national space agency, the Senegalese Space Study Agency. which will be led by Maram Kaire as head - as announced by Senegal's President Macky Sall.[308]

Saudi Space Commission transformed into Saudi Space Agency

The Saudi Space Commission was transformed into the Saudi Space Agency. This change is expected to boost the space sector. The Saudi Cabinet approved this decision during the weekly Cabinet session on June 13th.[309]

[306] South Korea to launch $39 million fund to support space start.ups, Space Radar, March 2023
[307] AU-EU Space Dialogue Kickstarts in Dakar, Senegal, Space in Africa, Africa News, October 2023 ; Updates on the African Space Agency, Space in Africa, Africa News, October 2023
[308] President Macky Sall Announces the Launch of the Senegalese Space Study Agency, Space in Africa, March 2023
[309] Cabinet approves transformation of Saudi Space Commission into an agency, Zawya, June 2023

1.7.3 New appointments at key positions in agencies and institutions

Europe	esa	In December, the term of ESA DG Josef Aschbacher was extended until March 2029 (4-year period).[310] Dietmar Pilz took the position of ESA Director of Technology, Engineering and Quality and Head of ESTEC on May 1st.[311] In December, ESA appointed Laurent Jaffart as Director of Connectivity and Secure Communications, effective as of May 2024.[312] In December, ESA appointed Marco Ferrazzani as Director of Internal Services, effective as of 2024.[313]
Europe	EUSPA European Union Agency for the Space Programme	In March, mandates of the current Chair of the EUSPA Administrative Board, Mr. Vaclav Kobera, and Deputy Chair, Mr. Juan Manuel Codosero Bolaños, were renewed for a two-year term after a unanimous vote.[314]
Germany	Die Bundesregierung	In January, the long-time Lower Saxony Interior Minister Boris Pistorius was appointed as the new defence minister.[315]
Italy	ASI Agenzia Spaziale Italiana	In May, the Italian Committee for Aerospace Policies appointed Teodoro Valente new President of the Italian Space Agency (ASI), succeeding Giorgio Saccoccia.[316]
UK	UK SPACE AGENCY	Ian Annett stepped down from his role as Deputy CEO of the UK Space Agency: after more than 3.5 years, leaving his role in August.[317]

[310] Josef Aschbacher, ESA Director General, ESA, March 2021
[311] Dietmar Pilz, Director of Technology, Engineering and Quality, ESA, May 2023
[312] ESA Council Appoints Two New Directors, Spacewatch Global, December 2023
[313] ESA Council Appoints Two New Directors, Spacewatch Global, December 2023
[314] https://www.euspa.europa.eu/newsroom-events/news/euspa-renews-mandate-administrative-board-chair-and-deputy-chair
[315] Boris Pistorius neuer Verteidigungsminister, Die Bundesregierung, January 2023
[316] Spazio: Teodoro Valente nominato nuovo presidente ASI, ASI, May 2023
[317] UK Space Agency Deputy CEO to step down, Spacewatch global, June 2023

U.S.	NASA	In January, NASA appointed A.C. Charania as chief technologist, serving as principal advisor to Administrator Bill Nelson on technology policy and programs.[318] In February, NASA appointed Dr. Nicola Fox as the associate administrator for the agency's Science Mission Directorate.[319] In March, NASA named Steve Shih as first Diversity Ambassador and selected Elaine Ho as associate administrator for the Office of Diversity and Equal Opportunity.[320] In September, NASA appointed Charity Weeden as associate for the Office of Technology, Policy, and Strategy (OTPS).[321]
U.S.		In September, Chief Master Sgt. of the Space Force Roger A. Towberman appointed John F. Bentivegna as Chief Master Sergeant of the U.S. Space Force.[322]
UN	UNITED NATIONS Office for Outer Space Affairs	In June, Aarti Holla-Maini was appointed Director of UNOOSA by the UN Secretary General Antonio Guterres. She succeeds Simonetta Di Pippo (Italy). Between Di Pippo's and Holla-Maini's terms, the Chief of the Committee, Policy and Legal Affairs Section, Niklas Hedman, served as Acting Director.[323] Dr Driss El Hadani has been appointed Deputy Director at UNOOSA.[324]

Table 3: New appointments at key positions in agencies and institutions (Source: ESPI database)

[318] NASA Names New Agency-Wide Chief Technologist, NASA, January 2023
[319] NASA Administrator Selects New Head of Science, NASA, February 2023
[320] NASA Names Two Diversity Champions for Agency, NASA, March 2023
[321] NASA Names New Head of Technology, Policy, Strategy, NASA, September 2023
[322] Chief Master Sergeant of the Space Force transfers responsibility in historic ceremony, USSF, September 2023
[323] Ms. Aarti Holla-Maini of the United Kingdom - Director of United Nations Office for Outer Space Affairs, UN, June 2023
[324] UNOOSA Appoints Dr Driss El Hadani as Senior Adviser, Space in Africa, August 2023

1.8 International and bilateral collaboration in Space

1.8.1 Multilateral cooperation and initiatives

The table below summarises major bilateral and multi-party cooperation on space activities in 2023, including new partnerships and expanded collaborations between countries and organisations already working together.

Artemis Accords Signatories (2023)	ILRS Signatories (2023)	
	State-Signatories	Non-State Signatories
• Germany • Angola • the Netherlands • Iceland • Argentina • Bulgaria • India • Ecuador • Spain • Czech Republic • Rwanda • Nigeria	• Venezuela • Belarus • Azerbaijan • Argentina • Pakistan • Brazil • South Africa • Egypt	• Asia-Pacific Space Cooperation Organisation • NanoSPACE AG (Switzerland) • ILOA (Hawaii) • NARIT (Thailand) • University of Sharjah (UAE) • University Adriatic Aerospace Association (Croatia) • PT Universal Satelit Indonesia

Table 4: Artemis Accords vs. ILRS 2023 signatories

New members of UN COPUOS

Guatemala and Uzbekistan are the new members of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) in 2023. Although they were formally accepted in 2022 by General Assembly resolution 77/121, they participated for the first time in the meetings during 2023. No new members were accepted in 2023 to start participating in 2024.

Outcome of the work of the UN OEWG on Reducing Space Threats

The fourth substantive session of the UN Open-ended Working Group (OEWG) on Reducing Space Threats took place in Geneva from August 28th to September 1st. The session aimed to draft a report for the UN General Assembly's 78th session. Despite deliberations, the group failed to reach a consensus due to political disagreements, resulting in no substantive or procedural report. However, the Chair issued a summary outlining discussed topics, such as space object protection, hostile space object deployment, and military space policies.

Despite the lack of consensus, the session highlighted points of convergence and underscored the need for further dialogue on space security. ESPI attended the OEWG on Reducing Space Threats session and subsequently authored a detailed report on the proceedings and outcomes.[325]

New signatories of the Space Treaties

In 2023, significant updates include Panama ratifying the Outer Space Treaty on August 1, effective from August 9; Croatia acceding to the same treaty on March 13th, effective from March 10th; Saudi Arabia's withdrawal from the Moon Agreement on January 5th 2023, effective January 5th, 2024; Romania acceding to the Convention on Registration of Objects Launched into Outer Space on February 10th, effective February 9th; and Paraguay acceding to the same convention on January 19th, effective January 19th.

New commitmentns fo the U.S.-led ASAT test ban initiative

The U.S.-led initiative on the self-imposed commitment not to conduct ASAT tests, received additional support in 2023 from the EU, the Netherlands, Austria, and Italy.

Vienna Space Diplomat" (VSD) initiative

In June, ESPI launched the "Vienna Space Diplomat" (VSD) initiative: the platform aims to ESPI's mission of promoting space policy debate through a set of events and activities for diplomats and foreign policy practitioners through 3 formats:

VSD
VIENNA SPACE DIPLOMAT

UN COPUOS Side Events	VSD Forum	VSD Annual Reception

[325] What's next for Europe in multilateral engagement on Space Security? the UN OEWG and its success(ORS) (2024) ESPI. Available at: https://www.espi.or.at/reports/whats-next-for-europe-in-multilateral-engagement-on-space-security/ (Accessed: 12 July 2024).

1.8.2 Bilateral Cooperations

European (ESA/EU) Cooperation with international partners

European Cooperation with international partners include:

January	**France - Germany**	Germany and France released a Joint Declaration, committing to strengthening the EU towards more resilience, sustainability and independence/autonomy. The declaration includes a paragraph about cooperation in space, highlighting (1) the adoption and implementation of the EU Space Strategy for Security and Defence; (2) the development of a Roadmap with ESA and interested ESA MS for a thriving New Space ecosystem; (3) European launchers and European autonomous, independent, and cost-efficient access to space, incl. a dual launch of SYRACUSE and H2SAT military satellites by Ariane 5 in mid-2023 and the promotion of micro-launchers; and (4) exchanges on space-related defence issues, use of space for climate protection, and international cooperation for space exploration and human spaceflight.[326]
	EU-NATO	EU and NATO released the third joint EU-NATO Declaration. Space is included in paragraph 12, which declares that the EU and NATO will strengthen cooperation "[…] to address in particular the growing geostrategic competition, resilience issues, protection of critical infrastructures, emerging and disruptive technologies, space, the security implications of climate change, as well as foreign information manipulation and interference".[327]
	ESA-EC-EUSPA	ESA, the EC and the EUSPA signed a Coordination Arrangement for commercialisation initiatives to support entrepreneurship and strengthen the New Space industry in Europe.[328]
	ESA-EC	ESA and the EC signed a contribution agreement to build a "Copernicus mirror site" in the Philippines – an initiative called "CopPhil" which will be funded with €7.3 million.[329]
	UAE-South Korea	UAE Space Agency and South Korea's Science Ministry signed a MoU to expand cooperation in space, including cooperation in space exploration, EO, satellite communications, satellite

[326] French-German declaration, Elysee, January 2023
[327] JOINT DECLARATION ON EU-NATO COOPERATION BY THE PRESIDENT OF THE EUROPEAN COUNCIL, THE PRESIDENT OF THE EUROPEAN COMMISSION, AND THE SECRETARY GENERAL OF THE NORTH ATLANTIC TREATY ORGANIZATION, Consilium Europe, January 2023
[328] ESA, THE EUROPEAN COMMISSION AND EUSPA COORDINATE THEIR ACTIVITIES RELATED TO SPACE-BASED ENTREPRENEURSHIP AND NEWSPACE INDUSTRY, ESA, January 2023
[329] ESA and the European Commission uniting on Earth observation for the Philippines, ESA, January 2023

		navigation, exchange of space data, ground station, launch services, SSA and STM.[330]
	U.S.-Japan	The U.S. and Japan signed a space cooperation framework agreement for continued cooperation in space exploration, especially on Artemis, which includes Japan's plan to develop a pressurised rover for future missions.[331]
	EUSPA-France	EUSPA extends cooperation with CNES for the delivery of the Galileo Search and Rescue Service. The new Contract will further expand the cooperation between EUSPA and CNES in SAR activities.[332]
	Italy-Algeria	Italy and Algeria signed a MoU for cooperation in space exploration, EO, and space S&T: The cooperation will include joint (research) projects, exchange of knowledge in the fields of space S&T, and the organisation of joint workshops and training programmes.[333]
February	**ESA-Mexico**	ESA and the Mexican Space Agency (AEM) signed a Cooperation Agreement. The objective of the agreement is to enable the creation of a framework for enhanced cooperation in joint projects, particularly in education, EO, and integrated applications.[334]
	India-Egypt	India and Egypt strengthened their relations and cooperation (among other areas) in space, by initiating a strategic partnership. With regard to space, cooperation includes research, space science, satellite communications and applications of space technology to tackle societal challenges.[335]
	India-U.S.	The U.S. and India agreed to expand civil space cooperation. The agreement includes training Indian astronauts at NASA's Johnson Space Center and flying payloads as part of NASA's Commercial Lunar Payload Services (CLPS) program. As part of this programme, NASA is purchasing flights for payloads on commercial lunar landers currently under development.[336]
	U.S.-Israel	NASA and the Israel Space Agency (ISA) signed a Statement of Intent for their cooperation in NASA's contribution to Israel's Beresheet 2 lunar mission, planned to launch in 2025.[337]

[330] South Korea, UAE agree to expand space cooperation, Sankyung Today, January 2023
[331] United States and Japan sign space cooperation framework agreement, SpaceNews, January 2023
[332] EUSPA Extends Cooperation with CNES for the Galileo SAR Services, Spacewatch Global, January 2023
[333] SIGLATO PROTOCOLLO D'INTESA TRA ITALIA E ALGERIA PER LA COOPERAZIONE NEL SETTORE DELLE ATTIVITÀ SPAZIALI PER SCOPI PACIFICI, ASI, January 2023
[334] ESA signs Cooperation Agreement with Mexico, ESA, February 2023
[335] India and Egypt Expand Space Cooperation through a Strategic Partnership, Space in Africa, Africa News, February 2023
[336] United States and India expand civil space cooperation, SpaceNews, February 2023
[337] NASA, Israel Space Agency to cooperate on Beresheet 2 lunar mission, the Jerusalem Post, February 2023

	EUSPA-Czech Republic	EUSPA signed an agreement with the Czech government for a new HQ in Nová Palmovka in 2025. Due to the growth in Prague, EUSPA needs to be relocated to new premises. The new facility in Nová Palmovka provides more security and space and the use of a new data centre.[338]
	Hungary-Azerbaijan	Hungary and Azerbaijan signed a joint declaration on enhanced strategic partnership. The declaration is comprised of 6 documents, including 5 MoUs on further enhancing cooperation in the fields of energy, culture and tourism, food security, migration and space.[339]
March	**ASI-NASA**	ASI and NASA announced a partnership to build and launch the Multi-Angle Imager for Aerosols (MAIA) mission, an effort to investigate the health impacts of tiny airborne particles. Set to launch before the end of 2024.[340]
	Egypt-Belgium	Egypt and Belgium signed a MoU for space cooperation, which includes space exploration for peaceful purposes, space science and the development of satellites and has the objective of strengthening cooperation between the countries, exchange, visits, joint activities, training and capacity building.[341]
	Italy-India	Italy and India agreed to expand space cooperation. Areas of potential collaboration include remote sensing, satellite communications, space science, lunar exploration, and practical applications of space technology between ISRO and ASI.[342]
April	**ESA-Sweden-Axiom Space**	ESA, SNSA and Axiom Space signed an agreement to send an ESA astronaut to the ISS.[343]
	U.S.-South Korea	The U.S. and South Korea signed a "Joint Statement of Intent for Cooperation on Space Exploration and Science" to enhance space cooperation in areas of mutual interest, such as lunar exploration, Earth and space science, space communications and navigation.[344]
	U.S.-Poland	The Polish Space Agency and the USSPACECOM signed an SSA data-sharing agreement to enhance the safety, stability, security, and sustainability of space operations.[345]

[338] EUSPA signs agreement with Czech government for new headquarters, Spacewatch Global, February 2023
[339] Azerbaijan, Hungary sign joint declaration on enhanced strategic partnership, AA, February 2023
[340] NASA and Italian Space Agency Join Forces on Air Pollution Mission, NASA JPL, March 2023
[341] Egypt, Belgium sign MoU on ouster space exploration for peaceful purposes, Egypt Today, March 2023
[342] India-Italy Joint Statement during the State Visit of the President of the Council of Ministers of the Italian Republic to India (March 02-03, 2023), Italy Government, March 2023
[343] Sweden intends to send ESA astronaut to the International Space Station, ESA, April 2023
[344] United States and South Korea agree to enhance space cooperation, SpaceNews, April 2023
[345] USSPACECOM, Polish Ministry of National Defence, and Polish Space Agency Sign Space Situational Awareness Sharing Agreement, U.S. Space Command, April 2023

	Israel (IAI) - Azerbaijan	Israel Aerospace Industries (IAI) will supply Azerbaijan with two EO satellites for $120 million. This supply was decided because Azerbaijan lost contact with its EO satellite (one year before the end of its mission) and to strengthen defence ties between Israel and Azerbaijan.[346]
May	**U.S. – Australia**	The U.S. and Australia released the Joint Leaders' Statement – An Alliance for our Times, which agrees on cooperation in several domains, including space. The agreement highlights increasing investment between the U.S. and Australia sets out to establish a new ground station based in Australia to provide communication support to NASA's Artemis program.[347]
	U.S. - Philippines	The U.S. agreed to intensify cooperation with the Philippines in security, economic affairs, technology development and education – including fostering bilateral cooperation in SSA and space-based maritime domain awareness, to organise the first U.S.-Philippines Civil Space Dialogue in 2023, and the use of space-based technology in disaster/emergency management and response, healthcare, resources mapping and pollution monitoring,[348]
	Italy - France - Germany	The Italian Space Agency (ASI), the French Space Agency (CNES) and the German University of the Bundeswehr in Munich (UniBW) signed a MoU for cooperation in and promotion of the European New Space Accelerator Programme - SpaceFounders, which was launched by CNES and UniBw in 2021.[349]
	Iran - Oman	Iran and Oman agreed to cooperate in Information and Communications Technology (ICT) and in the space sector: in particular in developing and manufacturing EO and communications satellites.[350]
	Iran – Syria	Iran and Syria signed a MoU to strengthen cooperation in the information and communication technology (ICT) sector, by creating joint specialised working groups. The two countries also agreed to cooperate in the field of space services.[351]
	Iran - Russia	Iran and Russia announced a cooperation between the University of Tehran and the University of Moscow to jointly develop and manufacture a research satellite. Moreover, Russia and Iran expressed the need to expand scientific and

[346] Israel Aerospace Industries to Supply Azerbaijan With Satellites, HAARETZ, Israel News, April 2023
[347] United States and Australia Reach Agreement on Space, Spacewatch Global, April 2023
[348] From Japan to the Philippines: US expands SSA cooperation with Asian countries, May 2023
[349] Italy, France and Germany signed a Memorandum of Understanding on the Space Founders European Program, ASI, May 2023
[350] Iran, Oman agree to start space cooperation, english news cn, May 2023
[351] Iran, Syria sign MoU to expand ICT cooperation, Mehr News Agency, May 2023

		technological cooperation (especially in the Artificial Intelligence field).[352]
	UAE - France	France and the UAE discussed their countries' longstanding strategic partnership and further opportunities for bilateral cooperation in various sectors, including space and other sectors such as culture, environment, climate change, renewable energy, sustainable development ambitions, food security and advanced technology.[353]
	UK - Japan	UK and Japan signed a renewed Science and Technology Agreement in which both committed to develop joint R&D projects to tackle planetary issues including climate change and biosecurity to space sustainability, and to develop R&D projects.[354]
	ESA - UEFA	ESA partnered with UEFA to support the safety of football fans with space services, including EO satellites to monitor crowds to assist police forces, and telecommunications satellites to fill gaps due to overloaded terrestrial communications networks.[355]
June	**U.S. - India**	Based on India's signature of the Artemis Accords. the U.S. and India agreed to expand cooperation in spaceflight, planning to develop a "strategic framework for human spaceflight cooperation" and plans to launch a joint mission to the ISS in 2024. A joint project is the NASA-ISRO SAR (NISAR) Earth science mission, with a spacecraft built by ISRO which will use a radar provided by NASA, scheduled to launch in early 2024.[356]
	India-Egypt	India and Egypt signed a Strategic Partnership Agreement, paving the way for increased cooperation in key areas such as trade and investment, information technology, defence and security, renewable energy, agriculture, health, culture, and space.[357]
	Rwanda-Japan	The Rwanda Space Agency and Japan International Cooperation Agency agreed to strengthen space cooperation. The partnership is expected to advance the objective of using space for the inclusive socio-economic development of Rwanda.[358]

[352] Universities of Tehran and Moscow to build joint research satellite, Theran Times, May 2023
[353] UAE President, French President hold talks to further strengthen strategic partnership, WAM, May 2023

[355] How space will help football fans to celebrate sport, ESA, May 2023
[356] India joins Artemis Accords, will launch ISRO-NASA space mission to ISS in 2024, says White House, The Hindu, June 2023
[357] India and Egypt forge a strong strategic partnership for a shared future, Financial Express, June 2023
[358] RSA and JICA to Strengthen Space Collaboration for Socio-Economic Development, Africa in Space, Africa News, June 2023

	Algeria - Russia	Algeria and Russia signed a Government Agreement for cooperation in "space exploration and the use of outer space for peaceful purposes" to establish bilateral space cooperation in space sciences, technologies, and applications; space communications; satellite navigation and related technologies and services; space geodesy and meteorology; training and knowledge transfer, and international legal regulation of space activities.[359]
	Russia - Egypt	Russia and Egypt signed a cooperation agreement, which includes cooperation in space, including the production and launch of satellites, the development of human spaceflight programmes, space infrastructure, space exploration, and space education.[360]
	UAE - Philippines	The UAE and the Philippines agreed to strengthen cooperation in innovation and technology, including space and AI. PhilSA and UAESA also signed a MoU on space cooperation in this frame.[361]
	ESPI-South Korea	ESPI and KARI signed a MoU through which KARI strives to become more involved in the policy developments of space activities. ESPI aims to increase its global reach and engagement and strengthen relations with South Korea.[362]
September	**ESA-EU**	ESA and EU signed a 12-year ESA-EU Contribution Agreement for the secure connectivity satellite constellation IRIS^2.[363]
	ESA- Spain	ESA and Spain signed an agreement for Spain's national €80M Atlantic Constellation to be comprised of 16 small EO satellites. With 8 developed in Spain and 8 developed in Portugal and both countries contributing €40M each, the constellation will focus on monitoring the effects of climate change.[364]
	U.S-India	The U.S. and India released a Joint Statement reaffirming the partnership between the two countries, including space.[365]
	U.S.-Peru	The U.S. and Peru are considering the construction of a national spaceport in Peru. The partnership is based on the agreement between Peru's National Commission for Aerospace Research

[359] Algeria and Russia Sign Government Agreement for Peaceful Space Cooperation, Space in Africa, Africa News, June 2023
[360] Egypt, Russia to sign space cooperation agreement in July 2023, Egypt Today, June 2023
[361] Philippines to strengthen innovation, technology ties with UAE ahead of 50th anniversary of relations: Philippine Envoy, WAM, June 2023
[362] Signing of an MoU with the Korea Aerospace Research Institute (KARI), ESPI, June 2023
[363] ESA works with EU on secure connectivity, ESA, September 2023
[364] Spain Partner with ESA to Build €80M Atlantic Constellation, European Spaceflight, September 2023
[365] Joint Statement from India and the United States, the White House, September 2023

		and Development (Conida) and the U.S. Space Command in April.[366]
	UAE-Indonesia	UAE and Indonesia agreed to strengthen economic relations, calling on UAE and Indonesian companies to seize the investment opportunities in (air)ports, national defence and satellites. [367]
October	**Israel-Azerbaijan**	Israel and Azerbaijan signed a cooperation agreement for joint projects in space to develop space technologies and satellites, space exploration systems, and EO capabilities.
	South Africa – Tunisia	South Africa and Tunisia strengthen bilateral cooperation. The envisaged areas include economic cooperation, security, health, science (incl. space science) and technology.
	Nigeria-China	Nigeria and China cooperate to kick off the Crop-Watch Programme in Nigeria. the Chinese agricultural monitoring system, to enhance food security in Nigeria.[368]
November	**Italy-Latvia**	Italy and Latvia signed a MoU on space cooperation.[369]
	ESA-EC	ESA and the European Commission signed an agreement for cooperation to use EO data to address climate change.[370]
	UAE-U.S.	The UAE and the U.S. agreed to advance bilateral relations in science, technology and space for mutual benefit. It was unveiled, that two UAE astronauts could be part of the Artemis mission.[371]
December	**ESA-UNEP**	ESA and the United Nations Environment Programme (UNEP) signed a MoU to increase space technology and data use for environmental conservation, nature and biodiversity protection and restoration.[372]

Table 5: New bilateral collaborations signed in 2023 (Source: ESPI database)

[366] Peru's Air Force and the U.S. pave the way for a national spaceport in Peru, The Rio Times, August 2023
Peru's Paita Desert Could Become the Largest Spaceport in South America, BNN, September 2023
[367] UAE, Indonesia reviewing strengthening economic cooperation, Zawya, September 2023
[368] Nigeria Collaborates With China to Commence the Crop-Watch Programme in Nigeria, Space in Africa, Africa News, October 2023
[369] Latvia and Italy to collaborate in space sector, Labs of Latvia, November 2023
[370] ESA and EC to unite on climate action from space, ESA, November 2023
[371] UAE delegation meets the White House to advance bilateral relations in science, technology and space, Zwaya, November 2023 ; Two UAE astronauts could be part of Moon mission, Khaleejtimes, November 2023 ;
[372] ESA and UNEP collaborate for a greener future, ESA, December 2023

1.9 Rising Stars in 2023: Spacefaring Nations & Regions

In 2023, several regions and countries stood out in their sharp rise to become major global actors in space. These spacefaring nations and regions "rising stars" are India, the Gulf nations and Africa. Also, Türkiye, Azerbaijan, and Israel saw various notable developments. The U.S. and China signed various agreements with new space powers, with Japan trailing. Europe, instead, was much less active in terms of bilateral agreements both at European and national levels.

For example, an interesting multilateral initiative including three of these rising stars: under the I2U2 Group, the governments of India, Israel, the UAE, and the U.S. announced the plan to create a new joint space venture. The project aims to create a space-based tool for policymakers, institutions, and entrepreneurs, using EO data and space-based capabilities of the 4 countries, to boost their efforts and synergies in the use of space for environmental and climate change challenges.[373]

The following subchapters dive into developments of India, the Gulf nations and Africa.

1.9.1 India affirms itself among science & exploration (super)powers

Credit: indbiz.gov

India left a strong mark in 2023 with the Moon landing of Chandrayaan-3 - becoming the first nation to land on the lunar southern polar region and the fourth nation to achieve a soft landing on the lunar surface and subsequent announcements to land an astronaut on the Moon by 2040, the announcement of the national space station in LEO. Moreover, the successful launch of the solar mission Aditya-L1, the 2023 space policy to boost commercialisation, and an evolving space economy show the diversification of ambitions and expertise. The Indian space economy is projected to grow to $600 billion (from $447B billion in 2020) by 2025, according to estimations and forecasts published by Ernst & Young.[374]

Indian space policy and long-term vision

Indian Space Policy 2023 was approved

Credit: Vectomart

In April, the Indian Cabinet Committee on Security and the Central Government of India approved the Indian Space Policy 2023, published on April 20th. The policy aims to provide a framework for India's space sector for the next decade, bolster research, academia, start-ups, and industry and boost India's space missions. With regard to India's space governance, the policy aims to enhance the role of the Department of Space, boost ISRO's activities and delineate the roles and responsibilities of (1) the Indian Space Research Organisation (ISRO), (2) the public sector undertaking/commercial arm of the Department of Space NewSpace India Limited (NSIL), and (3) the public-private mediator the Indian National Space Promotion and Authorization Center (IN-SPACe), which was recently created. In particular:

[373] The I2U2 Group Announces Joint Space Venture, State Gov U.S., September 2023
[374] Taking advantage. India is taking on China in the $447 billion space economy, the Hindu Business Line, April 2023

- ISRO will focus on R&D of advanced space technologies.
- IN-SPACe will be the interface between ISRO and non-governmental entities.
- NSLI will carry out strategic activities related to the space sector in a demand-driven mode and will conduct the operational part of ISRO's missions.

Commercialisation and the involvement of the private sector are clear objectives of the policy as it aims to further open up the Indian space sector to private actors by facilitating private investment in the Indian space sector. This will allow India's private sector participation in end-to-end space activities, including the development and manufacturing of satellite launch vehicles, data collection and dissemination.[375]

Space Exploration & Science

Following lunar success, Prime Minister Modi announced increased ambition in space exploration

In August, ISRO successfully landed the Chandrayaan-3 Lander on the Moon's surface, becoming the first nation to land on the lunar southern polar region and the fourth nation to achieve a soft landing on the lunar surface.[376] Earlier in June, India became the 27th country to sign the Artemis Accords.[377] One month after the successful moon landing, on September 2nd, India launched its first mission to study the sun, the Aditya-L1 solar observatory from the Satish Dhawan Space Centre in Sriharikota Range. It carries 7 instruments to explore the Sun's dynamics and space weather.[378]

Two months after India's successful Moon landing and a Sun-studying mission in summer 2023, Prime Minister Modi announced India's updated plan to establish the Indian LEO Space Station "Bharatiya Antariksha Station" by 2035. Originally slated for launch in 2030, the project was delayed.[379] Moreover, Prime Minister Modi announced the plan to send an Indian astronaut to the Moon by 2040. The national space station will be a first step for human spaceflight. India aims to launch at least three astronauts to LEO in late 2024 or 2025.[380]

Milestones in India's Access to Space

India successfully launched SSLV rocket for the first time after launch failure

After a first launch failure in August, India's SSLV rocket was successfully launched in February 2022. Compared to India's GSLV and PSLV rockets, SSLV is designed to provide more affordable and flexible access to space. The payload comprised EOS 07, AzaadiSAT 2, and Janus 1.[381]

Multilateral and bilateral cooperation

The G20 Space Economy Leader Meeting took place in India

In April, India hosted the G20 Space Economy Leader Meeting as a precursor event under the country's G20 Presidency. ESPI Director H. Ludwig Moeller presented the Revolution Space report and its call for Europe to also increase its ambition, while linking it with the perspective of India.[382]

[375] Indian Space Policy 2023, ISRO, April 2023
[376] India's Chandrayaan-3 successfully lands on the Moon, ESA, August 2023
[377] NASA Welcomes India as 27th Artemis Accords Signatory, NASA, June 2023
[378] Aditya-L1: India's Sun mission reaches final destination, BBC, January 2024
[379] Prime Minister reviews readiness of Gaganyaan Mission, Press Information Bureau Government of India, October 2023
[380] India to launch test flight on Oct. 21 for future Gaganyaan astronaut mission, Space.com, October 2023
[381] India's SSLV rocket succeeds in second try, SpaceNews, February 2023
[382] SELM Event, Space Economy Leaders Meeting, ISRO Gov, April 2023; ESPI at the SELM meeting, ESPI, Linkedin, April 2023

India's Prime Minister Modi offers 5-point cooperation plan to BRICS countries

During a plenary session of the 15th BRICS Summit, India's Prime Minister Modi proposed a 5-point cooperation plan for further cooperation between BRICS countries in the 5 areas (1) space, (2) education & skill development, (3) skills mapping, (4) big cats and (5) traditional medicine.

With regard to space, he highlighted the ongoing work on the BRICS satellite constellation, proposing to consider creating a BRICS Space Exploration Consortium, under which the BRICS can work in areas like space research and weather monitoring.[383]

India and Egypt initiate strategic partnership to expand space cooperation

India and Egypt strengthened their relations and cooperation (among other areas) in space, by initiating a strategic partnership, which is based on four pillars: (1) Political and security cooperation; (2) Economic engagement; (3) Scientific and academic collaboration; and (4) Cultural and people-to-people contacts. Regarding space, the two nations agreed to expand cooperation in research, space science, satellite communications as well as applications of space technology to tackle societal challenges.[384]

U.S. and India released Joint Statement and expanded civil space cooperation

Credit: Kamal Sandesh

In February, during meetings in Washington D.C., the U.S. and India agreed to expand civil space cooperation. The agreement includes training Indian astronauts at NASA's Johnson Space Center and flying payloads as part of NASA's Commercial Lunar Payload Services (CLPS) program. As part of this programme, NASA is purchasing flights for payloads on commercial lunar landers currently under development. In 2024, NASA and ISRO will convene a meeting of U.S. CLPS providers with Indian aerospace companies. Moreover, a new initiative between the U.S. Department of Commerce and India's Department of Space was announced and aims to strengthen "commercial space engagement" and to enable partnerships between the commercial space sectors of both countries.[385] On September 8th, the U.S. and India released a Joint Statement reaffirming their partnership. India's Prime Minister Modi and U.S. President Biden called to "continue the work of transforming the India-U.S. Strategic Partnership across all dimensions". Paragraph 7 is about space and includes:

- President Biden congratulated for the success of Chandrayaan-3 and the successful launch of India's first solar mission Aditya-L1, in August and September respectively,
- President Biden and PM Modi welcomed efforts towards to establish a Working Group for commercial space collaboration under the existing India-U.S. Civil Space Joint Working Group.
- ISRO and NASA started discussions on modalities, capacity building, and training for a joint effort to the ISS in 2024 and affirmed to continue finalising a strategic framework for human space flight cooperation.
- India and the U.S. intend to increase coordination on planetary defence to protect the Earth and space assets from the impact of asteroids and near-Earth objects. This will include U.S. support for India's participation in asteroid detection and tracking via the Minor Planet Center.[386]

[383] Modi offers five-point cooperation plan to BRICS countries, Live Mint, August 2023
[384] India and Egypt Expand Space Cooperation through a Strategic Partnership, Africa in Space, January 2023
[385] United States and India expand civil space cooperation, SpaceNews, February 2023
[386] Joint Statement from India and the United States, the White House, September 2023

1.9.2 Regional Competition Leads to progress across the Gulf region

Credit: The National News

2023 saw flourishing space economies and developments in the Gulf (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE). Space endeavours are considered as one of the key domains within a broader plan to invest into high-tech industries and thereby diversify their economies.[387]

Moreover, their multilateral approach to strategic partnerships is remarkable – covering various regions and countries, including the U.S., China, Japan, Europe and many more. China has been cooperating with all Gulf nations, since the first China-Gulf Cooperation Council (GCC) Summit in December 2022. The GCC intergovernmental group comprises Saudi Arabia, the UAE, Bahrain, Kuwait, Oman and Qatar. While China is building partnerships in the Gulf across applications, exploration is one of the key pillars of cooperation. China facilitates the selection and training of GCC astronauts to join China's space station. and is considering building a China GCC joint centre for lunar and deep space exploration.[388]

United Arab Emirates (UAE)

UAE adopted national space fund and announced to update national space law

Credit: The National News

On February 6th, during the UAE's Cabinet meeting, the resolution establishing the UAE National Space Fund was adopted. The UAE Space Agency will manage and supervise the fund, which aims to develop national capabilities and infrastructure to support the space industry. The fund is part of a drive to diversify the national economy and strengthen the position of the UAE in the space sector. Moreover, the fund the adoption of governance systems to achieve leadership in the space sector, attracting specialised global companies, and building partnerships between domestic and foreign advanced technology companies.[389]

In November, the UAE announced to update the national space law to be adopted in Q1/2024.[390]

UAE's efforts in space exploration and science

On February 9th, it was announced that the UAE's (and the Arab world's first) interplanetary probe Hope had moved to a new orbit around Mars to study Deimos, one of Mars' tiny moons. The announcement was made on the second anniversary of the spacecraft reaching Mars.[391]In April, the UAE's Astronaut Sultan Al Neyadi became the first Arab spacewalker, having conducted a 6.5-hour maintenance mission outside the ISS alongside U.S. astronaut Stephen Bowen.[392]

[387] The Middle East Enters the Space Race, Stimson, November 2023
[388] China looks to build space partnerships with Gulf nations, SpaceNews, December 2022
[389] UAE foreign trade achieved AED2.233 trillion in 2022 with growth rate of 17%: Mohammed bin Rashid, Emirates News Agency, February 2023
[390] UAE to have new space law by first quarter of 2024: Space agency chief, Gulf News, November 2023
[391] UAE's Hope probe moves to new orbit to study Mars' tiny moon Deimos, the National News, February 2023
[392] UAE's Sultan Al Neyadi becomes first Arab spacewalker, the National News, April 2023

On May 28th, the UAE Space Agency announced the UAE's Mission "Max" ("Multiple Asteroid Exploration"), which will see the MBR Explorer spacecraft travel 5B kilometres to a region called Asteroid Belt EMA between Mars and Jupiter to study asteroids. The mission, whose planning started in 2019, will take a total of 13 years: 6 years for spacecraft development and 7 years travel time to the belt, including 6 asteroid fly-bys and fly-bys of Venus, Earth, and Mars.[393] In November, it was announced that the UAE will send new and experienced astronauts on missions in the near future and that the MBRSC is actively working to prepare the astronauts.[394]

UAE pushes use of space for climate

During the UAE Climate Tech Event in May, the UAE Space Agency announced phase 2 of its Space Analytics and Solutions (SAS) Programme to combat climate change. The second phase of the programme will include 3 new challenges that will offer entrepreneurs and researchers support to develop space applications to address climate change: (1) the Air Quality challenge to monitor and control air pollution, (2) the Infrastructure challenge to foster infrastructure monitoring, maintenance, and operations solutions, and (3) the Losses and Damages challenge to use satellite data to investigate the losses and damages caused by climate change.[395]

In August, the UAE's Ministry of Industry and Advanced Technology (MoIAT), the UAE Space Agency, and COP28 through the Office of the UAE Special Envoy for Climate Change (OSECC) partnered to enhance coordination between the advanced technology and space sectors and to encourage organisations (companies, global institutions, space agencies) to share their contributions to tackle global climate change at the Technology and Innovation Hub at COP28. Moreover, the cooperation aims to facilitate knowledge-sharing to accelerate and boost the development of advanced technology solutions for climate.[396]

UAE boost the space economy

- The UAE Government made a $5 billion commitment in a 17-year deal to buy broadband services from the UAE fleet operator Yahsat until at least 2043.[397]
- The UAE Space Agency and the Sharjah Research Technology and Innovation Park (SRTI Park) signed a cooperation agreement in the aerospace technology sector.[398]
- The UAE Space Agency and Dubai Electricity and Water Authority (DEWA) signed a MoU to jointly boost the space sector through supporting R&D and contributing to regulations.[399]

Bilateral cooperation

- **Europe:** The UAE Space Agency hosted an ESA delegation to discuss ways to intensify collaboration in space R&T. Moreover, ESA presented current projects and the UAE Space Agency presented the UAE's mission to the asteroid belt.[400] In November, ESA DG Josef Aschbacher called for exploring the potential for cooperation in space between Europe and the UAE, including his suggestion that ESA could cooperate with the UAE on a second Rashid lunar mission to fly a UAE lander to the Moon. Also at Dubai Airshow, ESPI Director, H. Ludwig Moeller participated in the panel "Investing in Space to Support the Country's Growth Plans".[401]

[393] UAE mission to asteroid belt: Codename Max, Spacewatch Global, May 2023
[394] UAE to send new and seasoned astronauts on human space missions 'soon', Khaleejtimes, November 2023
[395] UAE Space Agency showcases contributions to sustainability at the UAE Climate Tech, Zawya, March 2023
[396] UAE aims to mobilize global tech and space sectors for climate action ahead of COP28, WAM, August 2023
[397] UAE's $5 billion commitment opens doors for Yahsat, SpaceNews, September 2023
[398] SRTI Park and UAE Space Agency sign a cooperation agreement, Sharjah24, November 2023
[399] DEWA + UAE Space Agency to enhance the UAE's space industry, SatNews, November 2023
[400] The UAE Space Agency recently hosted a high-level ESA delegation to discuss ways to strengthen collaboration in space research & technology, Twitter, UAE Space Agency,
[401] Europe's space chief calls for greater UAE collaboration, the national news, UAE in space, November 2023 ; Dubai Airshow, ESPI, November 2023

- **France:** During a bilateral meeting in Paris, the UAE's President His Highness Sheikh Mohamed bin Zayed Al Nahyan and the French President Emmanuel Macron discussed their countries' longstanding strategic partnership and further opportunities for bilateral cooperation in various sectors, including space and other sectors such as culture, environment, climate change, renewable energy, food security and advanced technology.[402]
- **Armenia:** During the UAE-Armenia Business Forum in Yerevan, the UAE and Armenia signed 4 MoUs: 3 targeting their respective business sectors and one setting the frame to establish a UAE-Armenia Business Council. The two countries agreed to facilitate economic/trade links and to expand in sectors of common interest such as trade, technology, agriculture, food security, tourism & travel, renewables, transport, technological industries, space, and circular economy.[403] Furthermore, on the 25th anniversary of the establishment of the countries' diplomatic relations, the ambassadors of UAE and Armenia agreed to strengthen economic and trade links, provide support to companies to diversify partnerships and assist emerging businesses to expand in sectors of common interest, including space.[404]
- **U.S.:** In November, a UAE delegation met a U.S. White House delegation agreeing to advance bilateral relations in science, technology and space for mutual benefit. Moreover, at the Sharjah International Book Fair (SIBF) it was unveiled, that two UAE astronauts could be part of the Artemis mission – since January 2022, the UAE astronauts, Mohammad AlMulla and Nora AlMatrooshi, are undergoing training with NASA.[405]
- **Türkiye:** During Türkiye's President Erdogan's official visit to the UAE, the countries' Presidents agreed on a joint accord on the establishment of a high-level strategic council between the UAE and Türkiye as well as several agreements valued in total $50.7 billion, fostering their strategic partnership. The 14 agreements aim at diversifying the framework of the UAE-Türkiye Comprehensive Economic Partnership Agreement and deepening investment and include a space-related MoU on the development of joint launch vehicle capabilities for commercial purposes between the UAE Space Agency, the Turkish Ministry of Science, Industry and Technology, and the Turkish Space Agency.[406]
- **Russia:** In February, a delegation of the Russian State Space Corporation Roscosmos led by DG Yury Borisov visited the UAE Space Agency to discuss fields of potential collaboration and topics of shared interest. These reportedly included the peaceful utilisation of outer space, the 28th session of the UN Framework Convention on Climate Change (COP28) hosted by the UAE, as well as the crucial role of the space sector in supporting global initiatives to address climate change studies.[407] Moreover, in June, the UAE's PHI-Demo CubeSat was launched by a Russian Soyuz-2 rocket from the Vostochny Cosmodrome – marking the first mission under the UNOOSA's and Mohammed bin Rashid Space Centre's joint Payload Hosting Initiative.[408]
- **China:** Mid-March, Chinese startup Origin Space and the University of Hong Kong's Laboratory for Space Research) and the UAE University's National Space Science and Technology Centre signed a letter of intent to build a joint research and development centre in Abu Dhabi, bringing together researchers and engineers from China and the UAE. The centre will support the development of

[402] 15th session of the UAE-France Strategic Dialogue discusses growing cooperation between UAE & France (19 June 2023), Diplomatie Gouv France, June 2023 ; UAE President, French President hold talks to further strengthen strategic partnership, WAM, May 2023
[403] UAE, Armenia sign 4 MoUs during joint business forum in Yerevan, Gulf Today, September 2023
[404] UAE-Armenia relations are witnessing a new historical era: UAE Ambassador, WAM, June 2023
[405] UAE delegation meets the White House to advance bilateral relations in science, technology and space, Zwaya, November 2023 ; Two UAE astronauts could be part of Moon mission, Khaleejtimes, November 2023 ;
[406] UAE and Turkish Presidents witness announcement of accord and agreements worth over $50 bn to boost strategic partnership, WAM, July 2023
[407] UAE Space Agency receives a delegation from the Russian State Space Corporation to discuss fields of collaboration, Zawya, February 2023
[408] UAE satellite blasts into space on Russian rocket, the national news, June 2023

remote-sensing satellites to monitor agricultural systems, oil fields, and border security, enable the provision of data services for both countries and build telescopes for asteroids and space debris detection.[409] Moreover, the UAE National Center of Meteorology (NCM) and the China Meteorological Administration (CMA) signed a cooperation agreement to cooperate in meteorological science and technology to help mitigate damages due to weather disasters.[410]

- **India:** In November, a delegation led by the Indian National Space Promotion and Authorization Centre (IN-SPACe), comprising Indian non-governmental entities (NGEs) related to space, visited the MBRSC in Dubai. During the visit, IN-SPACe presented India's recent space sector reforms and 2040 goals to the MBRSC, and the parties agreed to continue the dialogue.[411]
- **Indonesia:** During the UAE-Indonesia Business Forum in Jakarta, the two countries agreed to strengthen economic cooperation, calling on UAE and Indonesian companies to seize investment opportunities in areas such as renewable energy development, environment, climate change, energy and food security, (air)ports, and national defence and satellites.[412]
- **Japan:** JAXA has and is collaborating with the UAE in the aerospace industry. JAXA's President Yamakawa Hiroshi praised the space partnership with the UAE, recalling the joint efforts in launching KhalifaSat in 2018 and the Emirates Mars Mission's Hope Probe in 2020, using Japan's H-IIA launch vehicles. This collaboration is set to continue, with plans for a science experiment onboard Japan's Kibo Experimental Module to advance future medicines and inspire space education activities within the Asia-Pacific Regional Space Agency Forum (APRSAF) framework, led by JAXA.[413] Also in July, the Mohammed Bin Rashid Space Centre (MBRSC) and the Japanese biotech firm signed a MoU to advance international collaboration and innovation in space science. The partnership seeks to introduce IDDK's cutting-edge microscopic observation technology and other services to the UAE's scientific community and beyond. The collaboration will explore opportunities for commercialising IDDK's services in the UAE and includes the development of modules for space experiments and the establishment of in-space manufacturing platforms with safe re-entry capabilities.[414]

Saudi Arabia

Saudi Space Commission will transform into the Saudi Space Agency

The Saudi Space Commission transformed into the Saudi Space Agency. The Saudi Cabinet approved this decision during the weekly Cabinet session on June 13th.[415]

Saudi Arabia withdraws from the Moon Treaty

On January 5th, UN Secretary General António Guterres released an official notification, stating that the Kingdom of Saudi Arabia withdrew from the 1979 Moon Treaty. Saudi Arabia was one of only 11 states that have signed the Treaty, with a short accession and signature in 2012. Saudi Arabia signed the Artemis Accords and is developing a space strategy expected to be released soon.[416]

[409] China and UAE team up to build Abu Dhabi space tech centre, SCMP, March 2023
[410] UAE and China to collaborate on advancing meteorological technologies, Meteorological Technology International, March 2023
[411] Indian Space Entrepreneurs visits Mohammed Bin Rashid Space Centre in Dubai, Singraulimirror, November 2023
[412] UAE, Indonesia reviewing strengthening economic cooperation, Zawya, September 2023
[413] President of Japan's JAXA praises partnership with UAE, WAM, July 2023
[414] MBRSC and IDDK partner to push the frontiers of space biotechnology, Zawya, July 2023
[415] Cabinet approves transformation of Saudi Space Commission into an agency, Zawya, June 2023
[416] Saudi Arabia's Moon Ambitions, Mideastspace, January 2023

Saudi astronauts flew to ISS on Axiom Space 2 Mission

Credit: SPA

The two Saudi astronauts Rayyanah Barnawi and Ali Al Qarni flew to the ISS as part of the Axiom Space 2 Mission (AX-2) for a 10-day stay on May 21st – 2 weeks later than planned. They are the first Saudi astronauts to visit the ISS. Rayyanah Barnawi is the first Arab woman aboard the ISS and Saudi Arabia's first female astronaut who travelled to space.[417]

Japan strengthening space cooperation with Saudi Arabia

Saudi Arabia is also solidifying its bilateral ties with Japan. A meeting between Saudi Crown Prince Mohammed bin Salman and Japanese Prime Minister Fumio Kishida resulted in the signing of 26 agreements and MoUs. These agreements cover a wide array of areas, including renewable energy, space, technology, and AI, aligning with the Saudi-Japanese Vision 2030.[418]

Bahrain

Bahrain's National Space Science Agency (NSSA) is reviewing new national space strategy

In May, Bahrain's National Space Science Agency (NSSA) reviewed its upcoming 2024-2028 national space strategy with 85 national stakeholders in a series of consultation meetings. The strategy plans to focus on supporting the development of skills in the space sector, creating research programmes, and providing space data, and establishing regional and international partnerships.[419]

Bahrain and Japan aim to increase cooperation in space science

During a visit to Japan in May, the NSSA and JAXA agreed to increase cooperation in space, in particular in space science. In November, a delegation of the NSSA visited JAXA to discuss increased cooperation between both agencies. The delegation visited key JAXA facilities, as well as the Kyushu Institute of Technology. [420]

Bahrain and India increased interest in cooperation in space

In November, the NSSA welcomed the Indian scientist Apathukatha Sivathanu Pillai, former Defence Research and Development Organisation (DRDO) chief controller, and BrahMos Aerospace's founder & CEO. NSSA expressed interest in enhancing cooperation with India in the space science sector and requested that a technical delegation from the NSSA visits ISRO facilities in the first half of 2024.[421]

UK increased cooperation with Bahrain and the UAE

The UK initiated cooperation with Bahrain and the UAE to develop space solutions tackling natural disasters and greenhouse gas emissions. With support from the UKSA International Bilateral Fund Dubai-based AzurX will create a "space bridge" between the UK and Gulf countries, connecting organisations in the UAE and Bahrain with UK-based companies. Bahrain's National Space Science Agency will also be involved.[422]

[417] Saudi Arabia's first female astronaut will travel to ISS on May 22, the National News, May 2023
[418] Saudi, Japanese leaders discuss enhancing cooperation, AA.com, July 2023 ; NSSA explores Cooperation with Japan Aerospace Agency, News of Bahrain, November 2023
[419] NSSA reviews upcoming strategy with Stakeholders, News of Bahrain, May 2023
[420] Push for more Bahrain-Japan Cooperation in Space Science, News of Bahrain, May 2023
[421] NSSA, Bahrain seeks to enhance India space co-operation, Zawya, November 2023
[422] UAE and Bahrain to work with UK to develop space technologies to help protect the planet, UAE in Space, the national news, September 2023

Oman

Oman plans to build the Middle East's first spaceport

Oman plans to build the Middle East's first spaceport, the Etlaq Space Launch Complex, in the port town of Duqm. It is planned that the spaceport will be fully completed in 3 years. The project is led by the National Aerospace Services Company.[423]

First launch of Oman satellite from the UK failed

In January, the first satellite of Oman (and 9 other satellites) was carried and launched by the LauncherOne rocket by Virgin Orbit in a horizontal launch with a Boeing 747 carrier aircraft from Spaceport Cornwall. The launch failed to deploy all satellites in the target orbits.[424]

Oman's ETCO SPACE launches its first satellite Aman-1

The Omani company ETCO SPACE launched its first satellite Aman-1 on November 11th. The EO satellite was launched aboard a Falcon 9 rocket from the US' Space Launch Complex 4E in Vandenberg, California. The Sultanate of Oman, represented by ETCO SPACE, collaborated with SpaceX, the Polish nanosatellite manufacturer SatRev, and TUATARA to develop, build, and launch the satellite. Aman-1 will collect high-resolution images, which will be evaluated using computer vision, machine learning and AI tools.[425]

1.9.3 Africa stepped up in space

A flourishing space economy in Africa

Credit: Romolo Tavani

2023 was another successful year for several African countries, with remarkably increased domestic activities in space, the first satellites launched and significant projections for the future development of Africa's space sector.

According to the African Space Industry Annual Report 2023 released by Space in Africa, the African space economy is projected to reach $22.6 billion by 2026. Moreover, the report states that the African countries' budget for space activities was worth $425 million, representing an approx. 15% decrease compared with the previous year. The significant decrease is attributed to a plethora of factors, such as fluctuation in foreign exchange rates and the completion of national space projects.[426] According to Space in Africa, as of June, over $4.7 billion were invested by African nations on 58 satellite projects in Africa (manufacturing and launch of satellites), 55 of which were manufactured by 15 countries across 4 regions.[427]

[423] Oman is building the Middle East's first spaceport, the national news, Gulf, January 2023
[424] LauncherOne: Virgin Orbit reveals why UK's first rocket launch failed as it plans further attempts, Sky News, January 2023
[425] Aman-1: The first satellite from Oman launched into space, Times of Oman, November 2023
[426] African Space Industry Annual Report, 2023 Edition, Space in Africa, August 2023
[427] Over USD 4.7 billion Spent on 58 Satellite Projects in Africa, Space in Africa, Africa News, July 2023

Developments in Africa's space governance, policy and laws

African Union Commission inaugurates the African Space Agency

On January 25th, the African Union Commission and the Egyptian government signed an agreement for the formal inauguration of the African Space Agency (AfSA) on the HQ of the new agency in Egypt's Space City. The agreement defines the relations and competencies of both parties. The AfSA aims to serve as a platform for space research and innovation for African countries and to strengthen space missions in Africa. The agency is also in charge of Africa's collaboration with Europe and other international non-African partners.[428] In October, updates on the evolution of the African Space Agency and space-related initiatives led by the AU Commission were presented. The structure and financing of the African Space Agency have been finalised and the AU plans to recruit 150 staff in three phases for the space agency. The next steps are to create "a well-coordinated and integrated space programme" for Africa, taking into account the different degrees of African countries in the space sector, and to develop a regulatory framework that supports the African space programme.[429]

National Developments

- **Ghana:** Ghana approved a national space policy, which provides a framework for sustainable development by using and leveraging space science and technology and coordinates the access to and consumption of space data for ministries, departments and agencies (MDAs) as well as their cooperation and how the data can support the domestic space sector development. It plans to restructure the Ghana Space Science and Technology Institute into a space agency.[430]
- **Senegal:** Senegal plans to establish a national space agency, the Senegalese Space Study Agency, to be led by Maram Kaire as head - as announced by Senegal's President Macky Sall.[431]

First African satellites launched

- **Côte d'Ivoire:** In July, Côte d'Ivoire announced the launch of its first satellite YAM-SAT-CI 01 (an EO nanosatellite), fully domestically manufactured, within the next 2 years.[432]
- **Tanzania:** Tanzania plans to build and launch its first national satellite, to monitor environmental developments and weather, improve surveillance, and provide connectivity services in Tanzania.[433]
- **Kenya:** In April, The Kenya Space Agency (KSA) launched its first 3U EO satellite Taifa-1, which will provide data on agriculture and support Kenya with food security and natural resources management.[434]
- **Djibouti:** In November, Djibouti launched its first EO satellite Djibouti 1A on board of SpaceX's Transporter-9 mission, which is expected to provide data to monitor agriculture and environmental changes.[435]

[428] AUC Inaugurates the African Space Agency, Space in Africa, Africa News, January 2023
[429] AU-EU Space Dialogue Kickstarts in Dakar, Senegal, Space in Africa, Africa News, October 2023 ; Updates on the African Space Agency, Space in Africa, Africa News, October 2023
[430] Ghana Approves Policy to Leverage Space Science and Technology for Sustainable Development, Space in Africa, Africa News, July 2023
[431] President Macky Sall Announces the Launch of the Senegalese Space Study Agency, Space in Africa, Africa News, March 2023
[432] Côte d'Ivoire is launching its first satellite for Earth observation – and it's locally made, The Conversation, July 2023
[433] President Samia Suluhu Hassan Reveals Plans to Launch Tanzania's First Satellite, Space in Africa, Africa News, May 2023
[434] Kenya to launch first Earth Observation Satellite with SpaceX, The Star, April 2023
[435] Djibouti Launches First Satellite, Djibouti 1A, Space in Africa, November 2023

Other space developments in Africa:

- **Egypt:** Egypt's MisrSat-2 successfully completes testing phase. This milestone of this Egyptian-Chinese MisrSat-2 technology transfer project laid the basis for the on-site testing and assembly of the Multi Transponder Mode and Frequency Modulation experimental work. Egypt and China cooperated to provide Egyptian engineers and scientists with satellite design and integration experience and knowledge, using facilities in Egypt.[436] Egypt's Nexsat-1 satellite was scheduled for launch from China end of 2023, but the launch was postponed and actually launched in February 2024. Egypt's EgyptSat-2, the nation's second Earth remote-sensing satellite, was set to be launched from China in October (also postponed to actual launch in April 2024).
- **Ghana:** The Ghana Space Science and Technology Institute (GSSTI) and the Tunisian Space Association signed a partnership agreement to cooperate and advance the countries' space sector development and future cooperation in space R&D and training. Areas of mutual interest are astronomy and EO, data-sharing for augmenting EO applications for environment management, precision agriculture, land use, air pollution, mining, forest management, and coastal area management.[437]

International and bilateral cooperation

- **Group on Earth Observations (GEO):** Nigeria's National Space Research and Development Agency (NASRDA) joined the Group on Earth Observations (GEO) - becoming the second African nation (after South Africa) to become part of the GEO initiative, an intergovernmental organisation comprised of 100 national governments that aims at improving the availability, access and use of EO data and supports decisions and actions based on EO data.[438]
- **Climate Observatory (CSO) Charter:** SANSA signed the Space for Climate Observatory (CSO) Charter: an international platform leveraging EO capabilities and aiming to enhance climate action through the optimised use of satellite data through international cooperation.[439]
- **Europe:** In January, the EC announced the establishment of an EU-Africa space flagship programme, which will focus on (1) innovation and a partnership, (2) space for green transition and (3) focus on establishing business ecosystems of start-ups and accelerators.[440]

  From October 24th to 26th, the EU and the African Union (AU) held a first-ever EU-AU Space Dialogue on cooperation in space, which took place in Senegal. The European delegation (DG DEFIS, DG INTPA, the EU's JRC, ESA and EUMETSAT) and the African delegation discussed joint initiatives and strategic partnerships in space – in space for sustainability and development cooperation, and space applications, incl. a dedicated event on IRIS^2 and related cooperation opportunities with African governments and industry by 2024.

  The space cooperation between Europe and Africa can address global challenges such as climate change, and disaster management through an effective early warning system and fishing monitoring. On the sidelines of the AU-EU Dialogue in Senegal, the Senegalese Space Study Agency (ASES) signed an agreement with ESA to harness the power of space technology for the socio-economic advancement of Senegal.[441]

  Also in October, the EU-Nigeria Strategic Meeting took place, with a €900 million financial package as part of the EU's Global Gateway Initiative and as part of EU-Nigeria cooperation to

[436] Egypt's MisrSat-2 Passes Another Milestone, Africa in Space, Africa News, May 2023
[437] Ghana and Tunisia Sign New Space Cooperation Agreement, Africa in Space, Africa News, June 2023
[438] Nigeria Joins the Group on Earth Observations, Africa in Space. Africa News, May 2023
[439] SANSA Becomes a Signatory of the SCO Charter, Africa in Space, Africa News, November 2023
[440] European Commission Plans for Africa and Latin America, Spacewatch Global, January 2023
[441] ASES to Collaborate with ESA to Leverage Space Technology for Socio-Economic Growth in Senegal, Space in Africa, October 2023

advance the country's green, resilient, digital inclusive transition. In particular, the EU will support Nigeria to achieve enhanced infrastructure connectivity to support agriculture, economic growth, health, education, sustainable development and environmental protection.

- **U.S.:** During the 2023 Esri User Conference in the U.S. in July, the Rwanda Space Agency (RSA) and Esri signed a MoU to launch a partnership and create a framework enabling the provision of geospatial services to boost social-economic development in Rwanda. The agreement supports the RSA's mission to increase the use of space and GIS solutions for socio-economic development in Rwanda. Moreover, the Kenya Space Agency (KSA) and TomorrowNow.org signed an LoI to launch a cooperation to utilise space data to enhance food security and climate change adaptation for better agricultural decision-making in in Kenya.[442]
- **China:** The China-Africa Cooperation Centre on Satellite Remote Sensing Application was inaugurated by the Ministry of Natural Resources of China. This programme aims to create a data-sharing platform and utilise remote sensing technology to monitor natural resources in coastal zones and mangroves across the African continent. During the inauguration, Egypt's Space Agency (EgSA) and the Chinese Land Satellite Remote Sensing Application Centre (LASA), signed a MoU to enhance Egypt's access to remote sensing data, enabling more informed decision-making.[443]

  Furthermore, Egypt's Nexsat-1 satellite, scheduled for launch from China end of 2023 was postponed and launched in February 2024. EgyptSat-2, Egypt's second Earth remote-sensing satellite, was set to be launched also from China in October (postponed launch in April 2024).

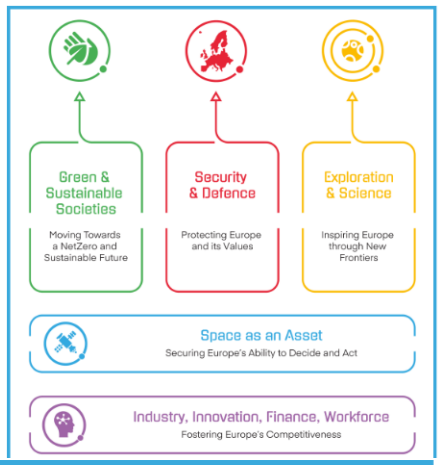
  Also in October, Nigeria and China cooperated to kick-off the Crop-Watch Programme in Nigeria. the Chinese agricultural monitoring system, which uses remote sensing and ground observation data to monitor crops, aims to modernise agriculture and enhance food security in Nigeria.[444]

  In January, the Republic of Djibouti signed an MoU with Hong Kong Aerospace Technology Group Limited and Touchroad International Holdings Group to develop an international commercial spaceport located in the Obock region. The 5-year $1 billion project will include 7 satellite launch pads and 3 rocket testing pads as well as port infrastructure and highways for the transportation of aerospace materials sent from China. Djibouti will not be the owner of the spaceport but will provide the necessary land with at least 35 35-year lease. Djibouti will only receive the infrastructure after a 30-year co-management contract with Hong Kong Aerospace Technology, planned to be signed in March – but it faced regulatory hurdles - which postponed the finalisation of the contract.[445]

[442] RSA and Esri Sign MoU to Boost Geospatial Services for Rwanda's Social-economic Development, Space in Africa, Africa News, July 2023 ; KSA and TomorrowNow.org Join Forces to Enhance Food Security and Climate Change Adaptation in Kenya, Space in Africa, Africa News, July 2023
[443] The China-Africa Cooperation Centre on Satellite Remote Sensing Application Takes Off, Space in Africa, Africa News, July 2023 ; EgSA and Chinese LASAC Collaborates for Enhanced Remote Sensing Capabilities in Egypt, Africa in Space, Africa News, July 2023
[444] Nigeria Collaborates With China to Commence the Crop-Watch Programme in Nigeria, Space in Africa, Africa News, October 2023
[445] Djibouti Signs MoU to Develop Commercial Spaceport, Spacewatch Global, January 2023 ; China's Space Dream Is a Legal Nightmare, Foreign Policy, April 2023

2 INDUSTRY AND INNOVATION

2023 saw various developments in industry & innovation, which can be broadly categorised in ESPI's 5 research themes, especially in the transversal theme "Industry, Innovation, Finance, Workforce" and in the three vertical themes (1) Green & Sustainable Societies, (2) Security & Defence, (3) Exploration & Science, as well as in the other transversal research theme "Space as an Asset".



Chapter Industry & Innovation	ESPI's 5 Research Themes	
Subchapters	Primary Research Theme(s)	Connected Themes
2.1.1 Verticalisation: Bringing the benefits of space into new economic domains		
2.1.2 Developments in in-orbit servicing and in-orbit assembly		
2.1.3 Space Cybersecurity in high demand		
2.1.4 Satellite Constellations		
2.1.5 Notable developments in the use of space to support the climate transition		
2.2.1 Promises of space nuclear propulsion		
2.2.2 Space-based solar power		
2.2.3 Conflicts worldwide spark new demand for GEOINT services		
2.2.4 Artificial Intelligence (AI) is making its way into the space sector		
2.2.5 Commercial spaceflight: from commercial launches, over commercial space stations, to the moon		
2.2.6 New Digital platforms emerge to process EO data		

2.1 Space Industry Highlights & Trends

2023 space industry highlights verticalization (space in other industry sectors), developments in in-orbit servicing, a boost in space cybersecurity, updates in commercial satellite constellations, and use of space for green.

2.1.1 Verticalization: Bringing the benefits of space into new economic domains

As space continues to boost other business verticals, three sectors have witnessed the most developments: the maritime, automotive and biotechnology domains. Some advancements in energy and terrestrial transport leveraging space also took place in 2023.

Space enters the maritime sector: from maritime surveillance to on-cruise connectivity

Within the maritime sector, progress was made to integrate space connectivity on ships:

Starlink:

- California-based Anuvu, announced in January the signature of a deal to resell Starlink broadband services for maritime operations, complementing their current effort to the sector from their GEO capacities.[446]
- Norwegian Cruise Line is currently conducting trials of SpaceX's Starlink internet service on one of its cruise ships, with intentions to expand its usage to more vessels, as well as other brands such as Oceania Cruises and Regent Seven Seas Cruises. The parent company of the cruise line, Norwegian Cruise Line Holdings Ltd., revealed these trials in April.[447]
- Australian-based Scenic Group, the parent company of Scenic Luxury Cruises and Tours and Emerald Cruises, added Starlink broadband services to their yacht fleet, as announced in June.[448]
- Starlink secured another contract within the maritime sector, Hapag-Lloyd will begin implementing Starlink connectivity across its fleet.[449]
- In September, Cunard, a British cruise line, unveiled an agreement to adopt SpaceX's Starlink internet service throughout its fleet.[450]
- SES and Starlink also revealed a partnership to provide connectivity for the cruise industry in September. This involved incorporating Starlink connectivity into SES offerings, with a solution in the fourth quarter of 2023 providing multi-orbit connectivity, combining medium Earth orbit and LEO connectivity.[451]
- Maersk, the Danish shipping and logistics giant, intends to implement SpaceX's Starlink broadband internet service on over 330 container ships, the company announced in October. Having conducted successful trials on more than 30 vessels, Maersk received favourable feedback from the crew regarding Starlink's performance.[452]
- Announced in October, Holland America Line, a cruise company, is currently upgrading the internet service on its fleet of 11 ships to SpaceX's Starlink service. It announced that it

[446] Anuvu gets deal to resell Starlink to maritime customers amid Telesat uncertainty, SpaceNews, January 2023
[447] Norwegian Cruise Line Plans Starlink Deployment, Via Satellite, April 2023
[448] Scenic Group Adding Starlink Internet Service To Its Yacht Fleet, Travel Pulse, June 2023
[449] Shipping Company Hapag-Lloyd Chooses Starlink for its Fleet, Via Satellite, September 2023
[450] British Luxury Cruise Line Cunard is Deploying Starlink, Via Satellite, September 2023
[451] SES Teams Up with Starlink to Package Connectivity for the Cruise Segment, Via Satellite, September 2023
[452] Maersk to Deploy Starlink on More than 300 Container Ships, Via Satellite, October 2023

anticipates completing the installation of Starlink Internet on the remaining five ships in its fleet by mid-December.[453]

Eutelsat:

- As announced in September, Can Marine Systems partnered with Eutelsat Communications to acquire satellite connectivity covering the Asia-Pacific region. With this agreement, Can Marine Systems will have access to Eutelsat Advance, the managed service offering from the operator that combines capacity from both GEO and LEO satellites.[454]
- Marlink, a service provider in maritime communications, committed to a multi-year, multi-million-dollar deal for high throughput Ku-band capacity in GEO on the Eutelsat 10B satellite. This capacity will cover regions including Europe, the Middle East, Africa, and essential maritime routes. The agreement between the two companies was announced in October.[455]
- MediaMobil, a telecommunications firm specialized in internet services provision to remote areas, has entered into an agreement with Eutelsat Communications for maritime connectivity services catering to ships and offshore vessels, as announced in November. Eutelsat will furnish its Advance managed service to establish connectivity for MediaMobil's extensive fleet comprising over 100 multipurpose, tanker, and offshore construction vessels.[456]

OneWeb:

Credit: Kymeta

- OneWeb launched in June an offer for maritime LEO broadband coverage services.[457]
- Announced in June, Kymeta's latest electronically steered Peregrine u8 LEO terminal became accessible for purchase by maritime market clients on OneWeb's LEO network. Tailored for large vessels, ranging from super yachts to commercial fishing and shipping vessels, the Peregrine u8 LEO terminal offers enterprise-grade connectivity via OneWeb. Kymeta assures that this new terminal will facilitate seamless and effortless connectivity for customers, ensuring they can stay connected at sea as easily as they would on land.[458]

Other telecommunications providers:

Credit: Aalyria

- Aalyria Technologies signed a new MoU with HICO Investment Group, to invest in innovative technologies within the maritime and logistics sectors, and aim to deploy around 200 of its optical communications platforms on commercial ships globally. Aalyria is also developing the Tightbeam laser terminal, designed to transmit data through the atmosphere at speeds of up to 100 Gbps. The overarching objective is to equip thousands of marine vessels with Tightbeam laser terminals.[459]
- As reported by Immarsat in November, Totoheo Maritime, a company specialised in satellite communications and technologies, surpassed 1,000 installations of Fleet Xpress terminals. [460]
- Axess Network secured a new contract in the maritime sector, as announced in April. Teleserve P/F, a communications service provider based in the Faroe Islands, will collaborate with Axess

[453] Holland America Implements Starlink on its Ships, Via Satellite, October 2023
[454] Eutelsat Signs Maritime Deal for Advance Managed Service, Via Satellite, September 2023
[455] Marlink Taps Eutelsat for a New Maritime Deal, Via Satellite, October 2023
[456] Eutelsat to Supply Maritime Connectivity to MediaMobil, Via Satellite, November 2023
[457] OneWeb targets maritime market with expanded satellite coverage, SpaceNews, June 2023
[458] Kymeta Releases Peregrine u8 LEO Terminal for OneWeb Maritime Customers, Via Satellite, June 2023
[459] Aalyria and HICO Plan to Deploy Laser Communications on Commercial Ships, Via Satellite, October 2023
[460] Totoheo Maritime Hits 1,000 Fleet Xpress Installs, Via Satellite, November 2023

Networks Maritime, a subsidiary of Axess Networks, to provide connectivity services for their clients' maritime operations in Northern Europe. Axess Maritime will supply a semi-global satellite connectivity service to Teleserve's fleet of 14 general cargo vessels, supporting their activities in and around the North Sea through a tailored 2-beam iDirect Ku network solution. Teleserve will gain access to Axess Maritime's advanced vessel monitoring portal, which allows real-time tracking of vessel performance and enables bandwidth adjustments on demand.[461]

Credit: Inmarsat

- South Korean Intellian Technologies and Slovakian Marlink, which provides managed satellite solutions primarily in the maritime sector, announced the renewal of their strategic partnership for another five years. Under this agreement, Intellian will continue supplying Marlink's end users with hybrid connectivity terminals. The partnership will involve collaborative product development aimed at enhancing hybrid connectivity solutions across GEO, MEO, and LEO networks.[462]

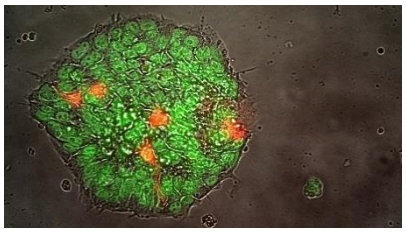
SIGINT and maritime surveillance services were also in the spotlight in 2023:

- Florida-based Blacksky Technologies and Virginia-based Spire Global announced in May the offering of a service to monitor ships via satellite. This SIGINT maritime tracking service utilises radio frequency emissions to autonomously assign tasks for imagery, identify and categorise vessels, and maintain ongoing monitoring of changes, by integrating data from Spire and prompting BlackSky's satellites to capture imagery automatically.[463]
- Virginia-based HawkEye 360 announced it had been awarded a contract from the U.S. Navy's Naval Information Warfare Center Pacific in October. They will share satellite radio frequency data, and provide analytics and training services to partner nations in Southeast Asia and the Pacific Islands for maritime surveillance.[464]

Space for health: notable developments in space for biotechnology and pharmaceuticals

In the field of biotechnology, there is a growing interest in leveraging space to facilitate advanced research:

- Swiss-based SpacePharma, a Deep Tech company conducting pharmaceutical R&D and manufacturing in space, announced in April the settlement of their European presence at the International Space University (ISU) in Strasbourg, which hosts a dedicated incubator.[465]



Credit: Cedars-Sinai

- California-based Cedars-Sinai is sending stem cells to the space station on Axiom Space's second private astronaut mission (Ax-2) in May to advance stem cell-based therapies. These hold promise for addressing age-related conditions, yet their production demands large quantities of stem cells, posing a challenge. To overcome this hurdle, researchers in regenerative medicine seek assistance from the International Space Station (ISS) National Laboratory. They aim to cultivate substantial amounts of high-quality adult stem cells for therapeutic purposes. Earth's 2D culture conditions have limited stem cell production due to their inability to mimic the native human body environment effectively. However, the

[461] Axess Networks Wins New Maritime Deal With Teleserve, Via Satellite, April 2023
[462] Intellian and Marlink Ink Partnership to Collaborate on Hybrid Satellite Solutions, Via Satellite, November 2023
[463] BlackSky, Spire roll out space-based maritime tracking service, SpaceNews, May 2023
[464] HawkEye 360 gets U.S. Navy contract for maritime surveillance in the Pacific, SpaceNews, October 2023
[465] Development Of Micro Labs For Space By SpacePharma At ISU Central Campus, ISU, April 2023

microgravity environment aboard the ISS facilitates three-dimensional cell growth, closely resembling natural cellular growth in humans. Leveraging microgravity as a platform offers a potential solution for enhancing stem cell production, thus improving treatments and patient outcomes back on Earth.[466]

- Germany-based Space Origami announced in June planning a mission to send a crystallisation experiment called DNA Origami to the ISS with two objectives: crystallising the experiment and studying how it behaves in space.[467]
- Sierra Space and Redwire announced a partnership for a space station biotechnology platform in August. The equipment, which will be provided by the last, will be installed on the Large Integrated Flexible Environment (LIFE) inflatable module from Sierra Space. The objective of such module would be to serve for commercial pharmaceutical and biotechnology research purposes.[468]
- German start-ups Rocket Factory Augsburg (RFA), ATMOS Space Cargo (ATMOS) and Yuri announced a partnership to develop an end-to-end microgravity service for biotech research and product development. This initiative, revealed in October, is aimed to be available from 2025 as also an alternative to the ISS laboratory.[469]
- California-based Varda Space Industries announced the launch of their first in-space manufacturing spacecraft for pharmaceutical drugs in June. Later in the year, the capsule struggled with the permits for Earth re-entry.[470]
- Japanese researchers from the University of Yamanashi's Advanced Biotechnology Centre and JAXA announced in October the growth of mouse embryos in space: an important development that suggests the possibility for humans to reproduce in space.[471]
- In September, Florida-based Redwire announced the successful 3D-bioprinting of human tissue in space on its 3D BioFabrication Facility (BFF) on the International Space Station. This supposes an advancement since this bioprinting is not easily done on Earth due to gravity.[472]

Credit: Redwire

- UK-based BioOrbit, announced in November developing a technology to manufacture cancer drugs in space. The start-up seeks to enhance the accessibility and convenience of antibody cancer treatments with a novel approach centred on drug crystalisation. Such drugs can be administered subcutaneously but protein antibody drugs pose challenges in crystallisation, yielding low-quality results on Earth. By doing this in space lacking Earth's gravity, BioOrbit aims to produce superior-quality crystals, offering potential advancements in cancer treatment delivery.[473]
- South Korea-based pharmaceutical company Boryung, announced the inversion of $50 million in Texas-based Axiom Space in December.[474]

[466] Cedars-Sinai to Send Stem Cells to the Space Station to Aid in the Advancement of Stem Cell-Based Therapies, ISS National Laboratory, May 2023
[467] Why should we analyse DNA origami in space? Space Origami, June 2023
[468] Redwire and Sierra Space partner on commercial space station biotech research platform, Space News, August 2023
[469] Three German NewSpace companies launch "Eva", the world's first end-to-end microgravity service for biotech research and product development, RFA, October 2023
[470] This Space Factory Will Attempt to Produce Medical Drugs in Orbit, Gizmodo, June 2023
[471] Mouse embryos grown in space for first time: Japan researchers, National News Agency of Bangladesh, October 2023
[472] Redwire demonstrates bioprinting human tissue in space, SpaceNews, September 2023
[473] UK start-up to develop tech for pharma factory in space, UK Research and Innovation, November 2023
[474] South Korean pharma invests $50 million in Axiom Space, SpaceNews, December 2022

- LambdaVision, a Connecticut-based pioneering drug startup, started to develop the first-ever cure for genetic blindness. Their plan involves manufacturing a retina, the tissue at the back of the eye responsible for converting light into optic nerve signals. To achieve this, lab workers meticulously deposit 200 ultra-thin layers of light-sensitive protein into a polymer mesh. However, this intricate process is challenging to master on Earth. Consequently, LambdaVision has partnered with Space Tango and is working closely with NASA, hoping that the ISS's reduced gravity environment will allow better production quality.[475]

Credit: LambdaVision

Space for the automotive sector: connected and autonomous cars

The automotive sector is exploring the integration of satellite connectivity in vehicles:

- Texas-based CesiumAstro announced its collaboration with various car manufacturers to explore the possibility of launching a LEO constellation tailored for the automotive industry, devising both a constellation plan and an antenna design specifically for vehicles. This collaboration includes, among others, Volkswagen.[476]
- EnSilica and VITES joined forces to provide a beam-former chip for satellite user terminals. Announced in October, the collaboration will see VITES utilising EnSilica's chip in its upcoming ViSAT-Ka-band terminal. The beam-forming chip from EnSilica is designed to empower VITES in developing ground-based flat panel user terminals for satellite communication systems, ensuring both power and cost efficiency. These terminals are versatile, catering to fixed installations as well as communication-on-the-move applications, including integration into vehicles for seamless communication while in motion.[477]

Credit: VITES

- UNIO showcased the outcome of a connected vehicle trial featuring a "bridge" device facilitating the seamless transition of vehicles from 5G to satellite connectivity. In November. During a live demonstration in Munich, Germany, a vehicle smoothly shifted between 5G data transmission and satellite connection without any disruptions to the data flow.[478]
- The Chinese company Geely announced the plan to launch 72 satellites by 2025 as a first phase of its constellation to provide intelligent driving functionality and to enable self-driving for Galaxy, the new range of electrified and fully electric cars.[479]

Space for Energy: supporting renewables and fossil fuel production

In the energy vertical, an American worldwide supplier of Internet of Things (IoT) solutions, ORBCOMM, revealed in March that FreeWave Technologies, a company specialised in industrial wireless technology, selected ORBCOMM's satellite technology to enhance their range of environmental IoT solutions to enhance the effectiveness, eco-friendliness and adherence to regulations of their remote industrial operations across the globe.[480]

Credit: ORBCOMM

[475] Drug startup aims to cure blindness by developing medications in space, New York Post, December 2023
[476] Why the Former CEO of Volkswagen America is Working with CesiumAstro on the Connected Car, Via Satellite, May 2023
[477] VITES Taps EnSilica for Terminal Upgrades, Via Satellite, October 2023
[478] UNIO Reports Connected Vehicle Demo with 5G and Satellite, Via Satellite, November 2023
[479] Chinese carmaker to launch 72 satellites to assist intelligent driving, Space.com., March 2023
[480] FreeWave Leverages ORBCOMM's Satellite IoT Technology to Automate Remote Industrial Operations, ORBCOMM, March 2023

Orbital Sidekick, a Californian startup company, announced in April the launching of two small satellites into orbit, dubbed GHOSt 1 and GHOSt 2, to monitor emissions from oil and gas pipelines worldwide. These dishwasher-sized satellites are equipped with advanced technology to analyse various wavelengths of light, enabling them to detect any potential hydrocarbon leaks from the pipelines.[481]

Oregon-based PacWave, which presented their project at the Ocean Energy Europe 2023 in September, is using satellite communications to monitor sea status for their solution to the development of wave power. This initiative is funded by the U.S. Department of Energy (DOE).[482]

Credit: Globastar

Globalstar Europe Satellite Services, the European arm of Globalstar, disclosed in August a collaboration with INEOS, a prominent global petrochemicals company, with operations spanning 194 facilities across 29 countries worldwide. This partnership involves utilising Globalstar's solutions to oversee and protect the transportation of highly volatile gases via rail and road across mainland Europe. INEOS Oxide, a division of INEOS, is implementing Globalstar's Ovinto Sat tracking solution for monitoring transportation activities.[483]

Singapore-based Kumi Analytics, a start-up developing a project management platform for carbon offsetting, was selected in October for the UK Seraphim Space accelerator. The company was selected with together with Aquascope, a start-up aiming to provide freshwater intelligence.[484]

Tenchijin, a space enterprise endorsed by JAXA, declared their collaboration with various municipalities across Japan in November to address the urgent challenges in water pipeline management. This comes as a fourth contract, having municipalities like Fukushima-shi, Setoshi, Aomori-shi or Maebashi-shi already partnered with the company.[485]

In November, the Ugandan government disclosed their plans to construct the longest heated crude oil pipeline globally, to transport oil from Uganda to the coast of Tanzania on the Indian Ocean. This pipeline will be equipped with electrical and fibre-optic cables to supply heat and enable real-time satellite monitoring to prevent leaks.[486]

Credit: Chimp Reports

As announced in December, Indian-based Aumsat Technologies LLP uses satellite-based radar analytics to tackle water scarcity. They utilise a device to detect pipeline leaks within 10-metre-thick concrete and identify water sources up to 60 metres underground.[487]

[481] Newly Launched Satellites Ready To Track Down Pipeline Leaks, JPT.75, April 2023
[482] Testing the Promise of Harnessing Ocean Energy with Satellite Technology, SpaceNews, April 2023
[483] Globalstar Reveals Details of Petrochemicals Deployment, Via Satellite, August 2023
[484] Seraphim unveils the 10 startups in its twelfth space accelerator, SpaceNews, October 2023
[485] Tenchijin Expedites Collaborations with Municipalities to Address Global Water Pipeline Management Challenges, Business Wire, November 2023
[486] Uganda to Use Satellites to Secure 1,443-km Heated Oil Pipeline, Chimp Reports, November 2023
[487] Using satellite technology to combat water scarcity in India, Prevention Web, December 2023

Space for transport: space is entering the aviation and railways sectors

Satellite connectivity services for the aviation sector is becoming commonplace:

American-based CesiumAstro announced in March the creation of a new multi-beam flat panel terminal for aviation, venturing into in-flight connectivity. This is the first user terminal for the aviation market from the company. The terminal can accommodate multiple Ka-band constellations and tracks numerous satellite beams facilitating smooth handoffs to execute make-before-break connections.[488]

American Delta Air Lines announced in November selecting Hughes Network Systems to provide in-flight connectivity for around 400 Boeing 717 and regional jets serving North America, marking Hughes' first direct-to-airline in-flight connectivity deal.[489]

Aerolineas Argentinas announced in November choosing Intelsat to deliver multi-orbit in-flight connectivity service across eighteen Airbus A330 and Boeing 737 MAX aircraft. Intelsat stated that the partnership will make the airline the first one in Latin America to deploy their latest electronically steered array antenna for in-flight connectivity.[490]

Canadian Porter Airlines, announced in October the extension of its collaboration with Viasat for in-flight internet services. A further set of 20 Embraer E195-E2 jets will be equipped with Viasat hardware, in addition to the initial 30 jets that already feature the internet service.[491]

Credit: Porter Airlines

Starlink has secured several agreements for its Starlink Aviation service:

- In January, Latvian airline airBaltic announced their intention to equip their Airbus A220-300 fleet with Starlink connectivity systems.[492]
- Japanese Zipair Tokyo announced in the same month the signing up to Starlink services to provide onboard connectivity to their passengers.[493]
- Air New Zealand announced in December partnering with Starlink to provide onboard Wi-Fi. By late 2024, they will commence with its installation on an ATR domestic aircraft, initiating a trial phase that will last from four to six months. Following the trial, Air New Zealand intends to extend the use of Starlink Internet across its fleet in 2025, contingent upon the trial's outcome.[494]
- In October, Qatar Airways announced selecting Starlink to provide passengers with in-flight connectivity, including Wi-Fi speed of up to 350 megabits per second for gaming, VPN access and sports streaming among others.[495]

Terrestrial transports, including railways, are also exploring the use of space systems:

The Hybrid Space-Ground Communication Network for European Rail Systems project kicked off in January by a consortium formed by Airbus Defence & Space, DB Engineering & Consulting, SNCF and RHEA System, with the European Space Agency (ESA). The project, co-funded by French Space Agency CNES and German Space Agency DLR, aims to develop an integrated solution for satellite-terrestrial operational communication services for safety-critical operations. Such a solution targets the German Deutsche Bahn (DB) and the French Société Nationale des Chemins de fer Français (SNCF).[496]

[488] CesiumAstro Jumps into IFC Market With New Phased Array Antenna, Avionics International, March 2023
[489] Hughes Lands Delta Deal to Connect 400 Regional Jets, Via Satellite, November 2023
[490] Intelsat and Aerolíneas Argentinas announce in-flight connectivity first, Developing Telecoms, November 2023
[491] Porter Airlines expands Viasat commitment for 20 more E195-E2 jets, Paxex.aero, October 2023
[492] AirBaltic equipará toda su flota con Starlink de SpaceX, EnElAire, January 2023
[493] Japan's Zipair signs up for SpaceX's Starlink, FlightGlobal, January 2023
[494] Air New Zealand partners with Starlink for onboard wifi, Airport Technology, December 2023
[495] Qatar Airways Selects Starlink to Enhance In-Flight Experience with High-Speed Internet Connectivity, Qatar Airways, October 2023
[496] RHEA Contributes to a Secure Space-Ground Communication Network for European Rail Systems, Rhea Systems, April 2023

2.1.2 Developments in in-orbit servicing and in-orbit assembly

In-Orbit Servicing (IOS) gained traction in recent years: extending satellite lifespans and functionalities. IOS involves one spacecraft supporting another in orbit, offering services like refuelling or repairs. In-orbit assembly combines modular platforms to create new objects, while in-orbit manufacturing uses techniques like 3D printing to build components directly in space, reducing reliance on Earth-based materials.[497]

Credit: Blue Origin

IOS services can be divided into: Active Debris Removal, Refuelling, Docking & Rendezvous and Proximity Operations, In-space Manufacturing & Assembly, and Last Mile Delivery.

Active Debris Removal (ADR)

ADR can be defined as the process in which a space system is being captured to relocate it to a graveyard orbit or to accelerate its atmospheric re-entry at the end of the satellite's life. This involves the capture of a noncooperative object.[498]

Swiss company ClearSpace leading European activities in ADR:

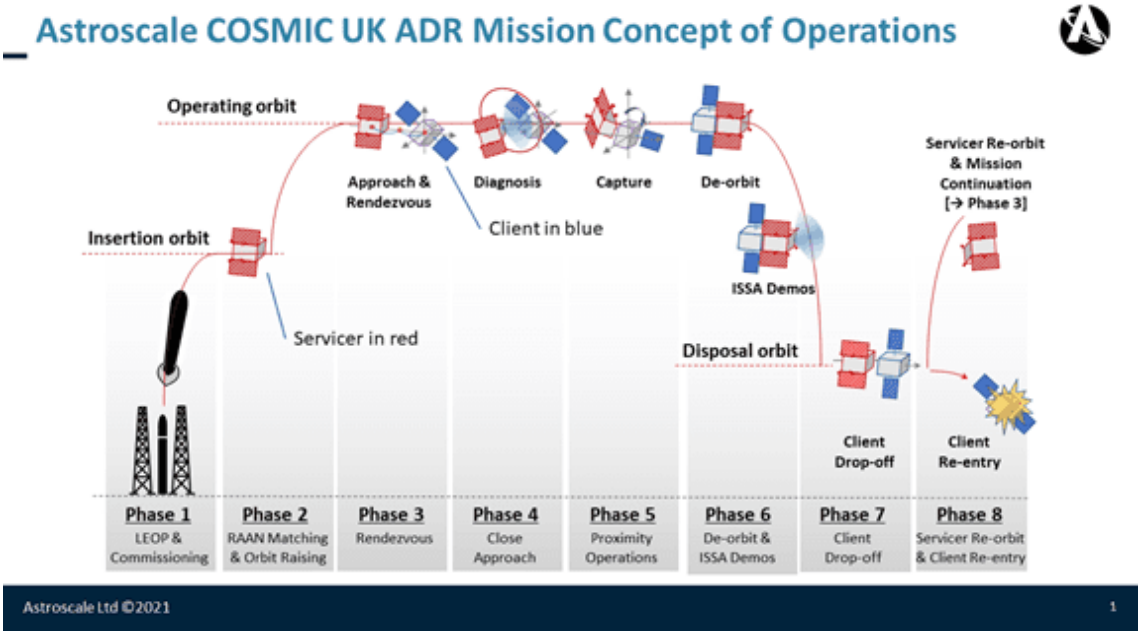
- In February, the Swiss company ClearSpace completed its first programme review with ESA, advancing its mission to remove large debris from Earth orbit. With the successful development of a four-armed capture system for its robotic satellite, ClearSpace secured full funding for detailed satellite design and procurement, aiming for a potential launch by 2026. This progress was bolstered by a €26.7 million Series A financing round to accelerate sustainable space use through collaboration with industrial partners.[499]
- In April, ClearSpace and U.S. company LeoLabs signed a MoU to collaborate on fostering a safe and sustainable space ecosystem. The MoU solidified their intent to build upon previous collaborative efforts and explore new initiatives to promote space safety and address challenges posed by space debris and traffic management.[500]
- In May, ClearSpace and Arianespace agreed to launch ClearSpace-1 with the Vega C launcher in late 2026. The spacecraft will perform a test in a sun-synchronous drift orbit before capturing and deorbiting the piece of debris.[501]
- In June, ClearSpace completed the System Requirements Review for its CLEAR Mission assessing technical requirements and investigating the satellite's functionality, design, and operational objectives. The next step in the development of the mission is the Preliminary Design Review.[502]

Credit: ClearSpace

[497] ESPI Report 87 – On-orbit Servicing, Assembly, and Manufacturing: State of Play and Perspectives on Future Evolutions – Full Report, ESPI, October 2023
[498] Ibid.
[499] Revolutionary Space Debris Removal Mission Advances to Next Phase, clearspace.today, February 2023
[500] ClearSpace and LeoLabs partner to advance a safer, more sustainable space environment, clearspace.today, April 2023
[501] Arianespace to launch the first active debris removal Clearspace mission with Vega C, Arianespace, May 2023
[502] ClearSpace reaches key milestone in the development of the national UK debris removal mission, clearspace.today, June 2023

Other European companies are developing and launching space safety missions:

- In March, Astroscale UK launched the COSMIC mission with the UK Space Agency and 10 UK-based partners. COSMIC builds upon Astroscale's ELSA-M servicer, which was developed under the Sunrise programme with the European and UK Space Agencies, along with OneWeb, and aims to remove two defunct British satellites from LEO by 2026, enhancing robotic debris capture. The spacecraft, equipped with a robotic arm, will safely capture and release satellites into lower disposal orbits for re-entry.[503]



Credit: Astroscale

- In June, French start-up Aldoria (formerly Share My Space) partnered with Astroscale Japan to optimise attitude assessment of space objects in LEO, crucial for in-orbit rendezvous. Aldoria's expertise in orbital object attitude analysis, using ground-based sensors provided optical data to characterise rotation rates and tumbling axis, enhancing Astroscale's collision prevention capabilities.[504]
- In June, CNES awarded French company Dark a contract for the world's first private emergency interception simulation. Dark's Interceptor system aims to capture large debris like rocket bodies in any orbit within six hours. CNES selected a rocket body from a list of 50 objects needing urgent removal from orbit. Dark targets a 2026 maiden launch for its Interceptor rocket and has initiated engine testing.[505]
- In November, Airbus launched the "Detumbler" device to prevent satellites from tumbling at the end of their operational life. Developed with support from CNES, it stabilises satellites using a central rotor wheel and magnets interacting with Earth's magnetic field. Scheduled for testing in early 2024, it aids future missions, particularly in ADR efforts.[506]

[503] Astroscale on course for first UK national mission to remove space debris, Astroscale, March 2023
[504] Astroscale x Share My Space, Aldoria, June 2023
[505] Dark and CNES are preparing the future of space protection and security, Dark, June 2023
[506] Airbus' patented "Detumbler" to tackle in-orbit debris, Airbus, November 2023

American start-ups are developing technology for ADR with contracts from NASA:

- In August, TransAstra secured an $850,000 NASA contract to develop an inflatable capture bag for orbital debris. This bag is flexible for various-sized objects and does not require docking. Collaborating with ThinkOrbital, TransAstra proposes transporting captured debris to an in-orbit processing plant for inspection, repair, and reuse, addressing space debris and promoting in-space manufacturing and construction for space exploration and national defence.[507]

Credit: TransAstra

- In September, UK start-up Turion Space secured £5 million contracts from NASA, the Space Force, and the Air Force. Supporting in-orbit mobility and debris removal, Turion aims to enhance Earth orbit's economic capacity through responsive Droids. Plans include launching Droid-2, the first docking mission, in October 2024. Turion plans a larger central craft, the Mothership, to host multiple micro-Droids for reconnaissance and debris removal.[508]

Refuelling

Satellite refuelling refers to the process of replenishing propellants and other consumables onboard satellites while they are in orbit. This **enables the extension** of a satellite's operational lifespan to maintain its orbit, adjust its position, or perform other manoeuvres as needed. It can also involve replenishing other consumables such as coolant, for maintaining optimal temperature conditions.[509]

European companies are developing projects for in-orbit refuelling:

- In May, ASI awarded Thales Alenia Space a €235 million contract for in-orbit servicing, part of Italy's space sector's investments through the recovery fund. Thales Alenia Space is leading a consortium, which includes Leonardo, Telespazio, Avio, and D-Orbit, for the project scheduled to launch by 2026. The initiative aims to extend the satellite lifespan using an autonomous robotic vehicle, addressing the demand for satellite services in navigation, connectivity, weather forecasting, and environmental monitoring through various robotic operations on existing satellites.
    - Leonardo is developing a dexterous robotic arm for these operations, in partnership with SAB Aerospace, the Italian National Institute for Nuclear Physics, and the Italian Institute of Technology.
    - Telespazio, together with Altec, will handle the ground segment design, development, and validation for the mission.
    - Avio will contribute to the project by designing and developing the Orbital Support Module and Propulsion for orbital stages.
    - D-Orbit will manage activities related to the target satellite platform and the refuelling system.[510]

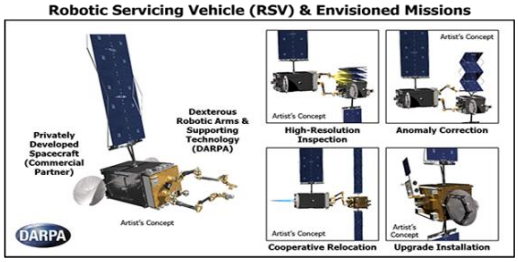
[507] TransAstra claims NASA contract for debris capture bag, SpaceNews, August 2023
[508] Turion Space Wins Six NASA and USAF Contracts, Payload, September 2023
[509] Op. cit. ESPI Report 87
[510] Firmato il contratto ASI-Thales Alenia Space per la prima missione italiana di in orbit-servicing, ASI, May 2023

- In September, The Exploration Company (Germany) and Spaceium (Canada) partnered to develop lunar and deep space exploration missions. Spaceium's in-orbit service station will refuel NYX spacecraft with cryogenic fuel, enhancing its lunar mission capabilities. In return, NYX will serve as Spaceium's primary servicing platform for its 2026 mission.[511]

Credit: The Exploration Company

U.S. companies and agencies are involved in programmes and missions for in-orbit refuelling:

- In the beginning of 2023, Galactiv unveiled the Active Space Servicer, a fleet of spacecraft designed for swift intervention in GEO. This service addresses satellite fuel depletion and repairs while mitigating space debris. Equipped with proven technologies, each spacecraft offers reliability and versatility, with refuelling capabilities and a modular design for reusability and easy repair.[512]
- In February, DARPA, Northrop Grumman, and the U.S. Naval Research Laboratory launched the Robotic Servicing of Geosynchronous Satellites (RSGS) spacecraft. Operating in GEO, RSGS is the first general-purpose "servicer" satellite for rendezvous, repair, and refuelling missions. Equipped with precision robot arms, RSGS aims to rendezvous with troubled satellites, offering vital repair and refuelling capabilities. NRL's robotics development initially focuses on a single servicing vehicle, with the potential for multiple RSGS vehicles.[513]



Credit: DARPA

- In May, Impulse Space and Orbit Fab announced a collaboration for a hydrazine refuelling demonstration mission in GEO. Utilising Impulse Space's Mira orbital service vehicle as the hosting platform, the mission seeks to develop commercial orbital refuelling services. The USSF Tetra-5 spacecraft will be refuelled with up to 50 kilogrammes of hydrazine using Orbit Fab's fuel depot featuring RAFTI refuelling port.[514]
- In July, the Space Force, in collaboration with industry partners, accelerated efforts to develop satellite servicing capabilities, including in-orbit refuelling. The Tetra-5 experiment, set for launch in 2025, aims to demonstrate hydrazine refuelling in geosynchronous orbit. The goal is to equip military satellites with sustained manoeuvrability by 2028, ensuring their agility and effectiveness in an evolving space domain.[515]

Credit: Orbit Fab

- In September, Astroscale U.S. collaborated with the USSF to co-invest $25.5 million in an in-orbit refuelling vehicle, with Astroscale providing $12 million. The initiative aimed to develop a prototype vehicle capable of refuelling satellites within 24 months. The Astroscale Prototype Servicer for Refuelling (APS-R) used a refuelling port from Orbit Fab, demonstrating potential for commercial-off-the-shelf solutions.[516]

[511] The Exploration Company and Spaceium: A Pioneering Partnership for Moon Missions and In-Orbit Refueling, Spaceium, September 2023
[512] Introducing Galactiv's Active Space Servicer, Galactiv, March 2023
[513] Space Robots Prepare to Grapple and Repair Satellites in Orbit, Communications of the ACM, February 2023
[514] Orbit Fab selects Impulse Space to support GEO refueling mission, Impulse Space, May 2023
[515] US Space Command says it needs more maneuverable satellites, Ars Technica, July 2023
[516] Space Systems Command awards $25.5 Million Contract to Astroscale U.S. Inc. for advancement of Space Mobility and Logistics capabilities, Space Systems Command, September 2023

Docking & Rendezvous and Proximity Operations (RPO)

In-orbit servicing missions usually involve several steps, which can vary depending on the mission. Among these, there are:

Rendezvous: the series of actions taken by the Servicer Spacecraft to transition its orbit from the departure of the previous customer or its parking orbit to the desired rendezvous orbit by conducting an orbital transfer or manoeuvres to reach the location of the rendezvous.

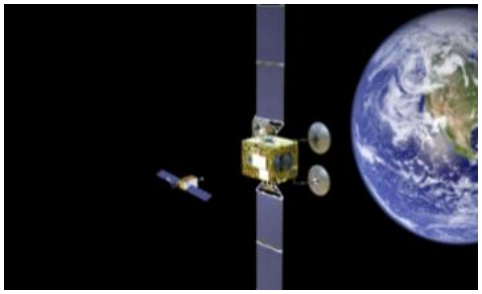
Docking: the servicer spacecraft approaches and establishes physical contact by docking with the serviced spacecraft through a dedicated interface or using another component to provide a service. Docking enables the servicer and the serviced spacecraft to exchange data, power, and components, and provide services such as refuelling, repair, reconfiguration, recharging, station-keeping, etc.[517]

European companies' developments in Docking and RPO:

- In February, Lithuanian-based Blackswan Space secured three contracts from ESA to enhance the GRALS facility at ESTEC, Netherlands. GRALS aids in R&D for space missions involving rendezvous, docking, and planetary landings, using robotic arms and a 33-metre linear track for hardware-in-the-loop tests. Blackswan Space will develop an open-source 3D model of a geostationary satellite to advance technology for rendezvous, docking, berthing, and capture.[518]
- In October, the Italian Tyvak International s.r.l., a subsidiary of Terran Orbital Corporation, secured a €4.5 million contract from ESA. Tyvak will lead proximity operations and in-orbit servicing missions deploying a nanosatellite from Space Rider. The nanosatellite will demonstrate in-orbit servicing capabilities by conducting proximity operations around Space Rider. The contract involves collaboration with Italian industries and research institutions, including the Polytechnic University of Turin and the University of Padova.[519]

U.S. companies and start-ups are developing projects for docking and rendezvous systems:

- As announced in February, Redwire Corporation collaborated with Starfish Space for the Otter Pup satellite docking mission. Redwire supplied its ARGUS space domain awareness camera, facilitating the first docking of two commercial satellites in LEO. The ARGUS system aided Otter Pup in precisely determining its docking target's position. Redwire also had the option to remotely install its Cerebro Resident Space Object tracking software into the ARGUS system, demonstrating space domain awareness for the U.S. DoD.[520]



Credit: Starfish Space

- In April, Lockheed Martin achieved a successful in-orbit demonstration of its In-space Upgrade Satellite System (LM LINUSS). The system, featuring two LM 50 12U CubeSats, showcased automated RPO capabilities for precise manoeuvring across multi-satellite constellations. This achievement validates manoeuvring capabilities for future space upgrades and servicing missions.[521]

[517] CONFERS On-Orbit Servicing (OOS) Mission Phases, CONFERS, October 2019
[518] Blackswan Space wins 3 new contracts from ESA, Blackswan Space, February 2023
[519] Terran Orbital awarded $4.7 million contract by European Space Agency, October 2023
[520] Redwire Partners With Starfish Space For Otter Pup Satellite Docking Mission, Announces Space Domain Awareness Demo Mission Opportunity, Redwire Space, February 2023
[521] Lockheed Martin CubeSats Successfully Validate Essential Maneuvers For On-Orbit Servicing, Lockheed Martin, April 2023

- In July, Astro Digital U.S. partnered with Astroscale Japan to integrate Astroscale's Generation 2 Docking Plate into Astro Digital's modular satellite bus. This aimed to enhance end-of-life servicing capabilities and promote responsible satellite operations. The Astroscale Docking Plate enables secure docking with in-orbit servicing spacecraft, facilitating satellite relocation or safe disposal.[522]

Credit: Astroscale

- In December, Orbit Fab partnered with Australian-based Space Machines Company (SMC) to enhance docking capabilities for SMC's Optimus Orbital Servicing Vehicle. By equipping spacecraft with fiducial markers, akin to QR codes, the collaboration aims to simplify high-speed orbit docking. These markers assist docking algorithms in accurately orienting the docking vehicle, facilitating safe and efficient rendezvous, docking, and refuelling operations in space.[523]
- In December, Rogue Space Systems Corporation secured its first confidential in-orbit service contract with a commercial constellation operator, undisclosed. The contract involves locating a satellite deployed from SpaceX's Transporter 9 mission and establishing communication and operations. Rogue's Mission Operations team will collaborate with the customer's ground station partner and satellite bus provider.[524]
- At the end of 2023, DARPA selected Firefly Aerospace to craft an analytical framework for in-orbit spacecraft hubs within the LunA-10 study. These hubs aim to expedite cislunar services, shortening mission response times. Firefly's framework will enable spacecraft docking and on-demand services like propellant and payload transfers. Their Elytra vehicles stationed at these hubs will provide responsive mission services for tasks such as payload delivery and orbital transfers.[525]

Credit: DARPA

China also completed a docking mission for its Tiangong Space Station:

- In June, China's Tianzhou-5 cargo spacecraft re-docked with the China Space Station after over a month of independent flight, as confirmed by the China Manned Space Agency (CMSA). Carrying six months' worth of essential supplies, including propellant and science facilities, the spacecraft delivered its cargo before detaching to make room for its successor, Tianzhou-6. It operated solo for 33 days before re-docking with the Tiangong.[526]

Credit: CMSA

[522] Astro Digital Embraces Responsible Satellite Operations with Astroscale's Simple and Innovative Docking Plate Integration, Astroscale, July 2023
[523] Orbit Fab and Australia's Space Machines Company cooperate on in-orbit servicing, SpaceNews, December 2023
[524] Rogue exercises its satellite operation skills to assist constellation owner, Rogue Space Systems Corporation, December 2023
[525] Firefly Aerospace Selected to Support DARPA LunA-10 with Framework for On-Orbit Spacecraft Hubs, Firefly Aerospace, December 2023
[526] Tianzhou 5 reconnects with Tiangong space station, China Daily, June 2023

In-space Manufacturing & Assembly

The capabilities of assembly and manufacturing in space represent advancements in space exploration and utilisation:

Assembly involves the bringing together of individual parts or components in space to form a single, functional structure. This allows for the creation of larger structures that would be impractical or impossible to launch in one piece due to volume constraints. The ability to assemble components in space unlocks numerous possibilities, such as constructing habitats in locations beyond LEO and assembling large telescopes and platforms. It overcomes limitations imposed by rocket fairing volume, enabling the realisation of ambitious space projects.

Manufacturing entails the fabrication of components or structures directly in space as needed. This provides greater adaptability in responding to unforeseen challenges and reduces the need to pre-launch all components. It enables the production of complex structures without the constraints of Earth-based manufacturing and transportation.[527]

In 2023, the U.S. and Europe developed programmes for in-space manufacturing & assembly:

- In March, the USSF awarded U.S. Arkisys a $1.6 million contract to showcase robotic satellite assembly. The project, part of a SpaceWERX SBIR contract, involves assembling a three-axis stabilised satellite using Arkisys' Port Module robotic arm. Collaborators Novawurks, Motiv Space Systems, Qediq, iBoss, and Texas A&M University demonstrated ground assembly with Novawurks Slegos modules, highlighting diverse capabilities.[528]
- In August, German DCUBED announced plans for a 2024 demonstration of in-space manufacturing, which will produce a 30cm high 3D printed truss structure. DCUBED aims to pioneer larger space structure manufacturing, with future plans for in-orbit experiments and mission demonstrations by 2026.[529]

Credit: Novawurks

Last Mile Delivery

Last Mile Delivery can be defined as the transport of a spacecraft from the separation phase of the launch to the final orbital destination using e.g., an Orbital Transfer Vehicle (OTV), which provides relocation or last-mile delivery services.[530]

In 2023, the Italian D-Orbit has been one of the most active in the OTV field:

- In April, D-Orbit launched Guardian, the 10th mission of their ION Satellite Carrier (ION) OTV. Deployed into a 500 kilometre polar orbit by a Falcon 9 rocket on April 14th, ION is designed for satellite deployment and orbital demonstrations. Guardian hosts various payloads, including Kepler's CubeSats, Visiona's VCUB1, EPICHyper-1 by AAC Clyde Space, SCORPIO for electronic intelligence, and MicroCMG by VEOWARE.[531]
- In June, D-Orbit launched "Above the Sky", its 11th commercial mission using the ION OTV. Lifted off on June 12th, from

Credit: D-Orbit

[527] Op. cit. ESPI Report 87
[528] Arkisys and partners to show how they would build a satellite in orbit, SpaceNews, March 2023
[529] DCUBED announces world-first in-space manufacturing demonstration, highlighting company's key business area, DCUBED, August 2023
[530] Op. cit. ESPI Report 87
[531] D-Orbit Launches ION's 10th Orbital Transportation Mission in Three Years, D-Orbit, April 2023

Vandenberg Space Force Base by a Falcon 9 rocket, ION entered a 525 kilometres Sun-Synchronous Orbit. Named "Savvy Simon", the mission will host AAC Clyde Space's Kelpie-2 and EPICHyper-2, Spei Satelles, Outpost's Mission 1, NaviLEO, ODIN-DU1 by ODIN Space, UKRI SWIMMR-1, and AlbaPod 6P PocketQube satellite deployers.[532]

- In December, D-Orbit signed two launch service contracts with South Korean start-up TelePIX. These contracts aim to launch and test TelePIX's On-Board Processor (OBP), Tetraplex, to enhance on-board processing capabilities. D-Orbit will oversee the technical guidance, transportation, integration, and launch of Tetraplex using its ION Satellite Carrier. The contracts include in-orbit demonstration services to validate Tetraplex's performance and improve satellite operations.[533]

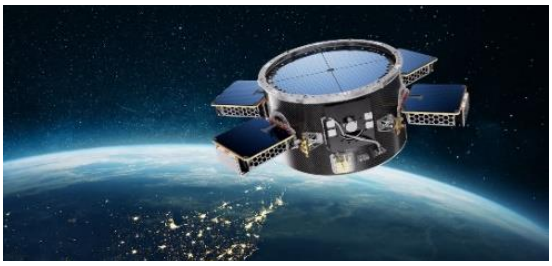
Spanish companies partnered to develop Spain's maiden OTV:

In September, UARX Space and Sener joined forces to develop Spain's maiden OTV, aiming for enhanced reliability and precision in orbital missions. The collaboration marks a step in the OSSIE spacecraft initiative, streamlining orbit exploration. The partnership bolsters UARX's growth strategy, with the OSSIE OTV set for launch in June 2025, accommodating payloads from across the globe.[534]

Credit: Sener

U.S. companies developed missions and projects to invest in OTVs:

- In January, Atomos Space closed a $16.2 million Series A investment round for its space tugboats. The investment aims to support the completion of its demonstration mission showcasing docking and towing capabilities. The company focuses on developing OTVs to manoeuvre satellites efficiently in space, reducing operational costs by eliminating the need for extensive navigation capabilities onboard the satellites themselves.[535]
- In July, Atomos Space announced its inaugural demonstration mission aboard SpaceX's Transporter-10 in Q1 2024, a crucial step in establishing its presence in orbital transfer services. The mission will deploy two spacecraft: the Quark OTV and the Gluon target vehicle. Atomos aims for a vertically integrated approach, designing and manufacturing both vehicles, with plans for Quark Mark II's development post-demonstration.[536]
- In August, Firefly Aerospace introduced Elytra, a new line of orbital vehicles, offering comprehensive mission services for commercial and government clients. Debuting with a 2024 mission aboard Firefly's Alpha rocket, Elytra enhances the company's prior "space utility vehicles" with improved capabilities and scalability. Comprising three models – Dawn, Dusk, and Dark – Elytra caters to diverse orbital requirements, extending mission lifespan, mitigating space debris, and ensuring rapid, affordable, and reliable deployment.[537]



Credit: Firefly Aerospace

[532] D-Orbit Launches 11th Orbital Transportation Mission in Three Years, D-Orbit, June 2023
[533] D-Orbit and TelePIX Announce Contracts for the in-orbit testing of Tetraplex, D-Orbit, December 2023
[534] UARX and Sener have partnered to work on OSSIE Orbital Transfer Vehicle, UARX Space, September 2023
[535] Atomos tows a $16M load of funding to create tugboats in space, TechCrunch, January 2023
[536] Atomos Space books launch to demonstrate rendezvous, docking and refueling in-orbit, TechCrunch, July 2023
[537] Firefly Aerospace Debuts Elytra Orbital Vehicles with Enhanced On-Orbit Mobility and Services, Firefly Aerospace, August 2023

2.1.3 Space cybersecurity in high demand

In 2023, cybersecurity solutions were in high demand in the space sector to protect space systems and companies against a skyrocketing number of attacks. According to the French market intelligence company CyberInFlight, 250 publicly disclosed cyberattacks on space systems can be traced back since the 1970s, 90 of which happened in 2023 alone.[538] This likely remains a low estimate as many attacks are not made public.

According to Northern Sky Research's "Satellite and Space Cybersecurity Markets" report, $33.2 billion of cybersecurity revenues are expected to be generated in the next ten years in the commercial segment.[539]

Current space cybersecurity solutions seem to be oriented toward the Zero Trust approach, which considers that no user can be trusted by default, that verification needs to be carried out explicitly, access privileges should be as limited as possible, and always assuming breaches.[540]

New commercial space cybersecurity solutions developments in Europe

In Europe, several companies released products dedicated to space cybersecurity and signed contracts with the industry and space agencies in 2023 with major milestones.

The Belgian company RHEA Group hit several key milestones in 2023:

- On January 9th, the Dover Pathfinder satellite, designed by RHEATech Ltd., was launched on board the Virgin Orbit jet. The satellite aims to maintain PNT capabilities in case of cyberattack. In case of jamming, the satellite can jump to another frequency and ensure the integrity and availability of PNT signals.[541]
- In March, RHEA System S.p.A., announced it would support the Italian company Argotec in the design and implementation of the security strategy of the Italian EO constellation programme IRIDE, which will include end-to-end protection on the space and ground segments. RHEA will provide its cybersecurity expertise and take part in the preparation and maintenance of the Security Management Plan.[542]
- In April, the French Institute for Technological Research (IRT) in partnership with RHEA Group, the French Space Agency (CNES), the National Centre for Scientific Research (CNRS), the Systems Analysis and Architecture Laboratory (LAAS), the Air and Space Military School, MyDataModels and Thales Alenia Space France, launched its Cyber Space Simulation Project. RHEA Group is responsible for the technical coordination of the project and will provide its cyber-range solution CITEF to develop a highly realistic simulation of a space system to simulate cyberattacks and detect security flaws. The project is expected to be finalised in 2026.[543]

The Swiss company CYSEC also reached significant milestones:

- In April, CYSEC organised the third edition of the CYSAT conference, dedicated to space cybersecurity, at Station F in Paris. During the conference, ESA set up a satellite test bench to demonstrate the hack OPS-SAT, a nanosatellite operated by the agency for demonstration purposes. Thales showcased its takeover of the satellite by exploiting vulnerabilities. This was a demonstration in which both Thales and ESA cooperated and exchanged information about

[538] CyberInFlight at Cyber Reslience in Space Workshop, Brussels, Belgium, 8 February 2024
[539] Space Cybersecurity, Current State and Future Needs, NSR, April 2022
[540] Zero Trust Architecture, NIST, August 2020
[541] World-First British Satellite to Counter £1 Billion Cyber Hacking Threat, RheaGroup, January 2023
[542] RHEA Supports Italian Earth Observation Satellite Constellation for IRIDE, RheaGroup, March 2023
[543] Cyber Space Simulation Project Launch – RHEA Takes Lead of Technical Coordination, RheaGroup, April 2023

OPS-SAT, with ESA always remaining in control of the system and isolating the ground infrastructure from actual operational missions.[544]

- In November, CYSEC successfully tested its ARCA Satlink product in orbit, which enabled to validate the space component of the product, secure sensitive TMTC data, and gain commercial maturity.[545] Arca Satlink is a software that provides end-to-end protection of TMTC and payload data to encrypt, decrypt, authenticate and verify, frames, to manage key lifecycle and virtual channel configuration and implements the Space Data Link Security (SDLS) protocol.[546]
- Also in November, CYSEC and ESA launched a competition as part of the Programme for Userbase Enhancement (Push). It called for ideas from companies looking to use satellite technology and services to improve their business. As part of the competition, ESA and CYSEC are looking to promote security and offer free of charge the tailoring and testing of CYSEC ARCA Satlink's solution on the architecture of the competition's winner.[547]

CYSEC's ARCA Satlink (Credit:CYSEC)

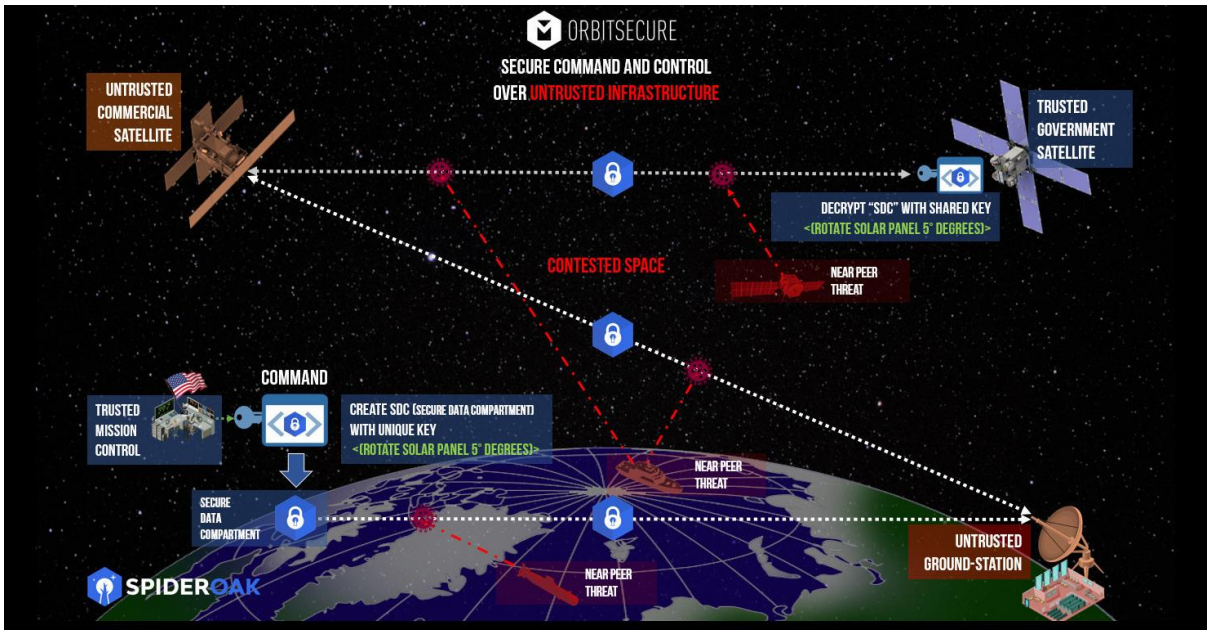
With the mounting demand for space cybersecurity solutions, some cybersecurity companies are also looking to enter the space sector in this vertical. For instance, in October British company Corero Network Security signed its first contract with an undisclosed global satellite service provider. The contract accounts for $500,000 and will provide the satellite company with ultra-low latency DDoS protection on its network of ground stations.[548]

While many companies are recording higher sales and developments in space cybersecurity products, some companies are deciding to let go of this vertical. In May, the British company Arqit hired financial adviser Silverpeak to sell its space division, which includes an unfinished quantum encryption satellite, patents, intellectual property, and several contracts worth about $65 million. Yet, Arqit declared it sees demand for quantum encryption increase.[549]

[544] Thales Seizes Control of ESA Demonstration Satellite In First Cybersecurity Exercise of Its Kind, Thales Alenia Space, April 2023
[545] Arca Satlink Successfully Tested in Space, Cysec, 2023
[546] Arca Satlink, end-to-end protection of TMTC and payload data, Cysec, 2023
[547] ESA Push : (Programme For Userbase Enhancement) Theme 1: Satellite as a Service with Arca Satlink, Cysec, 2023
[548] Corero Network Sec. - Significant New DDoS Protection Contract, Corero Network Security PLC, October 2023
[549] Arqit launches sale of satellite division, Space News, May 2023

The space industry in the United States sees value in Zero Trust

In the United States, one of the market leaders in space cybersecurity SpiderOak hit many milestones in 2023. SpiderOak is developing one software called OrbitSecure, which provides Zero-Trust end-to-end security by embedding airtight security into commands and data using secure data compartments. It integrates a private blockchain and lightweight authority protocol.



SpiderOak's OrbitSecure (Credit: SpiderOak)

- In January, SpiderOak announced the closing of a $16.4 million Series C funding round led by Empyrean Technology Solutions and involving Method Capital and OCA Ventures.[550]
- In March, SpiderOak announced the signature of a partnership with the national security space solutions company LinQuest to integrate SpiderOak's OrbitSecure software into the solutions provided to LinQuest's customers. LinQuest will complete in-depth testing and assessment of security, performance, and scalability of OrbitSecure in its laboratory.[551]
- In April, SpiderOak and Raytheon Technologies' BBN division announced a partnership to develop a new generation of zero-trust security systems for satellite communications.[552] Subsequently, in September, SpiderOak and RTX's Raytheon BBN division launched their D4-Secure cloud solution, which merges Raytheon BBN's on-orbit network resource and network management and orchestration solution with SpiderOak's OrbitSecure space cybersecurity software.[553]
- In May, SpiderOak announced it raised an undisclosed amount of money from several investors such as Accenture Ventures, Raytheon Technologies' RTX Ventures, and Stellar Ventures. This investment will accelerate SpiderOak's deployment of the OrbitSecure space cybersecurity software.[554]

[550] SpiderOak Raises $16.4 Million in Series C Round, SpiderOak, January 2023
[551] LinQuest and SpiderOak Establish Strategic Partnership to Offer Cyber Solutions to National Security Space Customers, Linquest, March 2023
[552] Raytheon and SpiderOak Collaborate to Secure Satellite Communications, SpiderOak, April 2023
[553] SpiderOak and RTX to Debut D4-Secure™ Cloud Solution at AMOS Conference, SpiderOak, September 2023
[554] Space cybersecurity firm SpiderOak gets new investors, SpiderOak, May 2023

- In June, SpiderOak conducted an on-orbit deployment and test of its OrbitSecure cybersecurity software on Ball Aerospace's payload on a Loft Orbital satellite, thereby providing a zero-trust application to Ball Aerospace. [555]
- In August, SpiderOak conducted an on-orbit demonstration of its OrbitSecure cybersecurity software on the ISS. SpiderOak demonstrated the transmission of operation traffic between ground networks and the ISS through NASA's Tracking and Data Relay constellation and in collaboration with Axiom Space and Amazon Web Services.[556]
- In October, SpiderOak signed an agreement with the U.S Space Development Agency to integrate SpiderOak's OrbitSecure software into the SDA's contribution to the Space Force's Rapid Resilient Command and Control effort and protect ground systems of military satellites.[557]
- In December, SpiderOak signed a partnership with TrustPoint Inc, a GNSS product and service provider to improve the security of TrustPoint Inc's GNSS infrastructure using SpiderOak's OrbitSecure Zero-Trust data exchange software, which uses distribution ledger and key distribution system. The partnership aims to enable Trustpoint to implement the first-ever zero-trust, end-to-end commercial PNT system on the space and ground segments.[558]

Besides SpiderOak, the year saw other important developments in the industry. Viasat announced a new Zero Trust threat-detection tool was deployed on its network, which was developed under the Enhanced Cybersecurity Services program run by the Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA).[559]

Orbit Communications Systems announced it upgraded the cybersecurity of its Gaia100 EO ground infrastructure systems. It introduced the NetShroud+ solution, which aims to protect ground stations from local and remote cyberattacks, notably by protecting against identity theft and unauthorised access to the antenna control unit. The solution integrates AI to detect anomalies and zero-day vulnerability exploitations in real time as well as protect against ransomware.[560]

Furthermore, the company Xage Security was awarded a $17 million Space Force contract to protect its Space Systems Command network. The terms include the protection of information networks, ground stations, modems and other Space Force systems, for the five coming years. Xage will deploy its Zero Trust platform across the Space Force's ground infrastructure.[561]

Academic actors have also secured public contracts. For instance, Johns Hopkins University Applied Physics Laboratory was awarded a $10 million Space Force contract in September to assess the software and cybersecurity of its Evolved Strategic Satcom ground segment, which is currently in development for nuclear command and control and communications.[562]

In light of the worsening threat landscape, the industry-led Space Information Sharing and Analysis Center (ISAC) established an Operational Watch Center in Colorado to monitor, analyse, and respond to cyber threats on space systems. It will start to operate 10 hours per day, five days per week to provide a 24/7 service.[563] DarkLight, Inc., which developed an AI platform to automate analysis, management, and reporting, became a member of Space ISAC.[564]

[555] Spideroak Demonstrates Cybersecurity Software on Orbit, SpiderOak, June 2023
[556] SpiderOak demonstrates zero-trust software on ISS, SpiderOak, August 2023
[557] Space Agency Awards SpiderOak Resilience Research Agreement, SpiderOak, October 2023
[558] TrustPoint Announces Strategic Partnership with SpiderOak, SpderOak, December 2023
[559] Viasat deploying 'zero trust' cybersecurity across global network, Space News, March 2023
[560] Orbit Adds Cybersecurity to its Ground Solutions, ViaSatellite, August 2023
[561] Cybersecurity firm Xage gets $17 million contract to protect Space Force networks, SpaceNews, September 2023
[562] Space Force selects university partner to evaluate classified ground systems software, SpaceNews, September 2023
[563] Space ISAC Stands Up Operational Watch Center to Respond to Threats in Real Time, ViaSatellite, March 2023
[564] DarkLight, Inc. – Space ISAC's Newest Member, Empowering Cybersecurity with Cutting-Edge Tools to Bolster Reporting Posture, Space ISAC, August 2023

Significant developments in quantum key distribution and post quantum cryptography

Beyond the development of proprietary solutions for space cybersecurity and the signing of contracts between cybersecurity providers and the space industry, many developments took place in the field of quantum encryption.

Several demonstration missions and experiments took place in 2023:

- BridgeComm announced it demonstrated quantum encryption technology over the company's optical ground modem. The demonstration was the first-time quantum encryption over free space optical satcom. It tested both AES-256 and post quantum cryptography Kyber-1024 between its internally developed space modem over a free space optical link to its optical ground modem. The company aims to integrate PQC on its optical space and ground modems.[567]
- Scientists from Russia's National University of Science and Technology (MISIS) and the Russian Quantum Centre (RQC) and scientists from the Chinese Academy of Science successfully established quantum communication over a distance of 3,800 kilometres between a ground station located near Moscow and another one located near Urumqi, Xinjiang, using the Chinese quantum satellite Mozi. The experiment led to the secure transmission of two images encrypted with quantum keys.[568]
- In early March, the American company QuSecure, Inc., announced it conducted end-to-end quantum-resilient cryptographic communications through space using a Starlink satellite. QuSecure successfully sent quantum-resilient data from their Quark server in Colorado to a Starlink terminal. QuSecure sent the signal via uplink to one of Starlink's satellites and then via downlink back to Earth through its QuSecure Quantum Secure Layer (QSL).[569] By the end of March, EvoNexus and Accenture demonstrated QuSecure's post-quantum cryptography protocol, which securely transmitted data over multiple orbits. This is another milestone compared to demonstrations over single-orbit protocols.[570]

Understanding quantum …

Quantum computing, which is not established yet, will be fundamentally different than traditional computing. Traditional computers are based on "bits" (successions of 0 and 1), which process the information step by step. Quantum computers will be based on the superposition of bits, whereby quantum bits will be able to be 0 and 1 at the same time. This superposition and the merge of quantum bits will enable incomparably fast data processing and computing power as well as the decryption of today's encryption keys.

To protect against the threat of quantum computing, several solutions exist, including:

- **Quantum Key Distribution (QKD)**, which *"utilizes the unique properties of quantum mechanical systems to generate and distribute cryptographic keying material using special purpose technology"*. [565]
- **Post-Quantum Cryptography (PQC)**, also called quantum-resistant cryptography, entails developing *"cryptographic systems that are secure against both quantum and classical computers, and can interoperate with existing communications protocols and networks."*[566]

[565] Quantum Key Distribution (QKD) and Quantum Cryptography (QC), NSA, 2023
[566] Post-Quantum Cryptography, NIST, 2023
[567] BridgeComm Demonstrates Quantum Encryption With Optical Ground Modem, ViaSatellite, April 2023
[568] Report : China and Russia Test Quantum Communication Link, The Quantum Insider, January 2024
[569] QuSecure Unveils Live End-to-End Satellite Quantum-Resilient Cryptographic Communications Link Through Space, HPC Wire, March 2023
[570] Accenture & QuSecure Team in First Successful Multi-Orbit Communications Link Showcasing Post-Quantum Cryptography Modernization, QUSecure, March 2023

Numerous contracts were signed in the field of quantum communications:

Credit: Thales Alenia Space

Thales Alenia Space signed two cybersecurity contracts with ESA for the ground segment of the 2nd generation of Galileo (G2G). TAS is leading a consortium to expand the security monitoring of the G2G system, with automated incident response and network traffic monitoring. TAS is expected to integrate cryptography that will withstand the threats from quantum computers.[571] In addition, TAS signed another contract with ESA to lead its TeQuantS project, which aims at developing quantum technologies for cybersecurity applications. By the end of 2026, Thales aims to build satellites and optical ground stations to demonstrate long-distance quantum satellite links. Along with TAS, the project includes Airbus Defence and Space, Alpao, Aurea Technology, Bertin Technologies, Miratlas, OGS Technologies, QTlabs, SigmaWorks, LIP6 at Sorbonne University, and the Nice Institute of Physics.[572]

The German company Mynaric was selected by the German government for three projects related to quantum communications as part of the QuNET initiative funded by the Federal Ministry of Education and Research (BMBF). The three projects aim to develop a scalable optical ground station prototype that can receive quantum keys from satellite networks, demonstrate an optical communications terminal for airborne high-altitude platforms that can exchange quantum keys through air-to-air and air-to-ground links, and to investigate compact optical technologies to enable quantum key and laser communication for fixed and mobile network nodes. Mynaric will receive around €5.6 million as part of these projects.[573]

The Singaporean company SpeQtral has developed three systems, SpooQy-1, which has a quantum payload with entangled photon source, and two detectors. SpooQy-1 is the first cubesat in the world to demonstrate operations of a polarisation entangled source and detectors in space. the company is also developing SpeQtre: a quantum payload with an entangled photon source and a single downlink, which is expected to be ready by 2025. By the end of 2025, SpeQtral aims to finalise SpeQtral-1, a commercial demonstrator mission to validate global QKD distribution from space using BB84 and BBM92 protocols. The company hit several milestones in 2023:

- In August, SpeQtral, NanoAvionics, and Mbryonics announced they would partner for the SpeQtral-1 mission. NanoAvionics will be the satellite platform provider and Mbryonics will provide the satellite optical terminal that will transmit the QKD photons from the SpeQtral quantum hardware to optical ground stations.[574]
- In November, SpeQtral and Quantum Dice, a spinout from the University of Oxford's quantum optics laboratory launched a new product called the Zenith Quantum Random Number Generator (QRNG), which aims to enable secure quantum communication technologies in the upcoming SpeQtral-1 satellite mission.[575]

Finally, In India, ISRO announced it aims to launch its own QKD satellite at the inaugural session of the Param Vikram 1000 High-Performance Cluster (HPC) computing facility at the Physical Research

[571] Thales Wins Cyber, Ground Tech Contracts for Galileo Second Generation, ViaSatellite, July 2023
[572] Thales Alenia Space to Lead ESA Quantum Satcom Project, ViaSatellite, January 2023
[573] Mynaric selected by German government for multiple projects to develop quantum communication capabilities, Mynaric, March 2023
[574] SpeQtral Announces Kongsberg Nano-Avionics and Mbryonics as Key Partners for SpeQtral-1 Mission, SpeQtral, August 2023
[575] Quantum Dice and SpeQtral Unveil Quantum Communication Developments with Zenith QRNG for SpeQtral-1 Mission, SpeQtral, November 2023

Laboratory (PRL). To do so, the PRL and the Space Applications Centre of ISRO will work together during the next two years.[576]

ENTRUSTED consortium demonstrated four operational GOVSATCOM use cases

With regard to GOVSATCOM as part of IRIS², also in March 2023, the ENTRUSTED consortium demonstrated four operational GOVSATCOM use cases, showcasing real-time satellite connections in an operational environment. The use cases demonstrated secure SATCOM services for land vehicles and fixed ground terminals, simulations of natural disasters and armed conflicts, highly secured video conferences, and pooling and sharing services for EU military operations.[577]

New partners joined SES-Led consortium for EAGLE-1

The SES-led consortium, driving the development of the quantum-secure EAGLE-1 system in collaboration with ESA, welcomed TNO and Airbus Netherlands B.V. to partner in designing and constructing an optical ground station for the mission. EAGLE-1, co-funded by ESA, the European Commission, and various European space agencies and industries, aims to showcase the viability of quantum key distribution technology via satellite within the EU and globally. It promises to enhance cybersecurity and lay the groundwork for a secure quantum communication infrastructure (EuroQCI). The partnership, sealed at the Space Tech Expo in Bremen, outlines a system capable of receiving quantum encryption keys from the EAGLE-1 satellite. TNO and Airbus Netherlands B.V. will spearhead the collaborative effort, with TNO overseeing design, adaptive optics, and system engineering, while Airbus Netherlands B.V. manages support technologies, control platform development, and implementation. The project also involves Officina Stellare (OFS), Celestia-STS, and Demcon, contributing to the telescope and dome design, optical digital modem development, and wavefront sensor design, respectively.[578]

QUID project kicked off for Italy's implementation of EuroQCI

In June, the QUID (Quantum Italy Deployment) project was kicked off by an Italian consortium selected by the EU to start Italy's implementation of the European Quantum Communication Infrastructure (EuroQCI), which aims to develop a European infrastructure for quantum communication. The consortium is led by the National Institute of Metrological Research (INRiM) and is further composed of the Italian Space Agency (ASI), the National Research Council (CNR), Coherentia, Thales Alenia Space (Italy), QTI, Leonardo, ThinkQuantum, Telecom Italy, Telsy, Telespazio, TOP-IX Consortium, Politecnico di Milano, University of L'Aquila, La Sapienza University, University of Naples Federico II, University of Padua, University of Trieste. In particular, QUID aims to expand the existing fibre optic and satellite communication infrastructures and extend the quantum communication network to the northeast of Italy.[579]

[576] ISRO aims to launch QKD satellite, Ahmedabad to play key role, Economic Times, June 2023
[577] Successful demonstration of GOVSATCOM use cases, EUSPA, March 2023
[578] SES-led EAGLE-1 Onboards TNO and Airbus to Deliver Ground Station for Quantum Key Distribution, SES, November 2023
[579] QUID: The implementation of quantum communication network in Italy begins, Inrim, June 2023

2.1.4 Satellite constellations

In the past years, the deployment and proliferation of large satellite constellations have revolutionised the landscape of commercial communications. Small to large constellations are now becoming commonplace in the field of commercial EO and navigation too. While LEO was in the spotlight in the past few years, renewed interest in GEO and MEO was identified in the U.S. market in 2023.

According to the Global Commercial-Satellite Constellations Market 2023-2032 report by Custom Market Insights, the market value estimation for the satellite constellation sector is approximated to be $15.6 billion, growing at a rate of 13.09% compound annual growth rate.[580]

Europe's involvement in the field of satellite constellations is growing:

The past decade saw a rise in plans of large constellations worldwide. Although Europe remained behind for a long time, many plans for small, medium, and large constellations from European companies have eventually emerged.

Credit: EUSPA

On the institutional side, a €6.4 billion euro plan was approved by the European Parliament on February 14th for the development of the Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS2), Europe's sovereign constellation.[581]

The network is expected to be deployed by 2027, while initial services will be available by 2025. After France's Eutelsat's merger with UK-based OneWeb, the UK Space Minister announced in November the intention to push for the use of the second generation OneWeb satellites rather than the development of new infrastructure for IRIS2, the EU's Infrastructure for Resilience, Interconnectivity and Security by Satellite initiative. [582]

Beyond IRIS², several other noteworthy developments took place.

ESA selected Canadian Square Peg Communications for 5G and 6G testing initiative

ESA selected the Canadian company Square Peg Communications to lead the implementation of an emulation environment for testing various scenarios across multiple satellite constellations under the Space for 5G and 6G Strategic Programme Line. Collaborating with WORK Microwave, Square Peg's high-performance RLS-2100 tester creates an emulation environment supporting terrestrial and non-terrestrial links for 5G application testing, offering a wide frequency range and seamless integration. The project enhances ESA's ability to test 5G scenarios flexibly and affordably across diverse satellite constellations, marking a significant advancement in space-based 5G technology. The RLS-2100 allows hardware-in-the-loop testing, realistic emulation of link characteristics, and the verification of link performance during handovers.

ESA and GSMA join forces for Next-Gen satellite and mobile networks

ESA and GSMA signed a Memorandum of Intent (MoI) to foster collaboration between the mobile and satellite industries and accelerate the development of satellite and terrestrial network technologies. Known as SCARLET-α, the $7 million project aims to strengthen the competitiveness

[580] Global Commercial-Satellite Constellations Market 2023-2032, Custom Market Insights, July 2023
[581] Europe approves multi-orbit connectivity constellation plan, SpaceNews, February 2023
[582] UK pushing to combine OneWeb Gen 2 and European sovereign constellation efforts, SpaceNews, November 2023

of both sectors by creating an ecosystem that fast-tracks new technology solutions for businesses and consumers. The focus will be on integrating satellite communications with 5G and future 6G networks to drive advancements and improve connectivity. Central to this partnership is the GSMA Foundry innovation accelerator, which will closely collaborate with ESA's 5G/6G Hub based at ECSAT. The joint effort seeks to capitalise on the increased adoption and integration of satellite technologies by the communications industry, which could lead to potential revenue gains of $35 billion by 2035, a 3% uplift in telecommunications industry revenues, according to recent research by GSMA Intelligence (GSMAi).[583]

Eutelsat OneWeb partners with operators in Taiwan, South Africa, India and South Korea

Taiwan's Chunghwa Telecom signed a multi-million-dollar distribution deal with Eutelsat OneWeb for LEO satellite services. This collaboration aims to enhance Chunghwa Telecom's communication services suite with additional space-based connectivity, providing resilience and complementing existing terrestrial networks. The partnership allows Chunghwa Telecom to integrate Eutelsat OneWeb's LEO satellite services into its offerings. The move is crucial for Taiwan, relying heavily on submarine cables for external connectivity, with satellites as a secondary option.[584]

Eutelsat OneWeb also signed a multi-year master distribution agreement with NEC XON, in South Africa, to bring high-quality LEO connectivity to Sub-Saharan Africa. The collaboration includes installation services and extensive training across the region, to address the growing demand for seamless and borderless connectivity. Eutelsat OneWeb's LEO satellite network will provide high throughput, low latency connectivity, supporting applications in cellular backhaul, oil and gas, agriculture, government, and mining.[585]

OneWeb India received regulatory approval from IN-SPACe, the Indian space regulator, to launch Eutelsat OneWeb's commercial satellite broadband services in India. Eutelsat OneWeb, with existing licenses from the Department of Telecommunications, aims to provide high-speed, low-latency internet connectivity across India, pending final spectrum authorisation.[586]

Eutelsat OneWeb entered a distribution partnership with Hanwha Systems to offer high-speed, low-latency connectivity services in South Korea. The partnership enhances connectivity for emergency services, disaster-prone regions, and areas with poor infrastructure. The collaboration involves Hanwha's participation in the 'commercial low-orbit satellite-based communication system' project for the Korean government, leveraging Eutelsat OneWeb's satellite network.

The following table summarises various 2023 announcements for various European constellations at different levels of maturity:

[583] GSMA and European Space Agency launch new communications innovation partnership, GSMA, July 2023

Company	Constellation	Planned satellites	Launched satellites
Rivada Space Networks	OuterNET	300	0
AIRMO	Climate-monitoring constellation	12	0
Vyoma Space	Flamingo	?	0
SatelliteVu	Thermal imaging constellation	8	1
Inmarsat	Orchestra	175	0
Apogeo Space	PiCo (FEES Cluster)	?	9
NanoAvionics	Smallsat constellation	72	3
Astrocast	IoT constellation	80	20
Horizon Technologies	Amber	20	1
Open Cosmos	OpenConstellation	25	1
Planet Labs	Pelican	32	1
Prométhée	JAPETUS	20	1
Saab, AAC Clyde Space, ORBCOMM	Constellation for maritime	100	1
Sternula	MARIOT	50	1

Table 6: Satellite constellation plans in Europe[587]

German businesses are leading the market in this field:

- In February, German-based Rivada Space Networks announced securing the launches and financing for the deployment of 300 satellites by mid-2026, to be built by Florida-based Terran Orbital. The first satellites are expected to be ready for launch to LEO in 2025.[588] In June they announced their hope to secure funding from U.S. Ex-Im Bank.[589]
- Start-up Airmo announced in June raising €5.2 million euro for their climate-monitoring constellation aiming to measure greenhouse gas emissions.[590] Their satellites will be equipped with spectrometers and light detection and ranging (LiDAR) instruments, with the objective of measuring atmospheric carbon dioxide and methane. Mynaric was chosen by the Space Development Agency (SDA) under the U.S. Space Force to develop a ground terminal involving telescope and laser transmitter and receiver for optical communications with the agency's fleet of military satellites in LEO. This aims to demonstrate connections with space-based optical communications terminals.[591]

[587] ESPI launch database
[588] Rivada says it has launches covered for a constellation against the clock, SpaceNews, February 2023
[589] Rivada seeks Ex-Im financing for satellite constellation, SpaceNews, June 2023
[590] Airmo raises 5.2 million euros for climate-monitoring constellation, SpaceNews, June 2023
[591] Mynaric to design optical ground terminal for U.S. military constellation, SpaceNews, August 2023

- In August, German-based Vyoma announced the order of pilot satellites for a proposed space debris-monitoring constellation from Bulgarian-based EnduroSat. The technical details of the constellation were stated to be confidential, but the constellation will be comprised of microsatellites in LEO. The instruments to be equipped are optical telescopes whose objective would be to catalogue objects bigger than 10 centimetres.[592]

Credit: EnduroSat

In the UK, several operators have further developed their plans for communications and Earth observation constellations:

- OneWeb announced in March that it would focus on completing the ground segment after launching the final batch of satellites for their broadband constellation. The launch of these last 36 satellites expands the constellation to 618.[593]
- British-based Satellite Vu announced in May that it had raised 12.7 million pounds for their high-resolution of 3.5 metres per pixel thermal-imaging satellite constellation. Such constellation would comprise 8 satellites, and applications involve the monitoring of industrial activity, as well as climate ones.[594]
- Open Cosmos announced in September that it had raised $50 million to expand the company and constellation.[595] Horizon Technologies on their side was awarded a grant from UKSA to develop their EO constellation "Amber". Amber's payload can detect, geolocate and demodulate maritime RF from so-called "dark vessels".[596]
- Inmarsat is not ruling out ordering its own LEO constellation for its proposed mobile connectivity network, which would combine terrestrial 5G and connectivity from geostationary and non-geostationary satellites. [1]

Other European actors are also stepping up:

Credit: Defence Industry Europe

In Italy, Apogeo Space announced in June the signature of a deal for the deployment of 9 picosatellites in 2024, for their plans of a 100 tiny-satellites constellation for the connection of remote monitoring devices.[597] In parallel, the IRIDE constellation, an Italian government-funded constellation for Earth imaging as part of the post-covid Italian National Plan for Recovery and Resilience, has secured two launches with an option for a third with the European launcher Vega C as of March. This constellation will include 36 satellites equipped with optical and radar imaging payloads.[598]

In February, the Lithuanian satellite manufacturer and integrator NanoAvionics announced the expansion of their production capacity after the increase in planned satellite constellation operators' demand. Initially dedicated to manufacturing higher customised satellites, the new facilities have the capacity to build identical satellites for constellations given the evolution of the market.[599]

[592] Vyoma orders pilot satellites for debris-monitoring constellation, SpaceNews, August 2023
[593] OneWeb completes constellation deployment for global broadband, SpaceNews, March 2023
[594] Satellite Vu raised $15.8 million for thermal satellite constellation, SpaceNews, May 2023
[595] Open Cosmos raises $50 million to expand Earth observation satellite business, SpaceNews, September 2023
[596] Horizon Technologies recently awarded million £ grant from the UK Space Agency, SatNews, November 2023
[597] Apogeo Space orders second space tug for connectivity constellation, SpaceNews, June 2023
[598] Arianespace wins Vega contract for Italian imaging satellite constellation, SpaceNews, March 2023
[599] NanoAvionics expands production capacity for constellation transformation, SpaceNews, February 2023

Emirati Thuraya invested in the Swiss-based Astrocast LEO constellation, announced in April. Astrocast, currently operating 18 satellites, intends to broaden its fleet to offer connectivity for IoT devices.[600]

French Prométhée announced partnering with Hemeria for a 20-satellite constellation for EO.[601]

Sweden-based Sternula launched their first satellite as part of the MARIOT project, to demonstrate a VDES-based satellite towards a future constellation.[602]

The U.S commercial and institutional markets for satellite constellations keep rising

In the U.S., the development of satellite constellations remains ongoing, including with different applications:

An overview of the advancements in the US constellations' plans is displayed below:

Company	Constellation	Planned satellites	Launched satellites
Amazon	Project Kuiper	3236	2
EOS Data Analytics	EOSAgriSat	12	1
Muon Space	Climate constellation		1
Tomorrow.io	Weather forecasting constellation	30	2
TrustPoint	GNSS, PNT constellation		2
Turion Space	SSA constellation		1
Wyvern	Dragonette constellation	36	3
Anuvu	Anuvu Constellation	8	0
Sidus Space	LizzieSat	100	0
Capella Space	Acadia, Whitney	40	12

Table 7: Satellite constellation advancements in the U.S.[603]

In 2023, the Air Force Research Laboratory (AFRL) allocated $250 million in contracts to commercial satellite operators and defence contractors for various experimentation endeavours, including Intelsat, SES Space & Defence, Raytheon, Northrop Grumman and L3Harris Technologies. These initiatives are part of the Defence Experimentation Using Commercial Space Internet (DEUCSI), introduced in 2017 to investigate the capabilities of commercial space internet constellations across LEO, MEO and GEO and establish connections between military platforms and user terminals capable of communicating with multiple space broadband providers.[604]

[600] Thuraya invests in Astrocast's LEO constellation, SpaceNews, April 2023
[601] Geospatial imagery startup Prométhée selects Hemeria to build 20-satellite constellation with novel inter-satellite relay, Space Intel Report, June 2023
[602] Successful launch of Sternula-1, world first commercial VDES satellite, VDES Alliance, January 2023
[603] ESPI launch database
[604] Internet from space: U.S. Air Force bets on commercial networks, SpaceNews, January 2024

Funding was secured for the launch of several new satellite constellations:

Credit: BBC

- In January, U.S. Capella Space announced raising $60 million to scale up and accelerate the development of their new generation of radar satellites, which aim to provide better image resolution and quality.
- Florida-based Sidus Space announced in February having raised $5.2 million to back their planned multipurpose constellation, LizzieSat. The purpose of the constellation would be maritime monitoring and tracking, a system to be developed together in partnership with superyacht designer company Capital C. The companies signed an MOU by which Sidus will develop, deliver and maintain these maritime monitoring and tracking capabilities for the Capital C vessel fleet. [605]
- Massachusetts-based Tomorrow.io announced in June that it was raising $87 million for their weather satellite constellation. The constellation will provide weather and ocean surface wind data and sea surface heights. The company has also won contracts for military applications with the U.S. Space Force and the U.S. Air Force.[606]

Plans and launches for new constellations were announced:

- In June, the U.S. Space Force confirmed its interest in exploring various options for establishing a weather monitoring constellation, acquiring a small polar-orbiting constellation among them. Within the program, Electro-Optical/Infrared (EO/IR) Weather Systems (EWS), two companies: Orion Space Solutions and General Atomics were selected to develop the needed sensors for the satellites to cover their existing gap in weather coverage.[607]
- California-based Muon Space announced in June the launch of the first satellite of their climate-monitoring constellation. The applications of the constellation include measurements for flood and water issues.[608] In the same rideshare SpaceX launch, the first satellite of Turion Space SSA constellation was put into orbit.[609]
- On April, Trustpoint launched a PNT cubesat part for their global navigation satellite system.[610]
- NASA's Time-Resolved Observations of Precipitation Structure and Storm Intensity with a Constellation of Smallsats (TROPICS), comprising a quartet of cubesats for the monitoring of the development of tropical storm systems was launched in May and announced to be operational in time for the hurricane season in August. These satellites are equipped with microwave radiometers with the improvement for previous missions of revisiting the weather systems every hour due to the constellation.[611]

Credit: eoPortal

[605] Sidus Space raises $5.2 million for LEO constellation, SpaceNews, February 2023
[606] Tomorrow.io raises $87 million for weather satellite constellation, SpaceNews, June 2023
[607] Space Force exploring options to build weather monitoring constellation, SpaceNews, June 2023
[608] Muon celebrates launch of first satellite in Climate Constellation, SpaceNews, June 2023
[609] SpaceX launches eighth dedicated smallsat rideshare mission, SpaceNew, June 2023
[610] TrustPoint launches PNT cubesat, SpaceNews, April 2023
[611] TROPICS cubesat constellation ready for hurricane season, SpaceNews, August 2023

- In September, Virginia-based Intelsat announced its consideration for the development of a MEO constellation for 2027. The constellation would be complementing the company's presence in LEO and GEO.[612]
- As of October, the U.S. Space Force moved ahead with the planned procurement of satellites for a missile-warning and tracking MEO constellation.[613]
- In December, Amazon announced a successful test of the inter-satellite optical links between both of their satellite prototypes.[614]

Constellations operators provided updates regarding their systems' components and ground infrastructures:

- After OneWeb's loss of satellite thrusters from Russian supplier EDB Fakel, Massachusetts-based Busek announced the successful commissioning of the OneWeb satellites' new thrusters. The satellites rely on these for orbit-raising, station-keeping, collision avoidance and de-orbiting operations.[615]
- California-based Anuvu confirmed the plan to deploy a small GEO satellite constellation for connectivity and entertainment within the mobility market, announcing in February the leasing of the ground infrastructure from Telesat, a Canadian satellite operator.[616]

[612] Intelsat plotting a MEO constellation in 2027 with C-band windfall, SpaceNews, September 2023
[613] Space Force to begin procurement of missile-tracking satellites for medium Earth orbit constellation, SpaceNews, October 2023
[614] Project Kuiper prototypes successfully test inter-satellite optical links, SpaceNews, December 2023
[615] Busek ramps up production for OneWeb constellation, SpaceNews, February 2023
[616] Anuvu's small satellite constellation to use Telesat ground infrastructure, SpaceNews, February 2023

China extends its ambitions in the field of constellations

In China too, the year saw notable developments in the field of satellite constellations. An overview of the main advancements in China is provided in the table below:

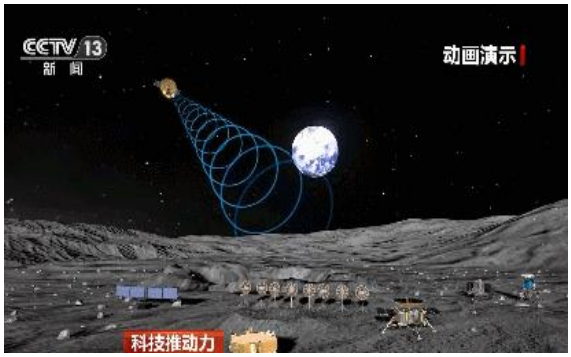
Company	Constellation	Planned satellites	Launched satellites
Digantara	Surveillance constellation	3236	1
EllipSpace	Starpool (Xingchi-1)	100	3
Kepler Communications	GEN2, Aether		2
Nara Space	Nanosatellite constellation	100	1
NuSpace	IoT connectivity constellation		1
PIESAT	Nuwa	4	4
Skysight	EO		3
Spacety	Mianyang, Fucheng	6	2
Xiyong Microelectronics Park	Tianmu-1		18
Galaxy Space	Yinhe	1000	3
Fleet Space	Alpha	140	7
Telesat	Lightspeed	198	3
Amini	EO constellation	6	0

Table 8: Satellite constellation advancements in the rest of the world[617]

- The China Aerospace Science and Technology Corporation (CASC) announced in early March the use of the Long March 5B for the launch of the planned national LEO broadband constellation "Guowang". Such constellation is aiming at international competition for satellite communications and infrastructure in LEO among other potential applications. It is planned to be comprised of 13,000 satellites manufactured by the China Academy of Space Technology (CAST) and the Innovation Academy for Microsatellites (IAMCAS).[618]
- GalaxySpace and Skysight made their respective launches, Lingxi-03 and Skysight AS-1, 2 and 3 satellites, respectively. The first will offer technical assistance for the implementation of China's LEO communications megaconstellation and the second will consist of a stackable, flat-panel communications satellite.[619]

[617] ESPI launch database
[618] China to begin constructing its own megaconstellation later this year, SpaceNews, March 2023
[619] Chinese commercial space sector gains momentum as private firms shore up sophisticated industrial chain, Global Times, July 2023; CGWIC Successfully launches Skysight AS-01-03 and Lingxi-03 satellites by LM-2D Launch Vehicle, China Great Wall Industry Corporation, July 2023

- In August, the Shanghai government announced the backing of a broadband mega constellation named "G60 Starlink" expected to comprise more than 12,000 satellites, with an initial phase consisting of orbiting 1,296 of them.[620] In December, China announced the successful production of the first of the satellites in their new facilities in Shanghai[621].
- In March, PIESAT confirmed the successful launch of the Nuwa constellation, an Interferometric Synthetic Apertura Radar (InSAR) satellite system.[622]
- Beijing municipal government announced in September the support to satellite constellations to promote the referenced as future industries. The following technologies were explicitly mentioned: satellites for communications, flat-panel, software-defined and standardised ones, as well as laser communications, high-precision radars, optical imaging and phased array antennas. Among the stated objectives, high-resolution, rapid revisit, full-coverage optical and radar remote sensing constellations, LEO IoT and LEO navigation constellations were mentioned. [623]
- China space authorities announced in October their intention to build a lunar satellite constellation for communications, navigation and remote sensing to support deep space missions. The Queqiao constellation will be composed of satellites orbiting cislunar space and Earth-Moon Lagrange points. The constellation will support taikonaut and surface spacecraft operations.[624]
- In November, Huawei announced their satellite mega-constellation, having already conducted the first in-orbit communication test.[625]



Credit: CGTN

Funds for the expansion of satellite constellations were also raised in various other locations around the world:

- Australia-based Fleet Space Technologies announced in May raising $33 million for its services of satellite-based mineral exploration. Using ground sensors distributed in specific areas on Earth, seismic data is sent to users via this LEO constellation, which currently is composed of 7 satellites. [626]
- In June, India-based Digantara announced raising $10 million for an SSA constellation system.[627]
- In August, Canadian-based Telesat's Lightspeed constellation for broadband is underway with launches expected to start in mid-2026. This occurrence caused the transition to smaller satellites, prompted by the alteration of manufacturers owing to production delays moving from Thales Alenia Space to MDA. The performance is expected to be identical to the switch from analogue terminals to digital beam-forming array antennas.[628]

[620] China could be planning a second broadband megaconstellation, SpaceNews, August 2023
[621] First satellite for Chinese G60 megaconstellation rolls off assembly line, SpaceNews, December 2023
[622] CGWIC successfully launches PIESAT-1-A-01 and PIESAT-1-B-01-03 satellites by LM-3D launch vehicle, China Great Wall Industry Corportation, March 2023
[623] Beijing to foster commercial space and satellite constellations as key future industries, SpaceNews, September 2023
[624] China wants a lunar satellite constellation to support deep space missions, SpaceNews, October 2023
[625] Huawei confirms satellite megaconstellation, Advanced Television, November 2023
[626] Fleet Space secures $33 million for mineral exploration constellation, SpaceNews, May 2023
[627] Indian SSA startup raises $10 million, SpaceNews, June 2023
[628] Telesat's initial LEO constellation fully funded after manufacturer switch, SpaceNews, August 2023

- Canadian-based Kepler Communications, announced in April raising $92 million to deploy an optical data relay constellation.[629]
- Canadian MDA Satellite Systems announced in November the start of development of a non-geostationary constellation comprising 36 satellites for a value of $131 million for an undisclosed customer.[630]
- Korean-based Nara Space announced in November the successful launch of their first cubesat towards their planned constellation.[631]
- In September, Singapore-based NuSpace announced the launch of their first satellite towards their planned IoT constellation.[632]
- Kenya-based Amini announced in November the raising of $4 million for their constellation plans: an Africa-focused environmental information constellation. The objective is to have their first satellite launched in 2025.[633]

[629] Kepler Communications raises $92 million for optical data relay network, SpaceNews, April 2023
[630] MDA gets $131 million from mystery NGSO constellation customer, SpaceNews, November 2023
[631] Nara Space successfully launches cube satellite, The Korea Herald, November 2023
[632] NuSpace and Oxford Space Systems mission successfully launched, SpaceWatch, September 2023
[633] Amini raises $4 million for Africa-focused environmental constellation, SpaceNews, November 2023

2.1.5 Notable developments in the use of space to support the climate transition

The year 2023 saw many developments in the field of Earth observation and, more broadly, the use of space for climate-related purposes. In light of the Global Stocktake, an essential component of the Paris Agreement aiming to monitor the implementation and evaluation of the progress towards climate objectives, the use of space proved to be an essential tool for states to communicate their nationally determined contributions (NDCs) at COP28.

In addition, there was also a renewed interest from the private sector in space-based climate data thanks to the adoption of Environmental, Social, and Governance (ESG) in many corporations. Equally remarkable, the increasing number of extreme weather events and rising national security concerns pushed several states to announce plans to develop their own EO satellite or constellations.

Rising interest in commercial space-based data to support the green transition

In 2023, both states and the private sector in many verticals showed a significant interest in commercial EO systems and data to monitor GHG emissions; ocean, sea, coastal, and water basins; forests; as well as agricultural activities:

Emissions	• In June, the German start-up Airmo raised €5.2 million in pre-seed funding. The funds included a founding round of €1.7 million led by Findus Venture, which also included Ananda Impact Ventures, Pi-Labs, E2MC, Antler, etc. The rest of the funds raised by Airmo come from a €3.7 million ESA contract through Phi-lab's InCubed public-private partnership. Airmo plans to launch a constellation of 12 satellites equipped with spectrometers and LiDAR instruments to measure carbon dioxide and methane.[634] • In August, GHGSat announced it ordered four 16U cubesats from Spire Global to further develop its greenhouse gas-monitoring constellation, which currently counts nine satellites. GHGSat aims to launch the four satellites in 2024. The new satellites will aim at providing more data regarding industry-generated GHG emissions. GHGSat already uses payloads from the Swiss company ABB to monitor methane emissions.[635] • In November, the French company Kayrros launched the free version of its methane tracking platform, providing an overview of the world's biggest emitters based on satellite data. The map was released ahead of COP28 where methane reduction was on the agenda.[636] • In December, GHGSat signed a partnership agreement with the Emirati company Yahsat and the Abu Dhabi National Oil Company (ADNOC) to monitor and reduce methane emissions. Towards this, they will establish a Centre of Excellence and use space-based data to monitor GHG and methane emissions coming from oil and gas facilities and develop mitigation measures. The Centre of Excellence will be open to national oil companies in the Middle East, North Africa, and Central Asia.[637]

[634] Airmo raises 5.2 million euros for climate-monitoring constellation, SpaceNews, June 2023
[635] GHGSat orders four more greenhouse gas monitoring cubesats from Spire, SpaceNews, August 2023
[636] Satellite imagery analysis firm launches free greenhouse gas tracker, SpaceNews, November 2023
[637] GHGSat signs strategic partnership with Yahsat and ADNOC supporting the mitigation of global energy sector's methane emissions, GHGSat, December 2023

Water	• In February, the Swiss Polar Institute (SPI) awarded a contract to Astrocast to develop a satellite communication system for remote snow, glacier and permafrost monitoring stations in Central Asia.[638] • In April, BackSky, through its reseller Telespazio, announced it will provide the Spanish local government of Aragon and the Geographic Institute of Aragon (IGEAR) with satellite data for crisis response including fires and floods.[639] • In June, the U.S. start-up Muon Space successfully launched its first satellite into orbit on the SpaceX Transporter-8 rideshare flight. Muon Space aims to launch a constellation of satellites to monitor climate change. It will test dedicated sensors that aim to provide sub-hourly global measurements in two launches scheduled in 2024. The constellation will focus on flood and water monitoring.[640] • In June, Tomorrow.io raised $87 million in a Series E funding round led by Activate Capital and including RTX Ventures, Seraphim Space and Chemonics. Existing Tomorrow.io investors include SquarePeg Capital, Canaan, ClearVision, JetBlue Ventures and Pitango. Tomorrow.io had already launched two radar satellites equipped with microwave sounders to gather weather data, ocean surface winds and sea surface heights.[641] • In September, ICEYE and the Federal Government of Australia signed a contract to provide SAR flood and bushfire risk data and insights to local governments. The contract continues the partnership between the two actors as the Australian Government has already been using ICEYE's Flood Insights product since October 2022.[642]
Forests	• In March, the U.S. company Chloris Geospatial raised money as part of a seed extension funding round led by AXA IM Alts and Orbia Ventures and involving At One Ventures and Counteract. The company aims to develop technologies using EO data for monitoring forest carbon dynamics, including forest growth and degradation.[643] • In March, the Finnish company CollectiveCrunch, which is developing a sustainable forestry platform using EO data, announced it raised €1.4 million as part of a funding round led by Nidoco AB.[644] • The Norwegian International Climate and Forest Initiative (NICFI) Satellite Data Program, which provides access to satellite data, focusing mostly on deforestation monitoring, was extended until September 2024. This Program was launched in 2020 and benefited 18,000 users worldwide. The Norwegian

[638] Astrocast and SensAlpin to develop IoT satellite comms for glacier and permafrost monitoring stations, Meteorological Technology International, February 2023
[639] BlackSky Reseller Telespazio to Provide Spain's First Ever High-cadence, Low-latency Imagery Service for Disaster Response, BlackSky, April 2023
[640] Muon celebrates launch of first satellite in Climate Constellation, SpaceNews, June 2023
[641] Tomorrow.io raises $87 million for weather satellite constellation, SpaceNews, June 2023
[642] Australian Government Selects ICEYE for Near Real-Time Flood and Bushfire Data to Strengthen Disaster Response, ICEYE, September 2023
[643] Chloris Geospatial Closes Seed Extension Round of Funding with AXA IM Alts and Orbia Ventures as New Investors, Chloris, March 2023
[644] CollectiveCrunch Raises €1.4M in Funding, Finsmes, March 2023

	government relies on Kongsberg Satellite Services (KSAT), Airbus, and Planet to provide access to satellite images.[645] • In June, Ororatech and Spire Global signed a contract to build and operate eight thermal imaging satellites to expand its constellation that focuses on wildfire monitoring. Ororatech already launched two satellites.[646] • In September, Planatek Italia signed a contract with the Saudi company Geosystems Middle East to provide EO services for afforestation purposes: the transformation of abandoned or damaged agricultural lands into forests. Planatek Italia will contribute to the Saudi Green Initiative, which aims to plant 10 billion trees on its territory along with land preservation measures and the development of a land monitoring platform to provide analytics and statistics.[647] • In September, OroraTech and the Australian Forestry Corporation of New South Wales (FCNSW) announced that they extended their partnership in the wildfire management field. The partnership's goal is to improve early detection time over 2 million hectares of forest using thermal sensors.[648] • In September, Maxar Technologies signed a three-year contract with the Guyana Ministry of Natural Resources to provide its Crow's Nest Maritime Monitoring and Security and Crow's Nest Maritime Tipping and Cueing Service products to monitor offshore oil drilling platforms and vessels. In addition, the Guyana Forestry Commission will use Maxar's data to monitor illegal deforestation and protect biodiversity.[649] • In November, Fairtrade International signed a partnership with Satelligence to scale satellite monitoring of forests and farms to fairtrade cocoa and coffee producers to connect fairtrade cooperatives and provide them with data on their deforestation risks and ensure compliance with EU deforestation regulations.[650]
Land	• In March, Satellogic and InnerPlant signed a partnership to develop and launch a hyperspectral instrument to detect crops that suffer from pathogens or a lack of water or nutrients.[651] • In March, Airbus Defence and Space signed an agreement with TerraNIS to export its precision farming and crop monitoring product outside of France. The product will be supported by ESA and CNES. Farmstar currently provides data on over 670,000 hectares of land.[652] • In April, the British start-up SatelliteVu was awarded a £300,000 contract from the Energy Entrepreneurs Funds to conduct industrial research for the SARM-PV project from The Energy Entrepreneurs Fund (EEF9), which aims

[645] NICFI prolongs public access to satellite images, SpaceWatch.Global, March 2023
[646] OroraTech orders eight more wildfire-monitoring satellites, SpaceNews, June 2023
[647] Planetek italia secures contract to support afforestation monitoring in saudi arabia, Planatel Italia, September 2023
[648] Ororatech Wins Contract To Improve Early Fire Detection In Australia, Orora Technologies, September 2023
[649] Maxar to Provide Environmental Monitoring for Government of Guyana, BusinessWire, February 2023
[650] Fairtrade producers set to expand deforestation monitoring through new partnership with Satelligence, Fairtrade, November 2023
[651] InnerPlant and Satellogic to Launch First-Ever Device for Detecting Human-Made Crop Signals from Space, Webwire, March 2023
[652] Airbus signs agreement with TerraNIS to export Farmstar in Europe, Airbus, March 2023

at developing and testing a high-resolution infrared monitoring service to spot faults in commercial solar farms through temperature anomaly detection.[653] In May, SatelliteVu raised £12.7 million to develop its thermal-imaging satellite constellation as part of a Series A-2 investment round involving Seraphim Space Investment Trust, A/O Proptech, Lockheed Martin, Ridgeline Ventures, Earth Sciences Foundation and Stellar Ventures.[654]

- In April, Nestle announced that Airbus will provide it with Pleiades Neo satellite imagery to monitor its efforts in reforestation as part of its Global Reforestation Program.[655]
- In May, the U.S. company HydroSat announced it raised $15 million to develop climate data, including measuring water stress in plants. The Series A funding round was led by Statkraft Ventures and included Blue Bear Capital, Hartree Partners, OTB Ventures, Freeflow Ventures, Cultivation Capital, Techstars, Santa Barbara Venture Partners, Expon Capital and Hemisphere Ventures. In addition, hydroSat received $5 million in public grants, including $1.2 million from the U.S. Air Force to investigate national security applications for thermal infrared data.[656]
- In May, IBM signed a partnership contract with NASA to develop a geospatial foundation model using AI to analyse natural disasters and climate change. The geospatial model will aim at converting NASA's space-based data into tailored maps to depict natural disasters and environmental risks on crops, buildings, infrastructures, forests, etc. The model aims to reduce data cleaning and labelling time through AI.[657]
- In June, the U.S. company HydroSat acquired the Dutch company IrriWatch, which generates agricultural data on crop, soil, and irrigation. Hydrosat intends to gather satellite thermal and multispectral infrared data in 2024.[658]
- In November, the Kenyan start-up Amini raised $4 million in a seed funding round led by Salesforce Ventures and the Female Founders Fund to launch a satellite to gather environmental data about Africa by 2025. Amini aims to launch a constellation of 6 satellites, along with the development of software for analytics on drought, flood, soil, and crop health in Africa.[659]

Table 9: Rising interest in commercial space-based data to support the green transition (source: ESPI)

[653] Satellite Vu receives funding to catalyse efficiency across commercial solar farms, SatVu, April 2023
[654] Satellite Vu raised $15.8 million for thermal satellite constellation, SpaceNews, May 2023
[655] Nestlé to pilot new cutting-edge satellite technology to drive transparency in its reforestation projects, Nestle, April 2023
[656] Hydrosat collects $20 million in investment and grants. SpaceNews, April 2023
[657] IBM partners with NASA to monitor natural disasters and climate change using AI, Business Insider India, May 2023
[658] Hydrosat acquires IrriWatch, SpaceNews, June 2023
[659] Amini raises $4 million for Africa-focused environmental constellation, SpaceNews, November 2023

National missions for climate purposes are developing:

Beyond the increasing use of commercial systems and data for climate-related missions, states are also developing national EO missions to simultaneously serve climate needs as and national security objectives.

According to Aravind Ravichandran from TerraWatch Space, although the EO sector is becoming increasingly commercially oriented, two-thirds of the EO market remains driven by government initiatives.[660]

Among the identified trends of the year is the development and launch of an increasing number of first sovereign EO satellites by new spacefaring nations:[661]

- In November, the Omani company Etco Space successfully launched Oman's first EO satellite Aman-1 on a Falcon 9 rocket from Space Launch Complex 4E in Vandenberg.[662]
- In January, Kuwait launched its first EO satellite Kuwait Sat-1 on board of a Falcon 9 rocket from Cape Canaveral.
- In April, the Kenya Space Agency (KSA) launched its first 3U EO satellite Taifa-1, which will provide data on agriculture and support Kenya with food security and natural resources management.[663]
- In November, Djibouti launched its first EO satellite, Djibouti, 1A on board of SpaceX's Transporter-9 mission. The satellite is expected to provide data to monitor agriculture and environmental changes.[664]
- In November, the Spanish state of Andalucia launched its first EO nanosatellite to support the agriculture and fishing sectors.[665]

Established spacefaring nations have ambitions to develop new plans for EO constellations:

- In March, ESA awarded a €112 million contract to TAS to build a constellation of six SAR satellites called IRIDE, with an option to build four additional satellites for €75 million, and another €30 million contract for an optical satellite. IRIDE is a national project funded by Italy's National Recovery and Resilience Plan and managed by ESA and ASI. It will provide environmental data to Italian governmental agencies on fires and coastal areas as well as weather data.[666]
- The UK announced it would join Spain and Portugal to build the Atlantic Constellation, an EO small-sat constellation that aims to enhance climate change and natural disaster monitoring.[667]
- The Polish Space Agency (POLSA) signed a contract with ESA to build an EO constellation called Camila. ESA will have a supervisory role and Polish companies will implement the project. The constellation is expected to support the agricultural, land management, and emergency response domains. 4 satellites will be developed, including three optoelectronics satellites and one radar satellite, which are expected to be launched in 2027.[668]
- Canada announced that it plans to invest $1 billion Canadian dollars in the next 15 years into the Radarsat EO constellation in order to support the country's climate resilience strategy.[669]

[660] Earth Observation in 2023 and Outlook for 2024, TerraWatch Space, December 2023
[661] Ibid
[662] Aman-1: The first satellite from Oman launched into space, Times of Oman, November 2023
[663] Kenya to launch first Earth Observation Satellite with SpaceX, The Star, April 2023
[664] Djibouti Launches First Satellite, Djibouti 1A, Space in Africa, November 2023
[665] Platero, el nanosatélite andaluz ya está en órbita, Area Investment, November 2023
[666] Thales to Build 6 Satellites for Italy's IRIDE Constellation, ViaSatellite, March 2023
[667] UK, Portugal, and Spain Partner on New EO Constellation, Payload, November 2023
[668] 2023: POLSA's year in space, POLSA, January 2023
[669] Canada's budget boost for Radarsat is part of its climate strategy, SpaceNews, October 2023

Finally, many public space missions and partnerships were announced or launched in 2023:

Credit: NASA

- In January, NASA announced that the Surface Water and Ocean Topography (SWOT) satellite started commissioning activities, which entails the activation of all scientific instruments prior to the official start of the mission. In late January, the Ka-band Radar Interferometer (KaRIn) was activated but then shut down. It was restored to operational conditions in March and started to provide its first images of water surfaces.[670]
- Also in January, the European Commission signed a contribution agreement with ESA to develop a national Copernicus data centre in the Philippines using €10 million of funding from the EU bilateral cooperation budget. The EU will support the uptake of Copernicus to support the Philippines with data on natural disasters and climate adaptation.[671]
- In March, ESA announced that its Earth Explorer missions, including SMOS, CryoSat and Swarm missions, which provide data on soil moisture, ice and magnetic field, were extended until at least 2025.[672]
- Also in March, ESA announced the HydroGNSS mission, which aims to produce data on soil moisture and other essential climate variables. will consist of two satellites. The stated objective is to reduce revisit time. [673]
- Also in March, NASA's Global Ecosystem Dynamics Investigation (GEDI) mission, which has an instrument on board of the ISS, was put in hibernation for a 13 to 18 months period, four years after its launch. GEDI will start its operations again for the period 2024 to 2030. The instrument is used to measure forests in 3D, including forest canopy height and the distribution of branches and leaves.[674]

Credit: NASA

- In April, NASA successfully launched its Tropospheric Emissions Monitoring of Pollution (TEMPO) instrument on a SpaceX Falcon 9 rocket from Cape Canaveral. The instrument will provide data with a four-square-mile resolution on air pollution in North America such as rush-hour traffic to pollution from forest fires and volcanoes. The instrument was hosted on an Intelsat telecommunications satellite.[675]
- In April, Dubai's Electricity and Water Authority successfully launched its second EO nanosatellite Dewa Sat-2 on a Falcon 9 rocket from Vandenberg Space Force Base. The satellite, built by Emirati company DEWA and Lithuanian NanoAvionics, is equipped with a high-resolution camera and infrared equipment to monitor GHG emissions. The primary aim of Dewa Sat 2 is to provide data to improve the operations, maintenance and planning of electricity and water systems.[676]
- Still in April, China and Brazil signed an agreement to develop and launch the Cbers-6 satellites, which is planned for launch in 2028. Cbers-6 is expected to be equipped with radar to monitor

[670] Engineers Check SWOT Science Instrument During Commissioning Activities, NASA, February 2023
[671] Global Gateway: European Space Agency and the Commission join forces on earth observation for the Philippines, European Commission, January 2023
[672] ESA's excellent Earth Explorer missions extended to 2025, ESA, March 2023
[673] HydroGNSS twice as good, ESA, March 2023
[674] Global Ecosystem Dynamics Investigation (GEDI), Earth Data NASA, 2023
[675] NASA's High-Resolution Air Quality Control Instrument Launches, NASA, April 2023
[676] DEWA successfully gets its second nanosatellite in space, Arabian Business, April 2023

the Amazon and more broadly the Brazilian and Chinese territories to support natural resource monitoring.[677]

- In November, China launched the Haiyang 3 ocean observation satellite on a Long March 2C rocket. The SAR satellite will provide data on water colour, water temperature, and sea ice.[678]
- During COP28, ESA awarded a contract to Airbus to start the next development phase of the TRUTHS satellites mission, which aims to provide solar radiation and radiation reflected from Earth back into space to enrich climate models. The next phase of development aims at analysing the instruments' performance and creating simulations and system modelling.[679]
- In November, UKSA announced £4 million in government funding for several space R&D projects, including allocating £206,000 to the University of Bristol to use NASA's UK-backed Surface Water and Ocean Topography (SWOT) mission to advance global flood modelling accuracy.
- In November, ESA announced that the CryoSat satellite, which monitors polar sea ice thickness and detects changes on ice sheets, was running on its backup propulsion system that has the potential to extend its life by five to ten years, following a fuel leak, which risked the life of the satellite by five to ten years.[680]

Credit: ESA

- In December, China successfully launched Egypt's MisrSat2 remote sensing satellite on board a Long March 2C rocket from the Jiuquan Satellite Launch Center. The satellite was developed by Aerospace Dongfanghong, a subsidiary of the China Academy of Space Technology, as part of a technology transfer project between the Egyptian Space Agency and the Chinese government. MisrSat2 will provide data for land and resource management, water protection, agricultural productivity, and coastal change monitoring.[681]
- Similarly, ISRO and the Mauritian Space Agency signed an MoU to design, assemble, integrate, test, launch and operate an EO satellite for Mauritius. The MoU foresees a 15-month partnership and specifies that ISRO will carry out in-orbit operations while Mauritius will use the ground station.[682]

[677] Cbers-6: Novo satélite de parceria entre Brasil e China deve custar mais de 100 milhões de dólares e entrar em órbita em 2028, G1, April 2023
[678] China launches new-gen Haiyang ocean monitoring satellite, SpaceNews, November 2023
[679] TRUTHS contract signature at COP28, ESA, December 2023
[680] Life beyond the leak for ESA's CryoSat, ESA, November 2023
[681] China's expertise elevates Egypt's space ambitions with MisrSat 2 launch, SpaceDaily, December 2023
[682] ISRO Signs MoU with MRIC to Construct Mauritius's EO Satellite, Space in Africa, November 2023

2.2 Other Outstanding Developments

Other outstanding developments include progress in R&D in space nuclear propulsion and space-based solar power, and use of space for security and defence and in this light increased demand for GEOINT services.

Moreover, 2023 saw developments in commercial spaceflight, a rising role of AI for space services and new digital platforms emerging to process EO data.

2.2.1 Promises of space nuclear propulsion

Advancements on reactor designs among other technological progresses at large in the aerospace sector are enabling a new era for nuclear space propulsion. Space nuclear propulsion involves the drawing of energy from fission, which in turn and compared to chemical propulsion provides unlimited energy density and thus enables longer missions like Mars.[685] The space propulsion market as a whole experienced growth during 2023 and this trend is expected to continue at a CAGR of 11.3% from 2023 to 2028, according to the Space Propulsion Markets and Markets report.[686] Most developments took place in the U.S. The rise of new ambitions in the field of space exploration is expected to generate an increase in developments in nuclear propulsion, especially among Asia-Pacific countries.

The U.S. is leading the emerging space nuclear propulsion market. In January, NASA and DARPA announced a partnership to showcase a nuclear thermal rocket engine in space, a pivotal advancement for NASA's manned missions to Mars on the Demonstration Rocket for Agile Cislunar Operations (DRACO) programme. The technical development of the nuclear thermal engine will be led by NASA's Space Technology Mission Directorate (STMD). DARPA, would develop the stage and the engine, including the reactor, and serve as the contracting authority, overseeing the development of the entire stage, including the reactor, and leading the programme's overall management, covering rocket systems integration, approvals, scheduling, security, safety, liability, and assembly and integration of the engine with the spacecraft. Through joint efforts, NASA and DARPA aim to assemble the engine for in-space demonstration by 2027.[687]

Chemical, electric, and nuclear propulsion[683] should not be confused.

Chemical propulsion is designed to generate thrust through chemical reactions such as burning liquid or solid propellant.

Electric propulsion on the other hand generates thrust by converting electrical energy into kinetic.

Nuclear propulsion generates thrust through nuclear reactions, granting practically unlimited energy.

Two types of nuclear propulsion systems exist:

- Nuclear thermal propulsion: involving the transfer of heat from the reactor to a liquid fuel, which is converted into a gas through a nozzle to generate thrust.
- Nuclear electric propulsion: involving a reactor to produce electricity to positively charge gas propellants and push the ions out through a thruster.[684]

[683] State-of-the-Art of Small Spacecraft Technology, NASA, September 2023
[684] Space Nuclear Propulsion, NASA, 2023
[685] Space Nuclear Propulsion, NASA, September 2020
[686] Space Propulsion Market Size, Share, Industry, Statistics & Growth Analysis Report, Markets and Markets
[687] NASA, DARPA will test nuclear engine for future Mars missions, NASA, December 2023

Towards this, in July Lockheed Martin secured the contract from DARPA for the nuclear thermal propulsion (NTP) system as part of the DRACO programme, which utilizes a nuclear reactor to rapidly heat hydrogen propellant, generating high thrust for propulsion. Such reactor will utilize a specialized high-assay low-enriched uranium (HALEU) to convert cryogenic hydrogen into intensely hot pressurized gas for efficient propulsion. Safety measures include activating the reactor only after the spacecraft achieved a nuclear safe orbit (1126,5 kilometres), to avoid any risks of propagating nuclear materials on Earth or in the atmosphere. Lockheed Martin teamed up with BWX Technologies to develop the nuclear reactor and produce the essential HALEU fuel.[688]

In May, Zeno Power Systems was awarded a $30 million U.S. Air Force contract to build a radioisotope-powered satellite by 2025. The company develops radioisotope power systems (RPS) that convert the heat from decaying nuclear materials directly into electricity. Unlike traditional RPS, Zeno's design is smaller and uses lower materials. This breakthrough technology, funded through a strategic partnership with private investors, promises constant manoeuvrability for military spacecraft without reliance on fuel. The system employs a novel approach, utilising strontium isotopes and thermoelectric generators, avoiding the limited supply of plutonium-238 typically used in NASA missions. [689]

In June, Westinghouse Electric Company and Astrobotic signed an MoU to collaborate on space technology programmes for NASA and the DoD, focusing on developing space nuclear technology and delivery systems. Westinghouse is developing a microreactor to power spacecraft in orbit or for deployment on the surface of extraterrestrial bodies and is doing this by building upon the initial design concept for a fission lunar surface power system developed with their recent contract with NASA/DoE. Astrobotic's expertise in lunar landers and rovers complements this effort, with the development of LunaGrid, a commercial power service tailored for the lunar south pole. [690]

In September, Intuitive Machines, Lockheed Martin, and Westinghouse Government Services secured contracts from the Air Force Research Laboratory to spearhead innovation in nuclear-powered space vehicles as part of the Joint Emergent Technology Supplying On-orbit Nuclear Power (JETSON) programme. The aim is to advance nuclear fission technology for small power reactors, providing a reliable energy source for satellites. Intuitive Machines will focus on designing a spacecraft concept utilizing compact radioisotope power systems and electric or hybrid propulsion. Westinghouse Government Services aims to mature relevant technologies and explore implementation strategies for high-power nuclear fission systems. Lockheed Martin Space will lead efforts to refine the technical design of the JETSON spacecraft systems and subsystems. These contracts, extending through December 2025, testify a concerted push towards leveraging nuclear technology to enhance space exploration capabilities, building upon earlier studies initiated by NASA for fission surface power systems.[691]

U.S.-based Ultra Safe Nuclear Corporation (USNC), secured a NASA to advance nuclear thermal propulsion (NTP) systems to enhance US civil science and cislunar capabilities, transitioning from design to equipment manufacture. USNC will leverage its expertise to manufacture and test advanced proprietary fuel, collaborating with commercial partner Blue Origin to optimise the design of an NTP engine tailored for near-term civil science and cislunar missions, building upon the

[688] Lockheed Martin selected to develop nuclear-powered spacecraft, Lockheed Martin, July 2023
[689] Zeno Power gets $30 million to build radioisotope-powered satellite for U.S. military, SpaceNews, May 2023
[690] Astrobotic and Westinghouse partner to power outer space, SpaceWatch Global, June 2023
[691] Air Force Research Lab awards design contracts for nuclear powered spacecraft, SpaceNews, October 2023

groundwork laid by NASA and DARPA's Demonstration Rocket for Agile Cislunar Operations (DRACO) programme.[692]

Credit: Rolls Royce

In December, Helicity Space, a California-based startup, secured $5 million in seed funding, backed by prominent space companies like Airbus Ventures, TRE Ventures, and Voyager Space Holdings. The focus of Helicity's work lies in innovating nuclear fusion propulsion technology for deep space missions, offering significantly higher energy efficiency and speed compared to traditional chemical propulsion systems. Their proprietary technology, the Helicity Drive, transforms electricity into plasma heating, which is essential for achieving nuclear fusion. Utilising magneto-inertial fusion methodology, the company compresses stable plasma jets with a magnetic nozzle, heating them to extreme temperatures to initiate fusion reactions. [693]

The European industry is developing nuclear propulsion systems

In March, Rolls-Royce received a £2.9 million grant from UKSA to explore the potential of nuclear power for future lunar bases. They aim to investigate the use of nuclear micro-reactors to enhance the sustainability and duration of missions to the Moon. This pioneering effort seeks to establish a reliable power source for essential systems such as communications, life-support, and scientific experiments. Collaborating with leading academic institutions, including the University of Oxford, University of Bangor, University of Brighton, University of Sheffield's Advanced Manufacturing Research Centre (AMRC), and Nuclear AMRC, Rolls-Royce aims to advance developments of space nuclear power, to have a reactor ready for deployment to the Moon by 2029. [694]

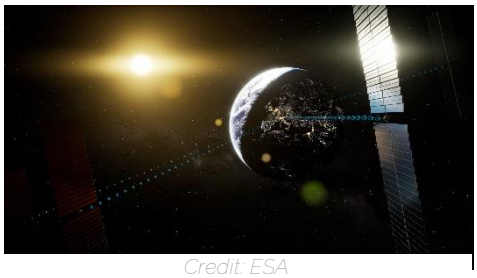
ESA is investing in multiple studies to investigate innovative applications of nuclear propulsion for deep space exploration. Among these studies is RocketRoll, led by researchers from the University of Prague and the University of Stuttgart, alongside engineers from OHB Czechspace and OHB System in Bremen. It explores the feasibility of an electric nuclear propulsion system, where electricity generated by a nuclear reactor powers electric ion thrusters.[695] In addition, the Alumni project is a collaborative effort between France's CEA, Ariane Group, and Framatome, focusing on a nuclear-thermal propulsion engine. By using the energy of a nuclear reactor to heat liquid hydrogen and propel it through space, this project aims to minimise astronauts' exposure to radiation and facilitate the transport of essential equipment for sustained exploration. On the side of this study, in October, France's Framatome unveiled Framatome Space, its new subsidiary dedicated to space exploration and to the use of nuclear technologies for the space sector.[696]

Pulsar Fusion, a UK-based company founded in 2011, started to build what it claims to be the largest practical nuclear fusion rocket engine ever fabricated. Scheduled for firing in 2027, this groundbreaking engine is expected to have the potential to propel spacecraft at speeds of up to 500,000mph, enabling travel to Mars in just 30 days. The company is assembling an 8m wide fusion chamber capable of containing plasma temperatures exceeding those of the Sun. Overcoming the challenge of confining super-hot plasma within an electromagnetic field is key, and recent advancements in machine learning offer promising avenues for progress. Pulsar Fusion is collaborating with Princeton Satellite Systems to harness data from reactors, using computer simulations to refine the design of their Direct Fusion Drive (DFD) rocket.[697]

[692] USNC wins NASA nuclear propulsion contract, Nuclear Engineering International, October 2023
[693] Helicity Space ignites deep space nuclear fusion engine with new funds, Interesting Engineering, December 2023
[694] Government signs £2.9m Moon base nuclear power deal with Rolls-Royce, BBC, March 2023
[695] Europe wants to build a nuclear rocket for deep space exploration, space.com, May 2023
[696] Framatome Space: contributing to the next giant leap, Framatome, October 2023
[697] Pulsar Fusion to build nuclear fusion-fueled rocket engine, Aerospace Testing International, July 2023

In the rest of the world, Russia's Roscosmos announced in April that its planned nuclear-powered space tug to remove space debris is scheduled to be ready by 2030.[698]

2.2.2 Space-based Solar Power



Credit: ESA

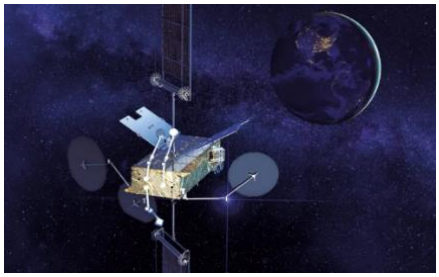
Space-Based Solar Power (SBSP) presents a viable solution for accessing solar energy continuously from Earth's orbit. With the world's focus on achieving Net Zero carbon emissions, SBSP offers eight times more power than terrestrial solar panels by tapping into the constant supply of solar energy in space. Renewed interest in SBSP stems from the urgency of addressing climate change and advancements in space technology, including reduced launch costs. Challenges remain, including deploying and maintaining massive solar arrays in orbit and efficiently transmitting energy back to Earth. Two concepts are considered: optical solar radiation collection and microwave transmission. The first SBSP test mission is anticipated by 2030, with a full satellite constellation by 2040.[699]

Europe's is advancing R&D in SBSP

While solar and wind power are expected to dominate electricity generation, their intermittent nature poses challenges. To bridge this gap, Europe is exploring SBSP as a promising solution. The International Energy Agency's Net Zero 2050 scenario highlights the pivotal role of SBSP in ensuring continuous, uninterrupted power supply.[700]

Several companies entered this vertical in Europe, achieving significant milestones in 2023.

Thales Alenia Space was the European company that was the most active in 2023 in SBSP projects:



Credit: Thales Alenia Space

- In February, TAS completed testing of SolarFlex, a flexible solar array with high power density, part of its INSPIRE product line. SolarFlex, developed with the Czech BSTG consortium, is compact, allowing two satellites under a launcher's fairing. Supported by CNES, the Czech government, and the Belgian Science Policy Office (BELSPO), SolarFlex offers advanced solar power solutions for space missions.[701]
- In March, TAS secured a €43 million contract for the EuroHAPS project funded by the European Defence Fund. The project aims to enhance intelligence, surveillance, and reconnaissance capabilities. Coordinated by TAS, the consortium comprises 21 partners and 18 subcontractors from 11 countries, developing stratospheric demonstrators including a Stratobus, solar-powered airship, Hybrid High Altitude Airship (HHAA), and Autonomous Stratospheric Balloon System (ASBaS).[702]
- In October, TAS UK and Space Solar announced a collaboration to develop the first commercial SBSP system, aiming to establish baseload technology and energy sources in space. The partnership, supported by the UK government's Department of Energy Security and "Net Zero

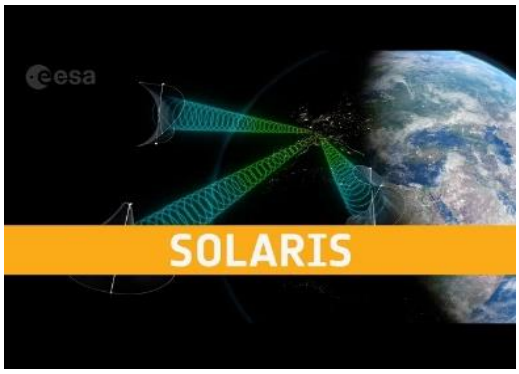
[698] Russia Sets 2030 Timeline To Launch Its Nuclear-Powered Zeus Tug That Can Clean Mounting Space Debris, The EurAsian Times, April 2023
[699] New Satellite Successfully Beams Power From Space, Universe Today, June 2023
[700] SBSP in support of Net Zero, ESA, 2023
[701] SolarFlex solar arrays set to fly on Space INSPIRE satellites, Thales Alenia Space, February 2023
[702] Thales Alenia Space signs contract with European Commission and announces kickoff of EuroHAPS project for the demonstration of stratospheric platforms, Thales Alenia Space, March 2023

Innovation Programme", focused on Space Solar's CASSIOPeiA system, featuring a new format microwave antenna and high-efficiency photovoltaics for wireless power transfer.[703]

Other European companies accelerated SBSP projects:

- In April, the German company DCUBED developed deployable and body-mounted solar arrays for two orbital transfer vehicles operated by Atomos Space. These deployable solar arrays aim to provide ample power to the spacecraft while optimising launch space.[704]
- In November, DCUBED partnered with U.S. company Solestial to develop a new space solar array. The product involves manufacturing the array's back structure in space after deployment, cutting costs and mass, especially for smaller satellites. Cost savings could be up to ten times cheaper than existing solutions, with a 1kW version expected by 2025 and a 10kW version by 2026.[705]
- In July, Airbus subsidiary AALTO HAPS signed an MoU with Bermuda-based Paradise Mobile to introduce HAPS-based solutions to the region. AALTO's Zephyr solar-powered aircraft offers low-latency 4G/5G services above conventional air traffic, complementing terrestrial networks. Set to launch commercially in 2024, this collaboration aims to provide coverage areas and enhanced services, particularly during critical events, through swift deployment capabilities.[706]

Space agencies, international organisations and academia put their attention on SBSP:



Credit: ESA

In April, ESA awarded concept studies for commercial-scale SBSP plants under the SOLARIS initiative. Led by Arthur D Little (ADL) and TAS Italy, these aimed to explore space-based solar energy's feasibility to meet clean energy needs on Earth. ADL's study proposed Direct Sun Reflection (DSR), involving industry leaders like ENGIE and Thales France, envisioning a proof-of-concept mirror by 2025 and full-scale operations by 2043, promising enhanced cost-effectiveness in energy production.[707]

In June, UK Energy Security Secretary Grant Shapps allocated €5 million in government funding for Made in UK SBSP technologies. The fund, with €3.8 million from the Department for Energy Security and Net Zero and €1.2 million from the UKSA, supported projects by Cambridge University, Queen Mary University in London, MicroLink Devices UK, University of Bristol, Satellite Applications Catapult, Imperial College London, and EDF Energy R&D UK Centre.[708]

[703] Space Solar and Thales Alenia Space in the UK working together to deliver space-based solar power, Thales Group, October 2023
[704] Atomos Space and DCUBED partner on the Development of Deployable Solar Arrays for Meson and Gluon Spacecraft, DCUBED, April 2023
[705] DCUBED and Solestial debut new product at Space Tech Expo charting the future for solar panels in space, DCUBED, November 2023
[706] AALTO HAPS and Paradise Mobile, the Bermuda-based Mobile Network Operator, Sign a Strategic Agreement to Develop Stratospheric Connectivity Solutions, AALTO HAPS, July 2023
[707] Arthur D. Little pioneers clean energy from space with direct sun reflection, Arthur D. Little, February 2024
[708] UK shoots for the stars as space-based solar power prepares for lift-off, GOV.UK, June 2023

U.S. companies are developing SBSP programmes and projects:


Credit: Redwire

- In March, Redwire Corporation integrated its Roll-Out Solar Array (ROSA) technology into Astrobotic Technology's Lunar Vertical Solar Array (VSAT) programme. ROSA features dual motors, enabling extended lunar operations with multiple extensions and retractions. Notably, the system meets NASA's requirements for autonomous solar arrays, capable of reaching a height of at least 9 centimetres and relocating as needed on the lunar surface.[709]
- In March, Above Space (formerly Orbital Assembly) secured a $1.7 million contract from the USSF via the Direct to Phase II SBIR programme. The contract aimed to develop rapidly deployable structural solutions supporting solar panels, power systems, and communication arrays in space. These lightweight, efficient structures will bolster in-space infrastructure, meeting the demand for robust and sustainable systems.[710]
- In June, Redwire secured a follow-on contract from Boeing for two additional Roll-Out Solar Arrays (ROSA) for the ISS. Having already deployed six arrays, each contributing over 20 kW of power, the full set of eight will provide over 160 kW for over a decade. Redwire's involvement extends to ROSA variants for NASA's Gateway programme and the Ovzon 3 spacecraft in geostationary orbit.[711]
- In August, Solestial announced plans to supply solar arrays for space tugs developed by Atomos Space. These arrays will be integrated into Atomos' OTVs to enable the movement of satellites between LEO and GEO. Solestial's technology will support high-power electric propulsion, facilitating in-space transportation services for satellite operators. Initial testing will involve a small photovoltaic panel on a demonstration OTV, with larger solar blankets planned for subsequent flights.[712]

American start-ups are developing technology for SBSP, including:

- In June, Orbital Composites and Virtus Solis signed an MoU to commercialise a SBSP station. The two companies combined their expertise, namely 3D printing of SBSP platforms and wireless power transmission (WPT) technologies and planned a first on-orbit test of 100+ satellites for 2026.[713]
- In July, Orbital Composites secured a $1.7 million contract from the USSF through the SpaceWERX Orbital Prime initiative. Collaborating with Axiom Space and Northrop Grumman, Orbital Composites aimed to develop robotic platforms using 3D printing and advanced robotics for in-space servicing, assembly, and manufacturing (ISAM) applications such as satellite-based cellular broadband (SBCB) and solar power satellite (SBSP) deployment.[714]

[709] Redwire's Roll-Out Solar Arrays to Enable Lunar Power Infrastructure for Astrobotic VSAT Program, Redwire Space, March 2023
[710] 1.7 Million Dollar Contract Awarded to Above: Orbital Inc., Above: Space Development Corporation, March 2023
[711] Redwire Announces Follow-On Contract to Develop Additional Roll-Out Solar Arrays for the International Space Station, Business Wire, June 2023
[712] Solestial to supply solar blankets for Atomos space tugs, SpaceNews, August 2023
[713] Orbital Composites, Virtus Solis Team on Space-Based Solar Power Station, Payload, June 2023
[714] Orbital Composites wins $1.7 million Space Force contract, SpaceNews, July 2023

NASA awarded R&D contracts to commercial actors and academia:

- In July, NASA chose 11 U.S. firms for its sixth Tipping Point programme, investing $150 million for long-term lunar and space exploration tech. Partnerships entail funded Space Act Agreements lasting up to four years, with firms contributing a percentage of project costs. Two firms, focusing on lunar solar power systems, were among those selected:
  - Astrobotic Technology received $34.6 million to progress its LunaGrid initiative, focusing on lunar surface solar power generation and transmission. The funding aided the development of a CubeRover, enabling it to deploy a cable while traversing one kilometre from the lander. Once deployed, the lander's solar arrays will transmit one kilowatt of power to the rover, advancing lunar power technology.
  - Blue Origin received $34.7 million to enhance its Blue Alchemist project by manufacturing solar cells using lunar resources. This aims to advance the utilisation of lunar materials for solar cell production. Blue Origin successfully created solar cells in a terrestrial laboratory using simulated lunar materials, contributing to the project's progress and potential for future lunar energy applications.[715]
- In November, Solestial received a Phase II SBIR contract worth $849,954 from NASA, extending its Phase I contract awarded in January. The 18-month Phase II project aimed to develop 50-kilowatt class solar array wings. Collaborating with Opterus Research & Development, Solestial aimed to integrate its silicon solar blanket technology with Opterus' Retractable-Rollable Mast Array (R-ROMA) for scalable, tensioned solar array deployment, overcoming existing limitations.[716]
- In June, Caltech researchers achieved the first successful wireless power transfer using the Microwave Array for Power-transfer Low-orbit Experiment (MAPLE), a technology tested by the Space Solar Power Demonstrator (SSPD-1). This experiment, launched atop a SpaceX Falcon 9 on January 3rd, also included the Deployable on-Orbit ultralight Composite Experiment (DOLCE) and ALBA, testing various photovoltaic cells. The project is part of Caltech's Space Solar Power Project (SSPP), supported by over $100 million in donations and $12.5 million from Northrop Grumman Corporation.[717]
- In May, Momentus facilitated hosted payload support services for Caltech's SBSP Project payload. Deploying the Qosmosys Zeus-1 payload from its Vigoride-5 Orbital Service Vehicle, Momentus provides in-orbit support to Caltech. This included data provision, communication, telemetry, and resource optimisation for various tasks such as picture-taking and solar cell lighting.[718]

[715] NASA selects companies to advance lunar power and other technologies, SpaceNews, July 2023
[716] Solestial Awarded Nearly $1M in NASA SBIR Ignite Contracts for Next Generation Solar Array, Solestial, November 2023
[717] In a First, Caltech's Space Solar Power Demonstrator Wirelessly Transmits Power in Space, California Institute of Technology, June 2023
[718] Momentus Deploys Qosmosys Satellite and Starts Comprehensive On-Orbit Support of Caltech Hosted Payload, Momentus, May 2023

China also aims to accelerate in-orbit experimentation and collaborate internationally to shape the future of space energy:

- Chinese scientists and engineers are exploring SBSP technology to harness continuous solar energy and transmit it wirelessly to Earth. Multiple teams are developing the necessary technologies for construction and operation. The system would convert solar energy into electromagnetic radiation, like microwaves and laser beams, sent to Earth's receiving stations to generate electricity. Despite technical challenges, Chinese researchers are optimistic about SBSP's potential to address energy needs and reduce pollution, aligning with China's carbon emissions reduction goals.[719]

Credit: Xidian University

- In April, China moved forward with plans to construct a gigawatt-level SBSP station, intending to develop energy generation by harnessing solar energy in space and transmitting it wirelessly to Earth. With a power capacity of 1 billion watts, the envisioned station signifies China's commitment to leading in space power technology. This initiative holds the potential to reshape global energy infrastructure.[720]

[719] Country aims to shine in space-based solar power tech to boost clean energy, China Daily, December 2023
[720] China to build gigawatt-level space power station: leading expert, Global Times, April 2023

2.2.3 Conflicts worldwide spark new demand for GEOINT services

Geospatial Intelligence (GEOINT) consists in the use of imagery and geospatial data for the examination, assessment and visual representation of physical attributes and geographically linked events occurring on Earth.

Following the launch of the Alliance Persistent Surveillance from Space (APSS) initiative earlier in the year, an official from NATO acknowledged in May the growing trend of increased demand for intelligence, surveillance, and reconnaissance, leading to agreements with commercial satellite imagery providers.[721]

The United States keeps leading the GEOINT market in light of new conflicts

Most of the industry weight and advancements were driven by the National Geospatial Agency:

- In May, the National Geospatial-Intelligence Agency (NGA) revealed its plan to demonstrate a data processing node aimed at processing and distributing data in remote locations. The agency is presently developing four Joint Regional Edge Nodes (JRENs), with the initial deployment slated for the U.S. Indo-Pacific Command.[722]
- During that same month, an official highlighted the extension of collaboration with academia and industry in advancing Project Maven, a program established in 2017 to analyse data, imagery, and video from unmanned systems for target identification purposes.[723]
- The NGA director additionally revealed a collaboration with other government space organisations to create the Lunar Reference Frame, a mapping infrastructure aimed at facilitating a potential similar to GPS capability for the Moon.[724]
- In June, NGA awarded a prime contract to Axim Geospatial, previously acquired by NV5, under their 'GEOINT Enterprise Operations Service and Solutions Program' to implement process automation, computer vision capabilities, and algorithms tailored to address mission-specific challenges.[725]
- Later in December, the Agency issued an announcement as part of the initiative "Boosting Innovative GEOINT-Science and Technology BAA," aiming to tackle challenges in technical domains related to foundational GEOINT. The initial topic released under this initiative, the Geospatial-Intelligence Foundational Model, aims to create a foundational neural network model capable of answering geospatial questions using ground-level imagery and vector data as input.[726]
- In that same month and in an effort to fulfil the growing need for commercial GEOINT known as Luno A, NGA announced the lookout for procurement of unclassified data services.[727]

Other U.S defence agencies and companies also drove developments in GEOINT:

- Maxar Technologies, headquartered in Colorado, secured another U.S. Army contract in February, this time focused on developing immersive training and simulation software.[728]

[721] NATO hunger for info driving deals for commercial satellite imagery, C4ISRNET, May 2023
[722] National Geospatial-Intelligence Agency to demo data processing node, C4ISRNET, May 2023
[723] Geospatial-intelligence agency making strides on Project Maven AI, C4ISRNET, May 2023
[724] Intel agency mapping the Moon to support future lunar navigation, C4ISRNET, May 2023
[725] National Geospatial Intelligence Agency selects recent NV5 acquisition Axim Geospatial for geospatial contract valued up to $900 million, GlobeNewswire, June 2023
[726] NGA releases 1st topic call under boosting innovative GEOINT-science and technology BAA, ExecutivGov, December 2023
[727] Earth-mapping agency seeks more commercial imagery, data suppliers, C4ISRNET, December 2023
[728] Maxar wins more work on Army's One World Terrain virtual training tool, C4ISRNET, February 2023

- In April, NV5 Global, headquartered in Florida, revealed the acquisition of L3Harris Technologies, also based in Florida. The acquired company specialises in providing commercial geospatial technology and software business solutions.[729]
- In May, John Sherman, the Chief Information Officer of the Pentagon, emphasised that while there are calls for cautious advancement in powerful AI development until their effects are confidently manageable and positive, as outlined in an open letter signed by co-founders and CEOs including Apple, Getty Images, and X, implementing AI for national security remains crucial to maintain competitiveness and hegemony on the global stage.[730]
- In July, the U.S. Air Force revealed a $20 million award to Maxar to bolster their Red Wing GEOINT platform. This enhancement involves integrating new algorithms and advancements, notably AI technology. The existing platform generates actionable insights from raw observations through edge node processing and will now incorporate additional data sources and robust algorithms.
- In September, BlackSky Technology, headquartered in Florida, disclosed securing a contract worth over $150 million. The contract entails the delivery real-time, space-based tactical GEOINT-as-a-service to an international defence ministry customer.[731]

Europe's GEOINT market is growing

In Europe, GEOINT services were also driven by defence and intelligence needs:

- In January, UK-based Europa Technologies announced the reappointment by the Scottish Government to provide premium geospatial web services.[732]
- In March, the company announced partnering with Planet for their satellite data to optimise a monitoring solution for the defence and intelligence sector, by providing a high-revisit rate of sites of interest.[733]
- Luxembourg-based start-up Kleos Space filed for bankruptcy in July due to difficulties including launch delays, issues with satellite development, and challenges in accessing capital. The start-up was providing radio-frequency monitoring services to both government and commercial clients.[734]
- Greece-based Planetek Hellas, specialised in EO intelligence solutions for security, law enforcement and defence, announced in November a contract for a collaboration phase with ESA. This is a key component of ESA's EO for Civil Security Applications initiative. A significant aspect of the project resulting from this contract is dedicated to serving as a model example and demonstrating to INTERPOL's Counter Terrorism Directorate innovative methods through which global law enforcement agencies can combat terrorism and organised crime. Firstly, it involves the development and rigorous validation of EO-based strategies tailored specifically for security and law enforcement purposes, under the guidance of experienced security experts. Secondly, it aims to facilitate the seamless integration of EO services into INTERPOL's Counter Terrorism operations, combining them with open-source intelligence to substantially improve operational effectiveness and reduce response times.[735]

[729]NV5 completes the acquisition of L3Harris subscription-based geospatial software business, NV5, April 2023
[730] Pentagon won't pause pursuit of AI, CIO Sherman says, C4ISRNET, May 2023
[731] BlackSky wins $150+ million bid for GEOINT service, GW Prime, September 2023
[732] Europa Technologies reappointed by Scottish Government for premium PSGA services, Europa Technologies, January 2023
[733] Planet and Preligens partner to achieve near-persistent monitoring for Defense & Intelligence analysts, Preligens, March 2023
[734] Geospatial intelligence startup Kleos Space files for bankruptcy, SpaceNews, July 2023
[735]Planetek Hellas signs new contract with ESA to support the interpol's counterterrorism unit, Planetek Hellas, November 2023

- As a collaboration involving Europe and the US, in March Planet announced its collaboration with French company Preligens to strengthen a monitoring solution for the defence and intelligence sector. This partnership involves combining Planet's imagery with Preligens' AI and machine learning capabilities to achieve a high revisit rate for sites of interest.[736]
- Later in November, Preligens announced plans to develop a foundational model for geospatial data, further enabled by the allocation of 300,000 hours of computation on the Jean Zay supercomputer at the French Grand Équipement National de Calcul Intensif (GENCI).[737]
- SI Analytics, headquartered in South Korea, revealed in May some advancements in techniques for identifying missiles, launchers, and supporting infrastructure in North Korea. This project integrates EO data with AI-enhanced image analysis to detect and classify anomalies.[738]

The UAE saw many developments in the field of GEOINT through Bayanat

Bayanat AI, specialised in geospatial intelligence, and Yahsat announced in December their intention to merge following the recommendation of their respective Board of Directors. After the merger, the newly formed entity will be known as Space42. This merger aims to establish a dominant force in AI-powered space technology within the MENA region, with potential for substantial global expansion and synergies. By combining their resources, including strengthened finances, advanced AI technology, and diverse product offerings, the merged company aims to become vertically integrated and pursue opportunities in geospatial and mobility solutions, satellite communications, and business intelligence on both regional and international levels.[739]

Bayanat signed in October two MoUs with Xcalibur Multiphysics, a global leader in airborne geophysics, and Teledyne Geospatial, a provider of sensors and software for land and water mapping. This collaboration was part of the launch of the Smart & Autonomous Vehicle Industries (SAVI) Cluster in Abu Dhabi. Under these agreements, Bayanat will utilise technologies such as artificial intelligence, real-time computing, and digital mapping to drive innovation. Teaming up with Teledyne Geospatial, Bayanat aims to develop advanced survey technologies to enhance geospatial operations both on land and at sea. Additionally, in partnership with Xcalibur, Bayanat will introduce a pioneering geophysical autonomous system in the UAE, focusing on mapping strategic minerals, water resources, and renewable energy potentials like geothermal and hydrogen. The collaboration also extends to exploring international opportunities.[740] In May, Bayanat and Al Yah Satellite Communications Company unveiled an extensive Space Program with the objective of constructing national satellite remote sensing and EO capabilities within the UAE. This initiative is geared towards tapping into commercial opportunities in both the local and global EO market. The programme represents a key aspect of the collaboration between the two companies and ICEYE, a SAR satellite manufacturer headquartered in Finland. This expansion of Bayanat's expertise into the space sector not only aligns with the company's growth strategy but also positions it as a significant contender within the industry.[741]

[736] Planet And Preligens Partner To Achieve Near-Persistent Monitoring For Defense & Intelligence Analysts, Planet, March 2023
[737] Preligens to develop a foundation model for geospatial data, Preligens, November 2023
[738] South Korea company fuses AI with imagery to detect ballistic missiles, C4ISRNET, May 2023
[739] Introducing Space42, a new AI-powered space technology champion with global reach, and its Board of Directors, Yahsat, December 2023
[740] Bayanat Signs MOUs with Xcalibur Multiphysics and Teledyne Geospatial During the Smart & Autonomous Vehicle Industries (SAVI) Cluster Launch in Abu Dhabi, Bayanat, October 2023
[741] Bayanat, Yahsat and ICEYE announce an ambitious program to broaden commercial opportunities across the UAE space-ecosystem, Yahsat, May 2023

2.2.4 Artificial Intelligence (AI) is making its way into the space sector

Over the past few years, AI has become increasingly central to the operations of space companies, serving both commercial and security objectives. AI's application improves resource efficiency, predicting satellite failures and contributing to the sustainability of space businesses. As the space industry advances, AI plays a crucial role in enhancing efficiency, technology, and security on both commercial and national levels. However, challenges persist, including data interoperability issues, concerns about AI decision reliability, and the need to establish trust among stakeholders. Overcoming these challenges requires ongoing efforts in data standardisation, rigorous testing, and continuous human oversight. Therefore, successful AI integration into space operations relies on collaborative endeavours across public and private sectors - as well as international partnerships - to navigate complexities and unlock AI's full potential.[742]

Space Agencies are looking to take advantage of AI for their space programmes

ESA's Advanced Concepts Team (ACT) and the first ESA Φ-lab in Italy are at the forefront of deep learning research and the development of AI for EO missions. Moreover, the Software Systems Division within ESA's Directorate of Technology, Engineering, and Quality is exploring onboard AI solutions and applications of natural language processing in space technology. These initiatives signify ESA's commitment to leveraging AI to enhance space exploration and Earth observation capabilities.[743]

Notably, ESA embarked on several AI missions, further solidifying its position in the field:

- In January, ESA advanced the Cognitive Cloud Computing in Space (3CS), embedding AI accelerator chips on satellites. ESA Φ-lab, with Microsoft and Thales Alenia Space, launched a challenge for machine learning models tailored for an ISS optical sensor. Trials like Φ-sat-1 showcased onboard AI's cloud filtering from EO data. Missions FDL, Unibap, and D-Orbit Wild Ride improved onboard image classification and chip reprogramming, showing rapid data analysis potential.[744]

Credit: ESA

- On June 6th, ESA highlighted AI's role in verifying organic cotton farms in India using satellite data. Collaborating with German tech firm Marple, ESA aimed to use Sentinel-2 imagery to identify and categorise cotton fields by cultivation methods. Following a trial in Uzbekistan with 98% accuracy, this aligns with Global Organic Textile Standard's objectives.[745]
- In July, the Greek company Libre Space Foundation secured a €2 million ESA contract for the PHASMA project, developing three open-source CubeSats. The mission aimed to analyse space's electromagnetic spectrum usage. Utilising AI, experiments will assess terrestrial radio frequency transmissions, quantifying global spectrum use and identifying interference sources. Additionally, they will provide insights into the ionosphere and navigation systems like GPS, Galileart, BaiDu, and GLONASS.[746]

[742] Artificial intelligence aiding the space business across the board, SpaceNews, February 2023
Enlisting AI to secure the space domain, SpaceNews, February 2023
[743] Artificial intelligence in space, ESA, 2023
[744] ESA continues to explore the value of AI in space in partnership with Thales Alenia Space and Microsoft, ESA, January 2023
[745] ESA launches AI project to monitor organic cotton supplies, SpaceNews, June 2023
[746] Libre Space Foundation's 2 Million Euros PHASMA project with ESA for development of three open-source CubeSats, SatNews, July 2023

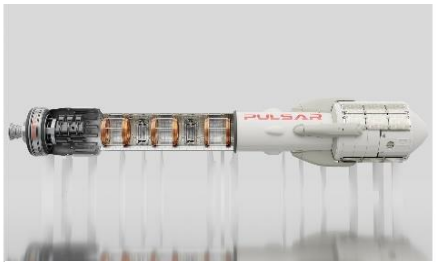
Other agencies around the world initiated AI programmes and missions:

- In February, IBM and NASA's Marshall Space Flight Center partnered to apply IBM's AI technology to analyse NASA's Earth and geospatial science data. As part of NASA's Open-Source Science Initiative, IBM's AI foundation models are adapted from natural language processing to decipher vast Earth data, expediting insights extraction.[747]
- In May, SkyWatch Space Applications advanced to Phase 2 of the Canadian Space Agency's (CSA) Artificial Intelligence and Big Data Analytics for Advanced Autonomous Space Systems challenge. The challenge targeted optimising space and EO asset operations through AI and big data analytics. SkyWatch aims to enhance mission planning, integrate data management, control distribution, and implement machine learning for CSA operations.[748]
- In June, NASA and IBM Research unveiled the HLS Geospatial Foundation Model (HLS Geospatial FM), an open-source AI model derived from NASA's Harmonized Landsat and Sentinel-2 (HLS) dataset. This collaboration offered a tool for tracking land use changes, monitoring natural disasters, and predicting crop yields. Available on Hugging Face, it stems from a partnership involving NASA's IMPACT team, IBM Research, Clark University, ESA, USGS, and Oak Ridge National Laboratory.[749]
- In August, the USSF awarded a $1.5 million contract to New York-based AI startup, Wallaroo Labs, to advance machine learning models for orbiting edge computers. Their software assesses AI performance on edge devices, aiding Orbital Prime's space debris cleanup programme. Partnering with SpaceWERX, Wallaroo.ai aims to deploy radiation-tolerant integrated circuits for machine learning models.[750]

The private sector is leading the uptake of AI for space systems

European companies developed AI-driven projects:

- In June, French company E-Space and U.S. company Comtech teamed up to deliver space-based communications and IoT services for government and commercial clients. Leveraging Comtech's tech portfolio and E-Space's LEO constellation, the collaboration aims to offer secure, global connectivity with edge AI capabilities.[751]
- In June, British company Pulsar Fusion partnered with American firm Princeton Satellite Systems to develop a high-speed space rocket, targeting Saturn's moons within two years. Utilising AI and machine learning, they aim to study plasma behaviour in rocket engine configurations, shortening the mission time to Titan. Through simulations, they aim at potentially reaching Mars in 30 days.[752]



Credit: Pulsar Fusion

- In July, UK companies Aspia Space and Origin Digital introduced AI-powered technology measuring grass height from space. Developed by Aspia Space, it replaced manual measurements, enhancing productivity and sustainability. Initially launched in Ireland, it plans

[747] IBM and NASA Collaborate to Research Impact of Climate Change with AI, IBM, February 2023
[748] Government of Canada Invests in SkyWatch to Build Advanced Autonomous Space Systems Using Artificial Intelligence and Big Data Analytics, SkyWatch Space Applications, May 2023
[749] NASA and IBM Openly Release Geospatial AI Foundation Model for NASA Earth Observation Data, NASA, August 2023
[750] Space Force extends Wallaroo's contract for on-orbit AI applications, SpaceNews, August 2023
[751] Comtech, E-Space Team Up to Make Space-Powered Connectivity Services Available and Actionable Anywhere, E-Space, June 2023
[752] UK Nuclear Fusion company announces space rocket US Partnership, Satellite Evolution Group, June 2023

global expansion, empowering farmers to optimise grass use and profitability. Aspia Space combines EO satellites with AI algorithms, promoting sustainable agricultural practices.[753]

- In November, Austrian company Blackshark.ai, known for pioneering 3D digital twin creation for Microsoft's Flight Simulator, secured a $15 million Series A extension, totalling $35 million with investments from Point72 Ventures, M12, Maxar, In-Q-Tel, Safran, and others. Investors recognised its potential in renewables, infrastructure monitoring, and urban planning. In the same month, the company introduced Orca Huntr, an AI-powered tool for geospatial intelligence. This tool simplifies object detection from orbital imagery with an intuitive interface, allowing users to identify and track features by scribbling on them.[754]
- In December, Thales Alenia Space, with Indonesian PT Len Industri, secured a multi-mission contract to deploy an EO constellation for the Indonesian Ministry of Defence. The constellation integrates optical and radar satellites operated via a multi-mission ground segment, with the involvement of the Italian Telespazio. Contract details remained undisclosed, but TAS aims to employ AI to enhance system responsiveness, boosting Intelligence, Surveillance, and Reconnaissance capabilities.[755]

U.S. companies were the most active in 2023 in the field of AI:

- In March, Cognitive Space and Terran Orbital unveiled the inaugural Software-as-a-Service (SaaS) AI-driven automated mission management system. By integrating Terran Orbital's GeoStare SV2 spacecraft onto Cognitive Space's CNTIENT platform, they facilitated EO and Non-Earth imaging (NEI) with agile boresight capabilities. Utilising machine learning in a cloud computing environment, CNTIENT streamlined collection planning and link management.[756]

Credit: Cognitive Space

- In March, Impact Observatory secured $5.9 million in seed funding to use AI for satellite imagery analysis, partnering with Esri, Microsoft's Planetary Computer, and AWS SageMaker. They launched their commercial space-based monitoring service, processing data from ESA Copernicus constellation. In July, it also teamed with Planet Labs PBC for AI analytics in land cover and land use monitoring, offering enhanced resolution.[757]
- In March, RS21 pioneered satellite monitoring with AI software SPAICE, recently patented for training algorithms using telemetry and historical data. USSF contracts highlighted its potential, applying analytics designed for biology to spacecraft monitoring.[758]

[753] Innovative new technology harnesses AI and satellite data to enable grassland farmers to remotely measure the height of their grass from space, Aspia Space, July 2023
[754] Blackshark.ai Closes an Oversubscribed Extension to its Series A Round, Totaling $35 Million, to Fast-Track Commercialization of its Unique GEOINT and 3D Mapping Technology, Blackshark.ai, November 2023
Blackshark.ai's Orca Huntr lets you build orbital intelligence models with a scribble, TechCrunch, November 2023
[755] Thales Alenia Space signs a multi-satellite contract with PT Len Industri to provide radar and optical imagery, Thales Alenia Space, December 2023
[756] Cognitive Space and Terran Orbital Announce World-First in SaaS AI-driven Earth Observation Satellite Operations, Cision US, March 2023
[757] AI-Powered Impact Observatory Announces Partnership with Planet to Deliver Near Real-Time Change Monitoring with Best-in-Market Accuracy, Frequency and Resolution, Impact Observatory, July 2023
[758] Albuquerque data analytics firm wins $3 million investment, Albuquerque Journal, July 2023

- In May, Planet Labs PBC partnered with AI analytics firms, enhancing insights from EO data. Partnering with SI Analytics boosted resolution and applied GeoAI Analytics for anomaly detection, highlighting AI-EO fusion.[759]
- In June, Sidus Space integrated hyperspectral and multispectral imaging with Edge AI into LizzieSat satellite, slated for SpaceX Transporter missions in 2024. Outfitted with Owl 1280 and Hawk 1920 HD cameras by Raptor Photonics, LizzieSat monitors services across sectors. Backed by extensive ground coverage and Edge AI, it delivered data swiftly for agriculture, climate change, and mining sectors.[760]
- In July, Lockheed Martin highlighted AI's role in future space projects, notably in its Destination: Space 2050 initiative. Exploring causal autonomy tools, it aims for super autonomous systems navigating unforeseen obstacles.[761]
- In August, Microsoft and Synthetaic unveiled a five-year collaboration: leveraging Microsoft Azure for Synthetaic's RAIC tool. This partnership grants Synthetaic access to nearly 1 million hours of cloud compute resources, fuelling the development of geospatial and imagery solutions. RAIC, accessible via Microsoft Azure Government Cloud, highlights AI's potency in deriving insights from vast datasets, ensuring stringent security and compliance for government agencies.[762]
- In August, Orbital Sidekick revealed findings from its GHOSt constellation. Equipped with advanced hyperspectral sensors, GHOSt 1, 2, and 3 capture 472 bands of light, providing 100 times more spectral data than traditional sensors. Onboard AI swiftly processed this data, benefiting various industries. OSK aims to expand its constellation by 2024.[763]
- In October, the Marine Corps Systems Command (MCSC) requested industry input for an AI chatbot programme to bolster its GEOINT system, the Distributed Common Ground/Surface System-Marine Corps (DCGS-MC). This aims to assess AI capabilities for handling requests concerning Marine Corps geospatial processes.[764]

Russia also advanced AI projects, emphasising collaboration with Russian enterprises:

- In November, JSC TERRA TECH, part of the Russian Space Systems holding, and JSC Management Company of Aerospace Innovation Valley partnered to develop the so-called Competence Centre for the Use of Results of Space Activities, previously created at the Innovative Scientific and Technological Center Aerospace Innovation Valley. The agreement aimed to integrate AI into space data infrastructure, harnessing TERRA TECH's neural network expertise. INTC "Aerospace Innovation Valley" aims for nationwide tech sovereignty, with infrastructure development ongoing.[765]
- Always in November, TERRA TECH JSC proposed sharing space technologies through Earth Remote Sensing (ERS) cooperation at the EAEU Business Forum “Space Integration”. This initiative, part of the Digital Earth project, aims to empower nations with AI-driven spatial data processing. Commissioned by Roscosmos under Russia's Digital Economy programme, TERRA TECH's project serves as a model for unified monitoring systems, ensuring standardisation across EAEU countries.[766]

[759] Planet Announces AI Partnerships at GEOINT 2023, SpaceRef, May 2023
[760] Sidus Space to launch Lizziesat™ satellite with Edge AI, hyperspectral and multispectral imaging on SpaceX Transporter mission, Sidus Space, June 2023
[761] AI, quantum and nuclear technologies are key to Lockheed Martin's vision for Space 2050, SpaceNews, July 2023
[762] Microsoft signs new partnership with AI and data analytics startup, SpaceNews, August 2023
[763] OSK Debuts Initial Hyperspectral Insights from GHOSt Constellation, Orbital Sidekick, August 2023
[764] Marine Corps Begins Search for AI Chatbot to Support GEOINT Data System, Executive Mosaic, October 2023
[765] Terra Tech and Aerospace Innovation Valley will create a Competence Center for using the results of space activities, Terra Tech, November 2023
[766] Roscosmos proposes to scale up Russian space technologies to the EAEU countries, Terra Tech, November 2023

Asian actors also focused their attention on AI missions:

- In February, China launched a project utilising AI to address space debris. Led by the State Key Laboratory of Astronautic Dynamics (ADL), the initiative titled "Intelligent Modelling of Complex Evolving Environments for Space Debris and Autonomous Monitoring" integrates AI algorithms with domain expertise and it is designated under China's "New Generation of Artificial Intelligence 2022 Major Programme".[767]
- In April, Chinese scientists from Wuhan University conducted a "landmark experiment," granting an AI system full control of a near-Earth orbit satellite. Qimingxing 1, an EO satellite, autonomously operated for 24 hours without human intervention, directing its focus to specific Earth areas, including Patna city in India, and Osaka.[768]
- In August, Chinese firm STAR.VISION launched the WonderJourney-1A (WJ-1A) satellite from Jiuquan Satellite Launch Center. WJ-1A, equipped with integrated AI and String Edge AI Platform, enabled real-time observation and processing without data transmission to Earth. STAR.VISION plans to expand its satellite constellation to 20 units by 2024. In October, in collaboration with Rwanda Space Agency, STAR.VISION announced the success of the Algorithm Rideshare Programme aboard WJ-1A, showcasing public-private-academic collaboration.[769]
- In June, the Australian SmartSat Cooperative Research Centre (CRC) launched the $7 million SCARLET-α project. Over three years, eight partners, including Airbus, Asension, Deakin University, Defence Science and Technology Group, Leonardo Australia, Saab Australia, Swinburne University of Technology, and the University of South Australia (UniSA), will collaborate to develop autonomous algorithms for small spacecraft to make independent decisions and optimise resources.[770]
- In September, Singaporean start-up SpaceChain introduced I-Sat, blending AI with Earth imagery for efficient data analysis. I-Sat provided real-time analytics and natural language processing, easing information retrieval. SC Solutions, SpaceChain's U.S. branch, invited Earth-imagery providers and developers to join, with blockchain facilitating payment distribution. Pilot projects in Brazil showcase I-Sat's AI-driven capabilities in vegetation health and soil moisture analysis.[771]

Credit: News IADN on X

[767] China to study use of AI technology in avoiding space debris, Global Times, February 2023
[768] China scientists carry out 'rule-breaking' AI experiment in space, South China Morning Post, April 2023
[769] Chinese firm launches WonderJourney satellite with AI-powered 'brain', South China Morning Post, August 2023
China's STAR.VISION AI Satellite to Use Rwandan-Developed Technology, Space in Africa, October 2023
[770] SmartSat CRC Commit to Develop Autonomous Spacecraft, SpaceWatch.Global, June 2023
[771] SpaceChain pivots to combine AI with Earth imagery, SpaceNews, September 2023

2.2.5 Commercial spaceflight: from launches, over space stations, to the Moon

In 2023, the commercial space launch sector experienced significant growth and progress, with companies increasingly asserting their presence and driving various innovative initiatives to enhance space launch capabilities. Across continents from America to Europe and Asia, numerous commercial entities witnessed notable advancements and developments, signalling an advancement in the commercial space industry.

The U.S. was at the forefront of commercial space flight missions

- SpaceX achieved a remarkable 96 successful orbital rocket launches, with 91 utilising Falcon 9 and 5 deploying Falcon Heavy, surpassing their prior annual record of 61 in 2022. Notably, they landed their 250th orbital rocket booster and conducted 19 rocket launches and landings with a single booster. Additionally, they set a new record for the shortest time between orbital launches, under three hours. Excluding Starship test flights, SpaceX aims for 144 Falcon missions in 2024, prioritising Starlink satellite deployment.[772]
- Blue Origin's New Shepard rocket launched from west Texas, marking its return since a malfunction paused operations for over a year in September 2022. Following a comprehensive FAA investigation, 21 corrective actions were implemented. Carrying 33 science payloads and 38,000 postcards, the mission underscores Blue Origin's stride towards commercial space aspirations.[773]

Credit: Blue Origin

- In February, Sierra Space and the University of Notre Dame inked an MoU to advance space-based research LEO. Over five years, the collaboration will focus on Sierra Space platforms like the Dream Chaser spaceplane and Orbital Reef commercial space station. Leveraging Notre Dame's space research expertise, they aim to expedite innovations with potential terrestrial benefits. Together they will conduct microgravity experiments, develop hardware, and will explore commercial opportunities in space research and manufacturing.[774]
- In September, Axiom Space unveiled the full crew for its third mission, Ax-3, to the ISS, planned for January 2024. Led by Chief Astronaut Michael López-Alegría, the team included Italian Air Force Col. Walter Villadei, Türkiye's Alper Gezeravcı, and Sweden's Marcus Wandt, representing ESA. Ax-3 marked Europe's inaugural all-commercial astronaut mission.[775]

[772] SpaceX sets new rocket record with 96 successful launches in 2023, CNBC, December 2023
[773] Blue Origin Successfully Completes 24th Mission to Space, Blue Origin, December 2023
Blue Origin Takes Step To Resume Space Tourism Program With New Launch, Forbes, December 2023
[774] Sierra Space and Notre Dame to Push the Boundaries of Scientific Discovery in Space, Sierra Space Corporation, February 2023
[775] Axiom Space Announces Astronauts for Third Mission to ISS, Axiom Space, September 2023
Marcus Wandt will fly to International Space Station on third Axiom Space mission, ESA, September 2023

In China, 2023 proved a fruitful year also thanks toincreasing competition among Chinese commercial space firms

Different companies, including Galactic Energy, ispace, Landspace, Space Pioneer and state-owned spinoffs CAS Space and Expace all reached orbit this year, accounting for 16 of China's 58 orbital launches.

Galactic Energy:

- On January 9th, Beijing's Galactic Energy launched five satellites from Jiuquan Satellite Launch Center using its Ceres-1 rocket. The satellites served telecom, weather, and research purposes, marking the firm's fifth successful Ceres-1 launch and bringing the total to 19 satellites in orbit. Galactic Energy employed reusable liquid engines, unlike the many Chinese firms that rely on solid-propellant rockets.[776]
- On July 22nd, Galactic Energy deployed two satellites into orbit with a Ceres-1 rocket launch. This launch, designated LEMON TREE, commenced the firm's high-density delivery cycle for the year's latter half. The satellites include Qiankun-1, China's first ultra-low orbit test satellite, and another for hyperspectral remote sensing by ADA-Space.[777]
- On September 5th, Galactic Energy successfully launched from sea its Ceres-1 carrier rocket. The sea-launched variant, named Remote 1, deployed four satellites into orbit from the Yellow Sea, off the coast of Shandong province. This event marked China's first sea launch by a private company.[778]
- On September 21st, Galactic Energy's 10th launch attempt ended in failure, losing the Ceres-1 rocket and its payload. The launch from Jiuquan Satellite Launch Center, did not occur as expected, after nine successful missions. Despite this, Galactic Energy is planning the Pallas-1 maiden launch in Q3 2024.[779]
- On December 5th, Galactic Energy launched the Ceres-1 (Y-9) rocket from Jiuquan Satellite Launch Center, achieving the first successful morning and evening orbit launch by a domestic private rocket company. The launch deployed two satellites into a dawn-dusk orbit: the meteorological satellite Tianyan 16 and Star Pool 1A.[780]

iSpace:

- On April 7th, Chinese commercial launch start-up iSpace achieved its second successful flight of the Hyperbola 1 solid rocket. The rocket lifted off from the Jiuquan Satellite Launch Center, achieving orbit without carrying an active payload. The main purpose was to verify vehicle performance and gather flight data.[781]
- On November 2nd, iSpace successfully launched and landed its Hyperbola-2Y test article. The single-stage hopper, powered by methane-liquid oxygen, reached a height of 178 metres during its 51-second flight, demonstrating vertical take-off and landing capabilities. This marked progress towards a reusable medium-lift rocket, intending to launch Hyperbola-3 rocket in 2025, with plans for 25 launches annually by 2030.[782]

[776] Galactic Energy Launches Five Satellites into Space, SpaceWatch.Global, January 2023
[777] Six in a row! Ceres I Launch Vehicle Officially Launches High Density Launch Deliveries, Galactic Energy, July 2023
[778] Across the land and sea, Galactic Energy successfully completed the first sea launch in China's private commercial aerospace field, Galactic Energy, September 2023
[779] China's Galactic Energy suffers first launch failure, SpaceNews, September 2023
[780] The first dawn-dusk orbit launch mission was a complete success!, Galactic Energy, December 2023
[781] Chinese rocket startup bounces back from 3 straight failures with successful launch, Space.com, April 2023
[782] China's iSpace launches and lands rocket test stage, SpaceNews, November 2023

Landspace:

- On July 12th, Chinese private rocket company Landspace launched the Zhuque-2 rocket into orbit from the Jiuquan Satellite Launch Center. This marked the first methane-fuelled rocket globally to reach orbit. The Zhuque-2, despite carrying no payload, demonstrated advancements in performance and reusability potential.[783]
- On December 8th, Landspace successfully launched three satellites into orbit. The launch from the Jiuquan Satellite Launch Center marked the first time a methane-powered rocket succeeded in lifting satellites.[784]

Space Pioneer:

- In April, Space Pioneer, also known as Beijing Tianbing Technology, became China's first private firm to enter orbit using a liquid propellant rocket. This accomplishment was in part enabled by the strategic funding round obtained in February. Their Tianlong-2 rocket successfully launched the Ai Taikong Kexue satellite into a sun-synchronous orbit from the Jiuquan Satellite Launch Center.[785]
- In October, Space Pioneer secured funding for Tianlong-3's development, designed to carry 17 tonnes to LEO, with plans for over 12 launches annually from 2025. The C+ round raised several hundred million yuan, also supporting Tianlong-2 production. Funds will also aid in constructing a dedicated launch site at China's Jiuquan spaceport. Anticipating a launch in the first half of 2024, Space Pioneer aims for 30 missions annually.[786]

CAS Space:

- In April, Chinese researchers at the Chinese Academy of Sciences (CAS) executed a successful rocket vertical landing test at sea in Haiyang, Shandong Province. The test validated communication and spacecraft tracking technologies amidst sea clutters, showcasing the recovery of a 2.1-metre-long, 93-kilogram rocket stage. This advancement testifies to progress in developing a recyclable near-space experiment platform, offering improved prospects for rocket stage recovery and space tourism.[787]

Expace:

- On March 22nd, Expace's solid rocket Kuaizhou-1A successfully launched four meteorological satellites into orbit. The rocket lifted off from Jiuquan Satellite Launch Center. The satellites, named Tianmu 1, provided global commercial meteorological data services.[788]
- On June 8th, the Kuaizhou-1A rocket deployed Longjiang-3, an experimental stackable satellite. Developed by HITSat, it tested communication tech for China's satellite internet plans.[789]
- On July 19th, the Kuaizhou-1A solid rocket successfully launched four Tianmu 1 satellites from the Jiuquan Satellite Launch Center. The launch carried satellites designed to collect weather data and provide global commercial meteorological data services.[790]

[783] China's Landspace reaches orbit with methane-powered Zhuque-2 rocket, SpaceNews, July 2023
[784] China LandSpace's methane-powered rocket sends satellites into orbit, Reuters, December 2023
[785] Chinese rocket firm Space Pioneer set for first launch, SpaceNews, February 2023
Tianbing Technology has completed two consecutive rounds of strategic financing. China's first private liquid oxygen kerosene rocket is about to fly for the first time, Beijing Tianbing Technology, February 2023
China's Space Pioneer reaches orbit with liquid propellant rocket, SpaceNews, April 2023
[786] China's Space Pioneer raise funding for its Falcon 9-class rocket, SpaceNews, October 2023
[787] China carries out successful rocket vertical landing at sea, Global Times, April 2023
[788] Chinese solid rocket launches 4 weather satellites to orbit, Space.com, March 2023
[789] China's first stackable satellite reaches orbit on solid rocket launch, SpaceNews, June 2023
[790] China launches 4 commercial weather satellites to orbit, Space.com, July 2023

Commercial companies take their share of lunar ambitions

2023 saw the inaugural commercial lunar landing from the U.S., marking a significant step forward under NASA's Commercial Lunar Payload Services (CLPS) initiative. The Nova-C lunar lander, part of the IM-1 mission, was ready and underwent extensive testing and certification during the year.

However, in December, Intuitive Machines announced that its IM-1 lunar mission launch, in collaboration with SpaceX, was rescheduled to mid-February 2024 due to changes in SpaceX's launch schedule.[791]

Nonetheless, other U.S. companies focused on projects to advance lunar missions:

- In March, NASA picked Firefly Aerospace to transport payloads, including a lunar orbit satellite, to the Moon's far side. The contract, worth about £80 million, aims for a 2026 launch under NASA's CLPS initiative. Firefly, securing its second CLPS award, will manage end-to-end delivery services, carrying two agency payloads and an ESA-NASA communication satellite.[792]
- In March, Astrolab partnered with SpaceX to send its Flexible Logistics and Exploration (FLEX) rover to the Moon on a mid-2026 Starship mission, part of the Mission 1 to the Moon initiative. This was SpaceX's inaugural commercial contract for lunar cargo delivery. FLEX boasts a modular payload system, catering to scientific experiments and commercial ventures. In November, Astrolab's Mission 1 secured $160 million in contracts from eight enterprise customers, reflecting diverse lunar economy interests.[793]

Credit: Astrolab

- In November, Sidus Space secured an Indefinite-Delivery/Indefinite-Quantity (IDIQ) contract, valued at $10 million over 5 years, to support a U.S.-owned company's commercial lunar programme. The contract encompasses services vital for lunar transportation, infrastructure, and exploration, including Programme Management, Flight Software, Command & Data Handling (C&DH), and Electrical and Thermal support.[794]

Japan's ispace tried to land on the Moon with its HAKUTO-R Mission 1 Lunar Lander:

Credit: ispace

On December 11th, 2022, ispace launched its HAKUTO-R Mission 1 Lunar Lander, setting a record for privately funded spacecraft by travelling to the Moon. Despite initial communication issues, the lander successfully entered lunar orbit on March 20th. However, communication was lost after the scheduled touchdown attempt on April 26th, indicating an unsuccessful landing. Despite setbacks, valuable data from Mission 1 will inform future missions and provide insights to enhance performance and ensure success.[795]

[791] Intuitive Machines IM-1 Lunar Mission Launch Update, GlobeNewswire, December 2023
[792] NASA Picks Firefly Aerospace for Robotic Delivery to Far Side of Moon, NASA, March 2023
[793] Astrolab's FLEX Rover to be Launched on Upcoming SpaceX Mission to the Moon, Astrolab, March 2023
Payloads to be Launched on Upcoming SpaceX Mission to the Moon, Astrolab, November 2023
[794] Sidus Space awarded a 5 year, $10 million ceiling (IDIQ) commercial contract to support commercial lunar transportation, Sidus Space, November 2023
[795] ispace Releases Interim Success Report for HAKUTO-R Mission 1, ispace, February 2023
Japanese lander enters lunar orbit, SpaceNews, March 2023
Status Update on ispace HAKUTO-R Mission 1 Lunar Lander, ispace, April 2023
ispace Announces Results of the "HAKUTO-R" Mission 1 Lunar Landing, ispace, May 2023

Successful achievements in the realm of commercial space tourism

In the rapidly evolving landscape of human spaceflight, the emergence of space tourism stands as a relevant aspect of ongoing developments. Private spaceflight garnered significant attention, with the U.S. boasting the highest concentration of private missions striving to establish commercially viable human spaceflight services.

In 2023, Virgin Galactic was the only company offering commercial spaceflights for tourism and shifted its focus towards achieving a consistent monthly flight rate:

Virgin Galactic's fleet consisted of one spacecraft, VSS Unity. Its successor, VSS Imagine, is now awaiting deployment. Additionally, the company is developing its next-generation Delta class spacecraft, which is scheduled for passenger service by 2026.[796]

Credit: Virgin Galactic

During the year, Virgin Galactic conducted a total of seven monthly flights, encompassing three tourism excursions, one research expedition, and two test missions. These flights maintained an average rate of one every 40 days.

The crew complement for these missions comprised 32 individuals, consisting of Virgin Galactic personnel, researchers, and tourists:

- April 26th, Unity 24: Test flight with 2 crew members, CJ Sturckow and Nicola Pecile.
- May 25th, Unity 25: Test flight with 6 crew members, Michael Masucci, CJ Sturckow, Beth Moses, Luke Mays, Jamila Gilbert, and Christopher Huie.
- June 29th, Galactic 01: Research flight with 6 crew members Michael Masucci, Nicola Pecile, Colin Bennett, Walter Villadei, Pantaleone Carlucci, and Angelo Landolfi.
- August 10th, Galactic 02: Tourism flight with 6 crew members CJ Sturckow, Kelly Latimer, Beth Moses, Jon Goodwin, Keisha Schahaff, and Anastatia Mayers.
- September 8th, Galactic 03: Tourism flight with 6 crew members Nicola Pecile, Michael Masucci, Beth Moses, Ken Baxter, Timothy Nash, and Adrian Reynard.
- October 6th, Galactic 04: Tourism flight with 6 crew members Kelly Latimer, CJ Sturckow, Beth Moses, Ron Rosano, Trevor Beattie, Namira Salim.
- November 2nd, Galactic 05: Research / Tourism flight with 6 crew members Michael Masucci, Kelly Latimer, Colin Bennett, Dr. Alan Stern, Kellie Gerardi, and Ketty Maisonrouge.[797]

Virgin Galactic plans to reduce flights of its current suborbital vehicle, VSS Unity, and cease operations by mid-2024 to focus on its next-generation vehicles. The company will redirect resources to its Delta-class vehicles, laying off staff and cutting expenses.[798]

[796] Investing in Space: Virgin Galactic still has a big hurdle to clear for commercial service, CNBC, June 2023
[797] How many flights has Virgin Galactic flown in 2023?, Space Explored, November 2023
[798] Virgin Galactic to halt Unity suborbital flights by mid-2024, SpaceNews, November 2023
Virgin Galactic launches four private astronauts as it prepares to end Unity flights, SpaceNews, January 2024

Notable advancements in commercial space station projects

With the ISS nearing the end of its design life, the commercial sector is working on the next generation of space stations in LEO. U.S. companies like Blue Origin, Nanorack, and Northrop Grumman, recipients of awards from NASA's Commercial LEO Destinations (CLD) programme, were actively engaged in designing and testing these platforms. Safety remains paramount, but companies proceeded thorough testing with tight schedules, especially considering NASA's plans to deorbit the ISS by January 2031.[799]

- In 2023, Axiom Space, ahead of other CLD partners, finalised critical design reviews (CDRs) for its Hab One and Two space station modules. Currently, it is progressing through three phases of subsystem reviews. Manufactured by TAS, Hab One is set to be delivered to Axiom's Houston office by 2024 for final assembly and testing, with a scheduled launch in 2025.[800]

The remaining three CLD partners are advancing through different stages of system readiness and design reviews in collaboration with NASA:

- Blue Origin and Sierra Space have been in discussions about potentially ending their partnership on the Orbital Reef space station project. While both companies have expressed interest in the project since its announcement in 2021, other ventures, such as Blue Origin's Blue Moon lunar lander and Sierra Space's Dream Chaser spaceplane, have taken precedence. Despite winning a NASA contract for design work on Orbital Reef, both parties are reportedly considering parting ways to focus on their respective priorities.[801]

  Moreover, in April, Sierra Space and ILC Dover partnered to accelerate the deployment of high-volume LIFE inflatable modules. The collaboration focused on developing advanced spacesuits for various space missions.[802]

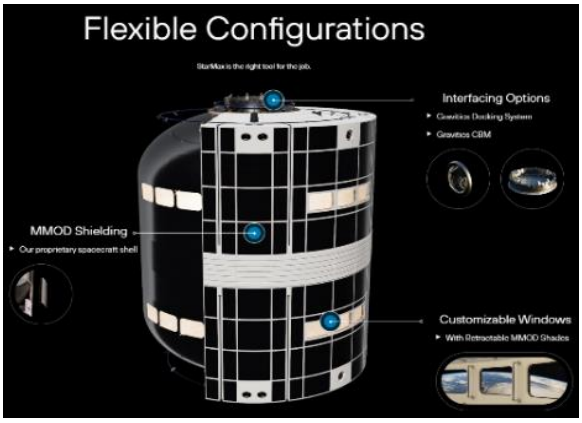
Credit: ESA

- Nanoracks targeted a single launch for Starlab in 2028. Furthermore, in November, ESA, Airbus, and Voyager Space inked a deal for the Starlab space station. The trilateral MoU aims to foster science, tech, and LEO exploration. It outlined access for ESA and its Member States to Starlab, research collaboration, and potential transport system development.[803]
- Northrop Grumman abandoned its independent commercial space station plans due to regulatory complexities and liability concerns. Instead, it announced a collaboration with Voyager Space, focusing on developing autonomous docking systems for its Cygnus cargo spacecraft to dock with Voyager's Starlab station.[804]

[799] Commercial Destinations in Low Earth Orbit, NASA, 2023
[800] Axiom Space Hab One Pressure Vessel Nears Completion, Aviation Week, October 2023
[801] Blue Origin, Sierra Space weigh future of Orbital Reef space station as partnership turns rocky, CNBC, September 2023
[802] Sierra Space and ILC Dover Partner to Build the Infrastructure in Space that will Accelerate the Commercialization of Low-Earth Orbit and Outfit the Astronaut Workforce of the Future, Sierra Space Corporation, April 2023
[803] Preparing for European commercial presence in Low Earth Orbit, ESA, November 2023
[804] Northrop Grumman to join Voyager Space commercial space station project, SpaceNews, October 2023
Northrop and Voyager emphasize benefits of commercial space station partnership, SpaceNews, October 2023

Since the CLD awards, new commercial players emerged in the space sector:

- California-based Above Space, formerly Orbital Assembly Corporation, is readying the launch of Voyager Station, the "world's first space hotel". Evolving from its original mission, the company now focuses on automated space platforms for both defence and commercial use. Voyager Station's construction will begin in 2025. Voyager Station, alongside the Pioneer-class station, the second commercial space station planned by Above Space, aims for extended and cost-effective space habitation primarily for tourists.[805]
- Vast Space aims to build artificial gravity space stations and in May it announced the plan to launch Haven-1 by August 2025. Initially operating independently, Haven-1 will later join a larger Vast space station. SpaceX will launch Haven-1 aboard a Falcon 9, followed by a Crew Dragon mission, Vast-1, carrying up to four astronauts. Vast plans to test station components in orbit and envisions larger space stations by 2028 and beyond, aiming for a fleet of stations in the solar system by the 2040s.[806]
- In June, NASA announced plans to repurpose components of SpaceX's Starship system for a functional space station, leveraging its capacity for crew and cargo transport to destinations like Earth orbit, the Moon, and Mars. With the spacecraft capable of accommodating up to 100 crew members, NASA envisions it as an "in-space LEO destination element". Collaborating with SpaceX, the agency is developing an "integrated LEO architecture", marking a significant step towards establishing sustainable operations in LEO.[807]
- Gravitics, funded with $20 million, unveiled StarMax space station modules in November 2022. Gravitics opted for customisable modules to integrate with existing stations, facilitating cost-effective expansion. In March, the company conducted a successful pressure test of StarMax prototype hull, demonstrating its spaceworthiness. The test subjected the system to pressures exceeding those experienced in space, reaching 26.6 PSIG while maintaining airtight integrity. Milestones included peak nominal pressure levels equivalent to sea-level pressure on Earth and exceeding the ISS's burst test level.[808]



Credit: Gravitics

[805] Voyager Station, the First Hotel in Space by 2027, ArchiExpo e-Magazine, November 2023
[806] Vast announces plans for first commercial space station, SpaceNews, May 2023
[807] NASA and SpaceX explore using Starship as space station, Institution of Mechanical Engineers, June 2023
[808] Successful First Pressure Test of the StarMax Prototype, Gravitics, March 2023

Europe also saw several developments regarding commercial space station plans:

In November, ESA unveiled the Commercial Cargo Transportation Initiative (CCTI) during the Space Summit in Seville, Spain This competition aims to enable European companies to demonstrate complete cargo delivery services to and from LEO space stations by 2028, fostering independent access to space. ESA plans to select up to three companies for initial contracts worth €75 million to initiate vehicle design work.

Contracts will be awarded in the late May 2024 Space Summit in Brussels, financing the first phase over two years. A second phase, including vehicle development and an ISS demo mission, will be funded at ESA's ministerial council in late 2025.[809]

Selected firms conducted activities, fostering industrial expertise, enhanced bartering prospects, and opened doors for European industry in the global market:

- ArianeGroup progressed testing on its Smart Upper Stage for Innovative Exploration (SUSIE), potentially proposing it for the CCTI initiative. The two-metre, 100-kilogram demonstrator underwent trials, with a plan for a 12-metre, seven-ton full-scale version. SUSIE could launch atop an Ariane 64 rocket or carry up to five astronauts. Planned tests include parachute and abort trials, along with hop testing until Q2 2025. Crewed SUSIE could launch in the early 2030s.[810]
- Rocket Factory Augsburg, spearheading a consortium integrated by them, ATMOS Space Cargo and Sener, introduced the Argo space station resupply vehicle. Designed to ferry payloads weighing up to 3.4 tonnes with 13 cubic metres of pressurised volume, Argo is adaptable to various launch vehicles.[811]
- Announced in December, The Exploration Company reached a milestone in Nyx Earth's development, completing its System Requirement Review. Nyx Earth aims to deliver four tonnes of cargo to LEO and return with two tonnes with a reusable capsule and expendable service module. Future plans include expanding its capabilities to cargo, crew, and lunar transportation: driving accelerated development efforts.[812]

Credit: ArianeGroup/The Exploration Company/Rocket Factory Augsburg/European Spaceflight

[809] Competition: developing Europe's space cargo return service, ESA, December 2023
[810] ArianeGroup begins testing prototype of multirole Susie upper stage, SpaceNews, November 2023
[811] RFA-Led Consortium Submit Argo for ESA Commercial Cargo Initiative, European Spaceflight, September 2023
[812] The Exploration Company Completes Key Review for LEO Cargo Vehicle, European Spaceflight, December 2023

2.2.6 New digital platforms emerge to process EO data

With the rise of space data analytics and the emergence of as-a-service business models, the EO domain has evolved and structured itself around new specialised offerings beyond simply providing EO data.

According to Aravind Ravichandran from TerraWatch Space, the EO value chain can be distinguished with a series of different layers involving data acquisition, platforms, analytics, insights, and applications. Space data platforms offer computer environments and infrastructure to access, process, and fuse various sources of data.**Error! Bookmark not defined.**

Many developments in the field of data platforms took place in 2023:

Microsoft aims to facilitate access to space data with Azure Space with its partners. In September, they announced the integration of Planetary Computer into Azure Space, a catalogue of intuitive APIs on a global scale of multiple petabytes in size. Part of Azure Space is the Azure Orbital Ground Station, which provides low-latency connection for space connectivity for both space agencies and start-ups. This solution showcased cloud-based Earth Science data processing and distribution with near real-time capabilities.[813]

In February, Washington-based Hydrosat was awarded a $1.2 million contract from the Air Force's AFWERX. The objective of this contract was to explore the applications of thermal infrared data for national security purposes. Hydrosat utilises satellite data analysis to examine environmental conditions on Earth, having developed an analytics platform using the data collected by NASA's MODIS and Landsat satellites.[814]

In July, Colorado-based Maxar Technologies unveiled its Maxar Geospatial Platform (MGP). It aims to streamline and expedite the retrieval of high-resolution Earth imagery, providing access to historical and up-to-date images via an online platform and an application programming interface. Future plans for the platform include allowing customers satellite tasking and tapping into advanced analytics.[815]

In September, the development of a software platform for space tracking was announced through an agreement between U.S. Science Applications International Corporation (SAIC) and LeoLabs. This platform will utilise data from the U.S. military's spacetrack.org, Leolab's conjunction messages and similar sources including the Space Force's Unified Data Library.[816]

California-based Esri and Microsoft announced in September the integration of the former's ArcGIS geographic mapping platform with Microsoft Azure Space to expedite the retrieval of data from Earth observation for users.[817]

In October, Delaware-based SeerAI, a Geodesic AI analytics software and data fusion platform company, catering to planetary-scale data, successfully concluded a $4.0 million seed funding round.[818]

[813] Microsoft Accelerates Innovation in Space with Azure Space and Partners, GW Prime, December 2023
[814] Hydrosat wins Air Force contract for thermal infrared data analytics, SpaceNews, February 2023
[815] Maxar unveils platform to speed up imagery access, SpaceNews, July 2023
[816] LeoLabs, SAIC to develop space-tracking software platform, SpaceNews, September 2023
[817] Microsoft and Esri to speed up access to Earth-observation data, SpaceNews, September 2023
[818] SeerAI closes $40 million seed round to fund further expansion into geospatial-AI and data fusion products, SeerAI, October 2023

Australian-based start-up Arlula announced in October obtaining the back of Lockheed Martin to support their EO platforms that allows the searching and ordering of satellite archives data for developers.[819]

Both Germany-based geospatial platform UP42, and OroraTech, a company in the sector of space-based thermal intelligence, announced in November the signature of a partnership intended to provide easy and fast accessible high-resolution thermal infrared imagery.[820]

Canadian-based Metaspectral, which provides a platform for analysing hyperspectral imagery, announced winning a $690K grant to assess the viability of quantifying and tracking carbon.[821]

Austin-based SkyFi announced in November integrating stratospheric balloon imagery from Colorado company Urban Sky, enhanced and high-resolution optical and stereo data from also Turkish IMPRO and SAR data from California-based Umbra, expanding the companies' EO capabilities.[822]

SkiFi also announced in the same month their partnership with ImiSight, an imagery and artificial intelligence platform, incorporating ImiSight's sophisticated analytics features into SkyFi's web and mobile applications, and merging SkyFi's image data with ImiSight's geospatial platform.[823]

Australian Nearmap, provider of solutions in location intelligence and aerial imagery, announced in December the acquisition of Betterview, a platform for property intelligence and risk management in the insurance sector. The objective of such acquisition was to strengthen the company's standing as a provider of imagery intelligence, data and solutions, and to augment their proficiency and resources for insurance clients and partners.[824]

In December, a space data platform was unveiled by California-based start-up OurSky. The platform aims to facilitate possibilities for real-time monitoring of celestial objects, convenient access to space observation data, and expedite the development of applications.[825]

[819] Lockheed Martin backs Earth observation data software startup Arlula, Business News Australia, October 2023
[820] Wildfire preparedness: UP42 and OroraTech facilitate geospatial data access with on-demand sensor tasking, Orora Technologies, November 2023
[821] Quantification and monitoring system for carbon management using hyperspectral imagery, CICE, 2023
[822] SkyFi is expanding horizons with aerial, SAR and global satellite imagery, SatNews, November 2023
[823] SkyFi and ImiSight: A partnership that enhances the world's clarity and the potential of analytics, SkyFi, November 2023
[824] Nearmap acquires Betterview, a complementary property intelligence platform, Nearmap, December 2023
[825] After raising $9.5 million, startup OurSky sees strong demand for space data platform, SpaceNews, December 2023

3 GLOBAL SPACE ECONOMY

3.1 Overview and main indicators

Each year, the Satellite Industry Association (SIA/Bryce) - the trade association of the American satellite industry, and the Space Foundation (SF) an American not-for-profit organisation advocating for the sector, release reports that break down the value of the global space economy.

SIA/Bryce estimated the global space economy in 2022 to be worth $385 billion, the Space Foundation estimates higher at $546 billion.[826]

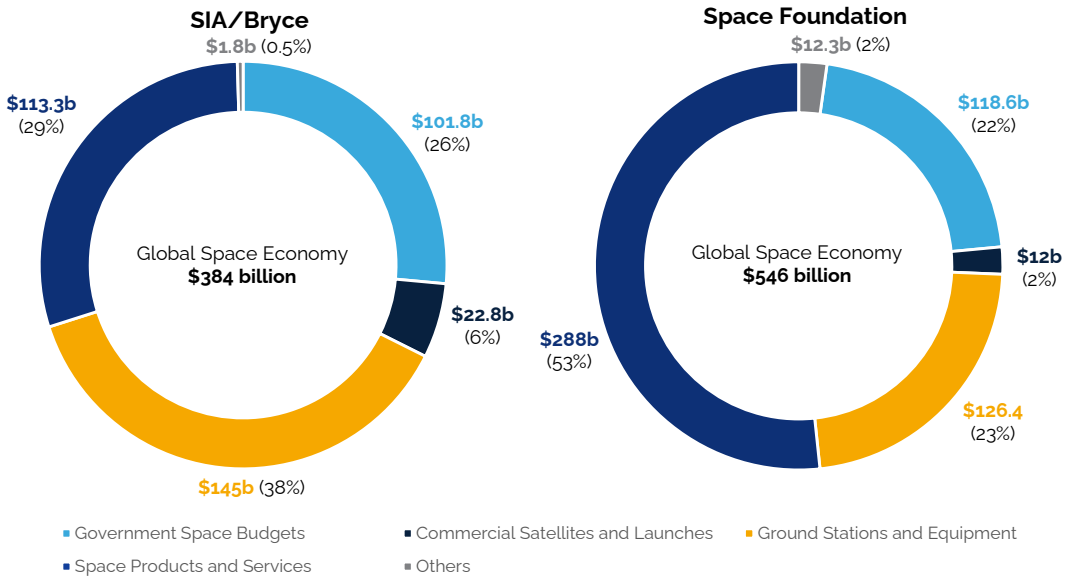


Figure 1: Global space economy estimations by SIA/Bryce/Bryce (left) and the Space Foundation (right)

The two estimations are broken down into four major segments:

- **Government space budgets**, which corresponds to the economic activity directly related to government spending. It covers in particular public space programmes and other activities of governmental space organisations (i.e., space agencies, development agencies, military organisations and bodies, etc.).
- **Commercial satellites and launches**, which corresponds to the economic activity of satellite manufacturers and launch service providers outside public markets (i.e. commercial space). It covers in particular the provision of commercial satellites and launch services to private operators.
- **Ground stations and equipment**, which corresponds to the economic activity related to the ground segment of space infrastructures including ground stations, teleports, networks and user equipment.
- **Space products and services**, which correspond, to the economic activity of companies selling space-enabled products and services such as Direct-to-Home services or satellite imagery products. This part of the space economy is usually referred to as downstream and is the most complex to delineate. As of 2023 publication based on 2022 data, this includes space tourism activities.

[826] 2022 Global Space Economy at a Glance. Bryce Space and Technology, 2023. (Link); The Space Report 2023 (Q2), Space Foundation, 2023.

The following table provides a more detailed overview of the global space economy estimations made by SIA/Bryce/Bryce and the Space Foundation for each segment:

	SIA/Bryce			Space Foundation		
	$384 billion			$546 billion		
Government Space Budgets	$101.8B	U.S. budget	$59.3B	$118.64B	U.S. budget	$69.5B
		Non-U.S. budget	$42.5B		Non-U.S. budget	$49.14B
Commercial Satellites and Launches	$22.8B	Satellites	$15.8B	$12B	Satellites	$7.91B
		Launches	$7B		Launches	$4.08B
Ground Stations and Equipment	$145B	GNSS[827]	$111.9B	$126.35B	GNSS	$126.35B
		Others[828]	$33.1B		Others	-
Space Products and Services	$113.3B	Consumer (TV, Radio, Broadband)	$85.8B	$288B	Television	$81.54B
		Enterprise[829]	$17.7B		Communications	$28.59B
		Remote Sensing	$2.9B		Remote Sensing	$5.63B
		Satellite Radio	$6.9B		Satellite Radio	$6.91B
		PNT[830]	-		PNT	$165.33B
Others	$1.75B	Insurance Premiums	-	$1.28B	Insurance Premiums	$0.62B
		Commercial Human Spaceflight	$1.5B		Commercial Human Spaceflight	$0.57B
		Space Sustainability Activities	$0.25B		SSA, On-orbit Servicing	$0.09B

Table 10: Detailed comparison of space economy estimations by the SIA/Bryce/Bryce and the Space Foundation

The two reports estimate the global space economy by recording government space budgets as well as space-related commercial revenues. However, methodological differences lead to some significant discrepancies in the estimation of the various segments and of the total space economy value.

Overall, there is a 14% discrepancy between the report's estimates of government space budgets, with SIA reporting a total of $101.8 billion, while the SF estimated it to be at $118.6 billion. According to SF, the U.S. made up 59% (~$70 billion) of global space budgets in 2022. The value represents a 2% growth in the U.S. share of space budgets as compared to its share in 2021.

While the distribution remained the same in relative terms in 2022, There is a stark difference in the budget growth estimates between SIA and SF. SIA estimates a $5.2 billion (-5%) contraction in global space budgets as compared to an over $10 billion (+11%) increase by SF.

[827] Includes GNSS chipsets and navigation devices.
[828] Includes network stations and user equipment such as satellite TV dishes or satellite mobile phones.
[829] Includes Transponder Agreements, Managed Services over FSS Bands, Mobile Voice and Data over MSS bands.
[830] Positioning, Navigation and Timing services, enabled by GNSS and augmentation system.

The two reports **also differ significantly in their valuation of the commercial satellite and launch markets.** Much of this difference comes from the respective valuations of commercial satellite manufacturing. SIA/Bryce estimates satellite manufacturing to be worth $15.8B, double SF's valuation of $7.91 billion. Still, the two sources begin to converge compared to 2021's 3x difference in valuations. SF continues to revise its estimates via the 2022 methodological changes, as explained in the previous edition of this yearbook.

SIA/Bryce and the Space Foundation estimate the total revenues stemming from ground stations and equipment segments to be $145 and $126.35 billion respectively. Interestingly, while SIA/Bryce estimates a 2% growth from 2021 to 2022, and a 9-year CAGR of 4% since 2014, SF's estimates seem much more conservative, with a reduction on ground stations and equipment revenue of -3% and a 9-year CAGR of only 1%.

The space products and services segment represents the revenues stemming from applications enabled by space systems, also known as **the 'downstream' segment**. This segment by SF's calculations **constitutes the largest share of the space economy**, representing 53% of the share in 2022, compared to SIA/Bryce's 30%. SIA/Bryce in turn represents the Ground stations and equipment segment as the largest, constituting 38% of the total. The largest portion of this economic activity is direct-to-home television, which SIA/Bryce reports at an estimated $85.8 billion and SF at $81.54 billion. The main difference between the two valuations is the inclusion of positioning, navigation, and timing (PNT) services enabled by GNSS in the Space Foundation's report. Whereas the Space Foundation lists this as worth $165.3 billion, making it the largest component of this segment, the SIA/Bryce does not appear to take it into account in its analysis.

2022 added two additional significant sources of revenue to the space economy reported by both SIA and SF. Commercial human spaceflight was estimated to have generated $1.5 billion and $0.57 billion, respectively. Space sustainability, including on-orbit servicing, has been valued at $0.25 billion by SIA and $0.09 billion by SF. Additionally, SF includes the value of insurance premiums at $0.62 billion, up 24% since 2021.

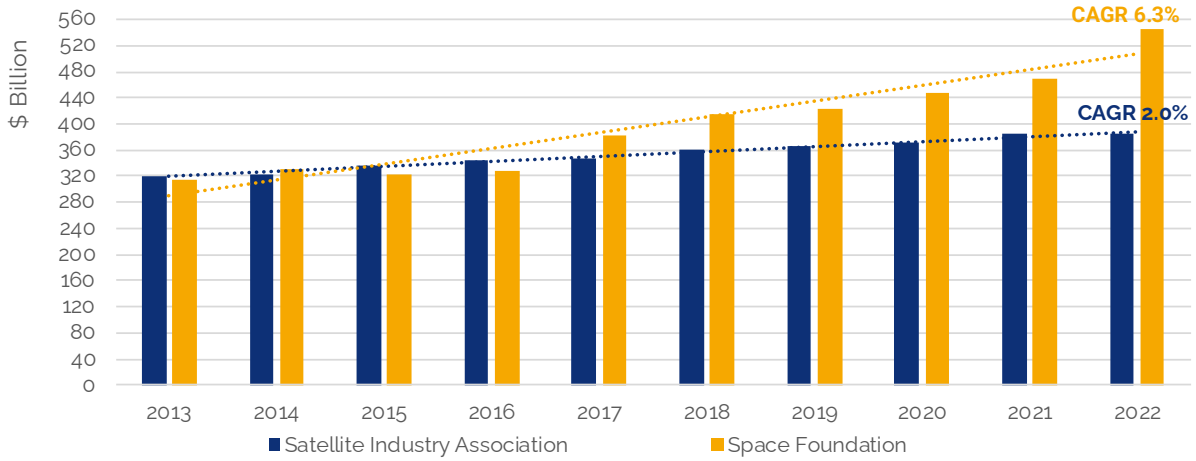


Figure 2: Global Space Economy Evolution (Source: SIA/Bryce, Space Foundation, ESPI)

The compound annual growth rate (CAGR) for the global space economy since 2013 is estimated to be 2% by SIA and 6.3% by SF. SIA estimates a small 0.4% contraction of the space economy between 2021 and 2022. In contrast, Space Foundation estimates a 16% YoY growth, thus increasing the disparity between the two reports. Whilst the SIA/Bryce and Space Foundation held broadly similar figures from 2013 to 2016, the inclusion of PNT services by the Space Foundation in 2017 continues to widen the gap against SIA/Bryce estimation.

Assessing the space economy: limits and pitfalls

Several organizations have forecasted that the space economy could be worth up to $1 trillion by 2040. While discussions about a trillion-dollar space economy can attract a lot of positive attention on the sector, the spotlight put on space economics raises questions about the methodologies used to estimate the size and growth of the space economy.

Perimeter of the space economy: where does the space economy start, where does it end?

By definition, the value of the space economy corresponds to the value of all final goods and services produced by the space sector. While the inclusion of the value of satellites and launch services in the space economy is straightforward, setting the limits of the space economy becomes increasingly difficult going down the space value chain and reaching "space-related" or "space-enabled" goods and services (e.g. navigation services, data analytics, TV broadcast contents). Definitions of the space economy perimeter vary greatly, and methodologies applied to estimate the economic value of downstream products may be contested. Yet, this peripheral part of the space economy accounts for a large share of the overall value as currently estimated.

Measuring the space economy: what is measured and how?

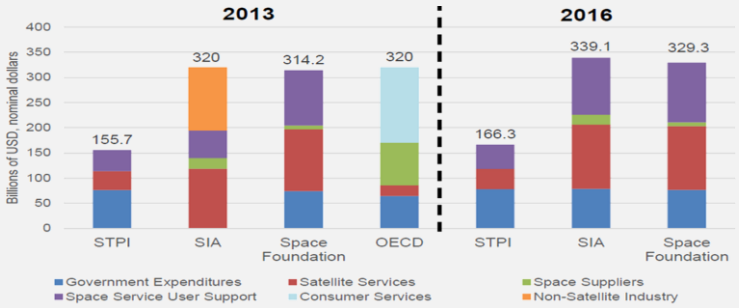
Space economy assessments use a mix of data to estimate the value of space goods and services including public budgets and expenditures, company revenues, price estimates and other indicators to assess the value of "space-enabled" goods and services. Methodologies are rarely disclosed which does not allow to verify their soundness and validity. An issue often underlined is the risk of double-counting (i.e. counting both expenditures to buy goods and services and revenues from selling those goods and services) which can lead to an overestimation of the size of the space economy.

An Input-Output model tries to tackle the issue of double-counting while also helping better estimate various economic impacts associated with space production. However, this approach has limitations concerning the amount and consistency through time of required data, rendering it more suitable for policymakers rather than private or consulting firms.

Macro-economic conditions: how to consider inflation or exchange rates?

The estimation of the global space economy over time also raises issues to account for macro-economic factors such as inflation or exchange rates fluctuation. Available estimations are provided in current prices (i.e. not corrected for changes in prices), which creates a bias in the perception of the space economy growth. Estimations are provided in US Dollars which also creates a bias related to the fluctuation of currency exchange rates over time. A direct conversion into US Dollars does not allow either to account for the major differences in purchasing power between different countries.

A study by the Science and Technology Policy Institute (STPI) addressed some of these pitfalls and found that existing estimations may be overestimating the size of the economy by twice their measured amount. This significant variation highlights the increasing need to elaborate a consistent estimate for space economy indicators as initiated recently by the U.S. Bureau of Economic Analysis.



3.1.1 Commercial satellites and launches

In 2022, the market for commercial satellites and launches was worth $22.8 billion according to the SIA and $11.91 billion according to the Space Foundation. The difference can be explained mainly by the different methodological approaches, with a particularly big discrepancy between the revenues generated by commercial satellite manufacturing, which according to SIA represented $15.8 billion, while according to SF amounted to $7.91 billion. Nevertheless, even though the total is quite different, the distribution between commercial launchers and commercial satellites manufacturing is quite similar, with only a minor difference of 3%.

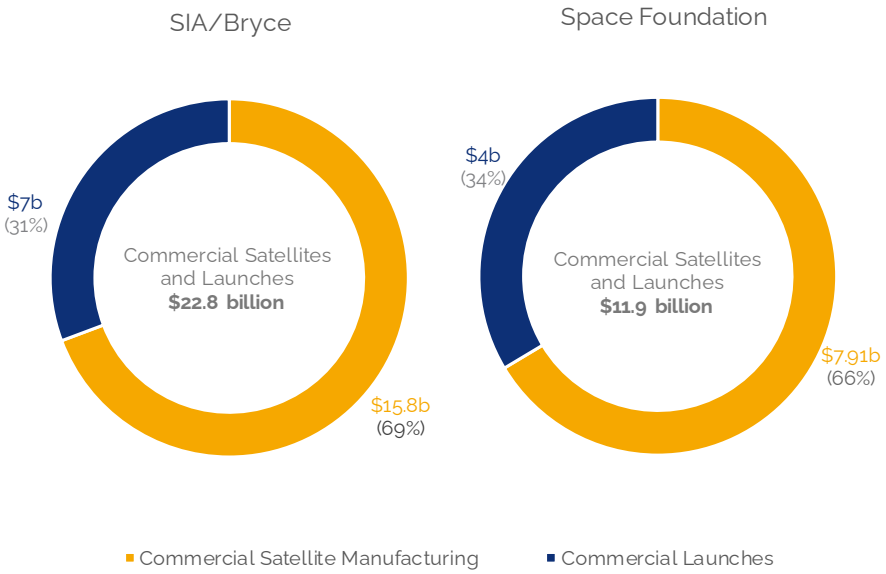


Figure 3: Commercial satellite and launch industry revenues (Source: SIA/Bryce, Space Foundation)

Since SF revised its valuations for commercial satellite manufacturing and launch in 2022, it reports a significant jump in both satellite manufacturing revenue (84% increase) and commercial launcher revenue (90% increase). The combined YoY increase as reported by SF is thus 86% ($5.51 billion) compared to a much more modest growth rate of 18% ($3.4 billion) as reported by SIA/Bryce.

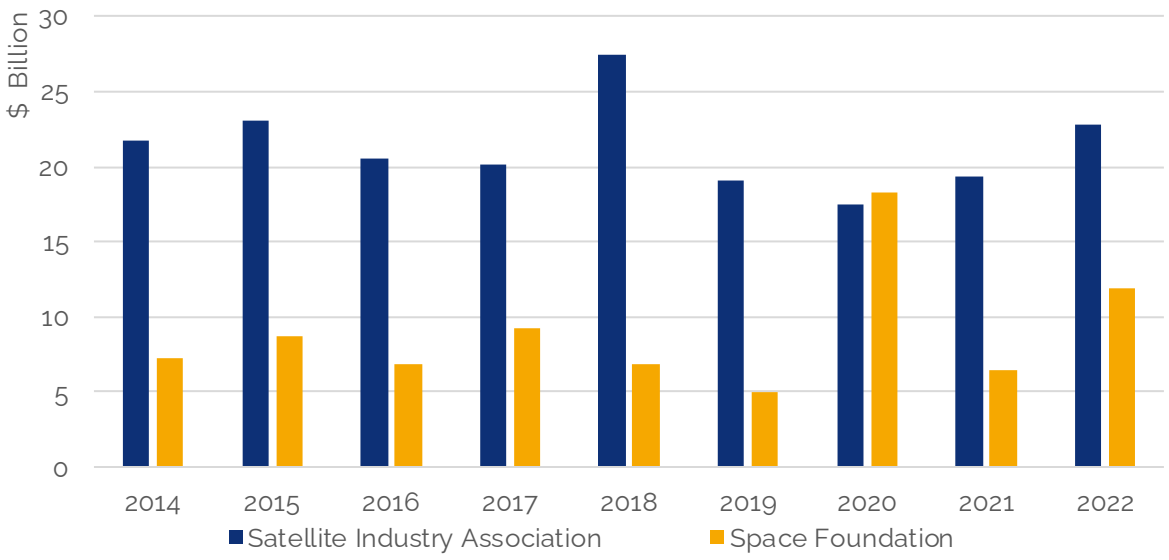


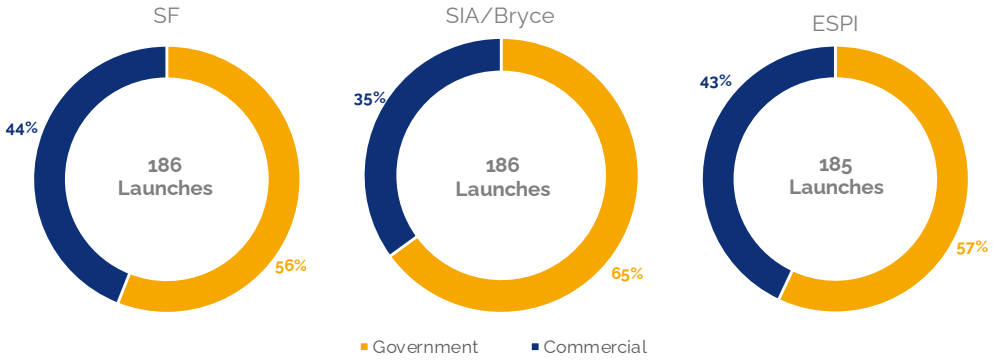
Figure 4: Commercial satellite and launch industry revenue evolution (Source: SIA/Bryce, Space Foundation)

3.1.2 Commercial launches

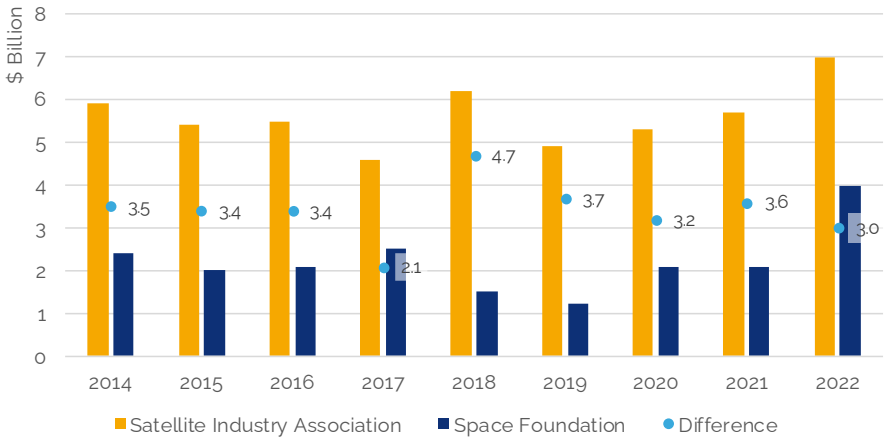
To estimate the economic activity related to commercial launches, both SIA/Bryce and the Space Foundation rely on a market valuation of launches operated during the year that they qualify as "commercial". The SIA/Bryce and the Space Foundation in 2022, have both documented 186 launches compared to ESPI's 185 (commercial and governmental).

The SIA/Bryce and the Space Foundation differ in their methodology for qualifying and counting commercial launches. While SF defines commercial launches as launches carried out for a non-governmental entity, SIA/Bryce classifies commercial launches as per the primary spacecraft and launch vehicle being commercially owned/operated. Accordingly, SIA/Bryce considers 66 out of 186 total global launches are commercial if we take the 2022 Launch Year in Review numbers by Bryce.

Worth noting is the difference to the reported 161 of the 186 launches as "commercially procured", given no further insight into the launch vehicles being commercial or otherwise we continue to assume around 35% of orbital launches are considered purely 'commercial'. The estimated total value of launches is $7 billion. On the other hand, the Space Foundation considers 81 launches to be "commercial", with an estimation of the total value of these launches at $4 billion.[831]



The difference in estimations between SIA/Bryce and the Space Foundation has been stable in the last few years, with an average variation of approx. $3.4 billion. The largest difference was in 2018 with a divergence in estimation of $4.7 billion, while the lowest difference was measured in 2017 with only $2.1 billion between the two estimates. The highest revenues from commercial launches have been measured in 2022 with $7 billion and $4 billion estimated by SIA and SF, respectively.



[831] Bryce Space & Technology's 2022 Orbital Launches Year in Review infographic, 2023 (Link); SIA president's report – SIA news & filings for June 2023, 2023 (link); Yearbook 2022 used the reported commercially procured numbers of 113 which includes government launch vehicles

Figure 5: Commercial launch revenues evolution (Source: SIA/Bryce, Space Foundation)

3.1.3 Commercial satellite manufacturing

According to SIA/Bryce, revenues of the commercial spacecraft manufacturing industry rose from $13.7 billion in 2021 to $15.8 billion in 2022. This represents a major growth of 15% as compared to 2021, but still under the peak of $19.5 billion recorded in 2018 by almost 20%. In 2021, the Space Foundation established a new methodology, retroactively reviewing its estimates from previous years. The organisation estimates the commercial spacecraft manufacturing industry to be worth $7.9 billion in 2022, representing a remarkable increase of 84% compared to the approx. $4.3 billion revenue recorded in 2021.

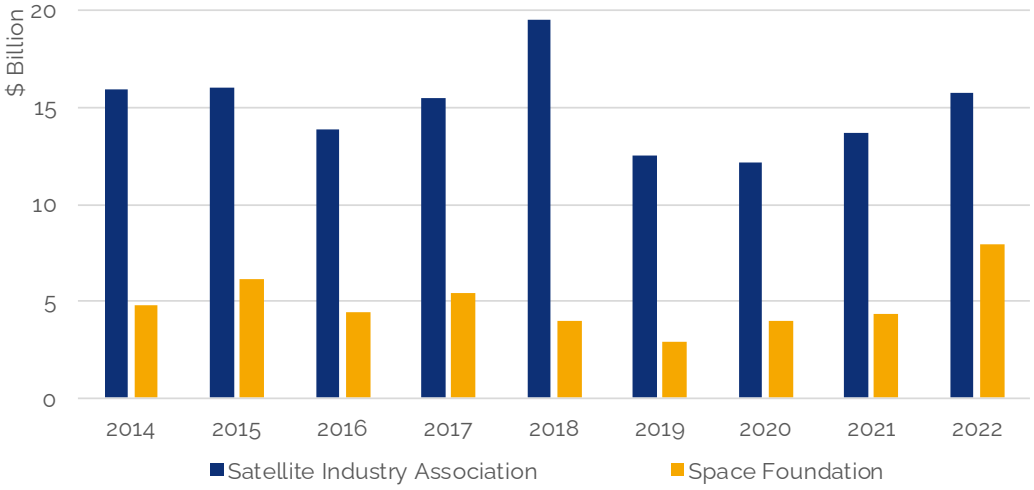


Figure 6: Commercial satellite manufacturing revenues evolution (Source: SIA/Bryce, Space Foundation)

Both the SIA/Bryce and the Space Foundation's estimates rely on a valuation of "commercial satellites" launched during the year, with different definitions of what is considered a "commercial satellite". In 2022, ESPI recorded a total of 2491 spacecraft put in orbit, of which 2491 (88%), were designated commercial spacecraft (i.e. spacecraft primarily intended to serve a commercial market and to make a profit). The SIA/Bryce tracked 2521 spacecraft, however, only includes 2325 (92%) satellites in its estimation in 2022. The Space Foundation, on the other hand, included 2348 spacecraft in its estimation in 2022, out of which 2136 spacecraft were considered commercial (91%).[832]

3.1.4 Ground stations and equipment

The SIA/Bryce and the Space Foundation estimate the total value of ground stations and equipment revenue in 2022 to be $145 billion and $126.35 billion, respectively. The difference between these two estimations is related to the value of GNSS chipsets and software, with a difference of $14.5 billion.

While SIA/Bryce continues to split their estimates between GNSS, network stations, and user equipment such as satellite TV dishes or satellite mobile phones, this year SF GNSS encompasses all other services. Accordingly, SIA/Bryce's estimate results in GNSS driving the vast majority (77%) of ground stations and equipment's total revenue for 2022, but the same data is not available from SF estimates.

[832] Bryce Space & Technology's 2022 Orbital Launches Year in Review infographic, 2023 (Link)

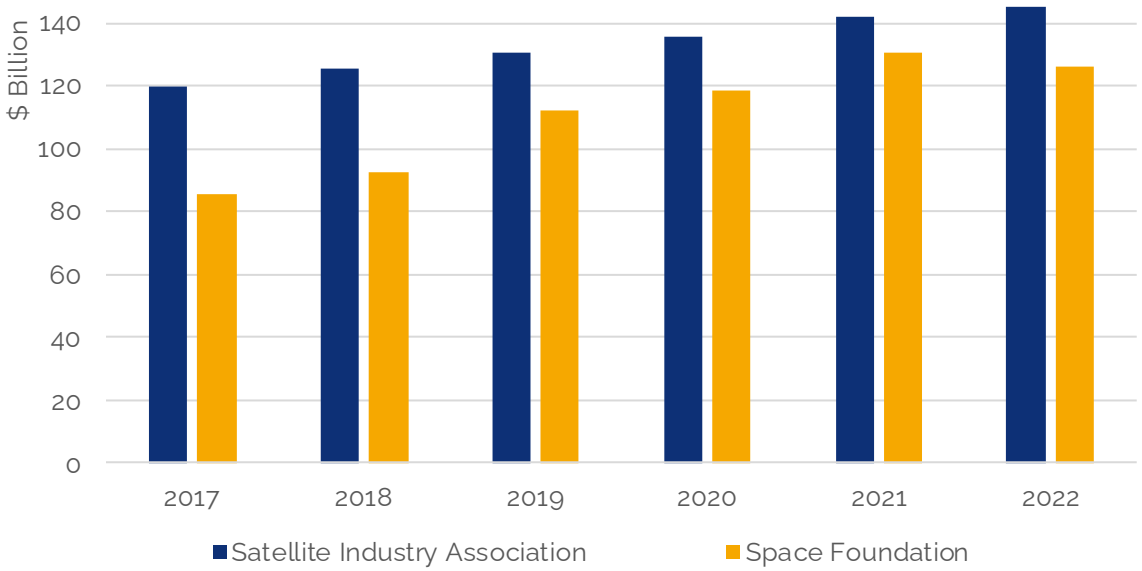


Figure 7: Ground stations and equipment revenues evolution (Source: SIA/Bryce, Space Foundation)

The SIA/Bryce data show a continuous growth with a year-on-year increase from 2021 to 2022 of 2.3%, nevertheless, it has slowed down when compared to a YoY growth of 4.7% in 2021. Long-term CAGR stands at 4% since 2014. In contrast, SF estimates a 3% decrease in total revenue growth for the ground stations and equipment segment, stemming from $130.3 billion in revenues in 2021 to the current $126.35 billion. The abovementioned difference in methodology does not account for the 5.3% difference in growth estimates as the constituent parts in SIA/Bryce's estimate both increased by around the same rate of 2%-3%.[833]

3.1.5 Space products and services

The segment of space products and services, corresponding roughly to the downstream sector, comprises the sales of a variety of space-based solutions to end-users including governments, businesses and individuals. Categories of space products and services include:

- **Television**: TV broadcast and Direct-to-Home services,
- **Communications**: Services ranging from texting and telephony to broadband internet,
- **Remote Sensing**: Wide variety of solutions enabled by optical and radar satellite imagery, from sales of raw data to turnkey analytics services,
- **Satellite Radio**: Radio services via satellites, usually for personal vehicles (mainly XM Sirius revenues),
- **PNT value-added services**: Wide variety of solutions enabled by GNSS signals (not included by the SIA/Bryce in their assessment).

The space products and services segment is estimated to be $113.3 billion by the SIA/Bryce and $288 billion by the Space Foundation. For the SIA/Bryce, revenues from space products and services segment reverted to previous trends, decreasing by -4.2% between 2022 and 2021. Since 2017 this segment has steadily declined at a rate of -2.1% per year. The Space Foundation's estimate, on the other hand exhibited a significant hike in growth of 28.5%, from $224.1 billion in 2021 to $288 billion in 2022. Its estimate pushes the compound annual growth rate since 2017 to 5.3%.

[833] According to original reported numbers as tracked by ESPI. SF revised the 2021 total revenue numbers and consequently reported a growth of 6.1% between 2021 and 2022. The disparity suggests a revision from an original $130.3 billion down to $118.6 billion for 2021.

This large discrepancy is due to the inclusion of PNT services by the Space Foundation. The PNT value-added services category includes in-vehicle navigation systems, fleet management services, and revenues from smartphone applications that use location-based services. The Space Foundation estimated this economic activity to be worth $165.33 billion in 2022, making it the category with most revenues, driving more than half of the revenues in this segment.

A general analysis shows that the estimates for the market size comparison in the period going from 2014 and 2017 were very similar between the SIA/Bryce and the Space Foundation. However, the decision by the Space Foundation to also include revenues stemming from PNT activities in their perimeter of analysis in 2017 has led to a growing divergence in estimates with the SIA/Bryce.

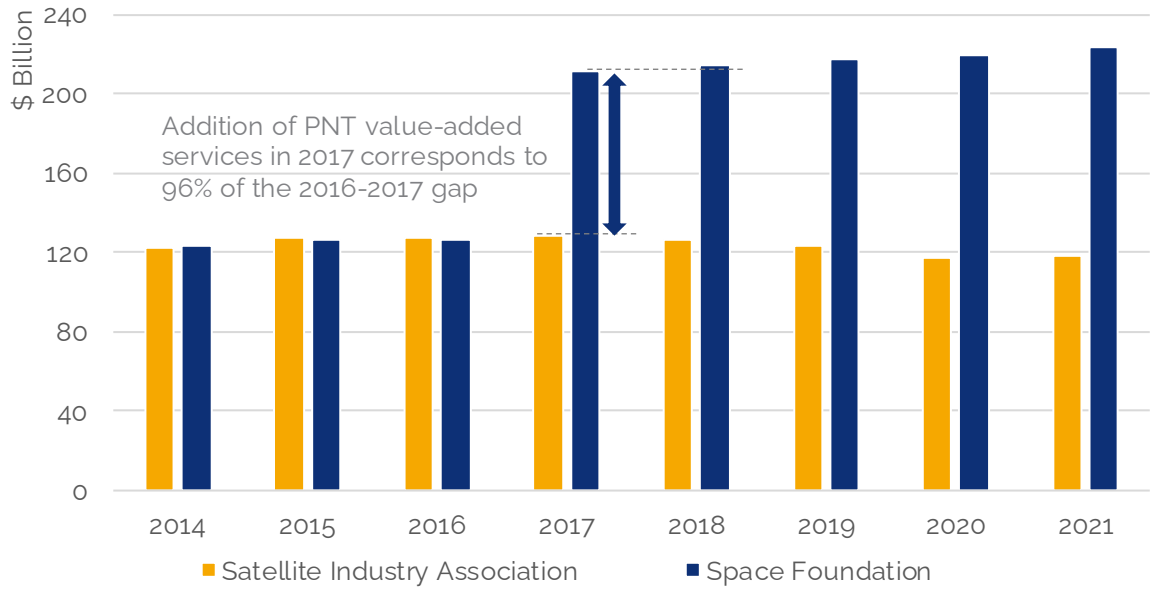


Figure 8: Commercial space products and services evolution (Source: SIA/Bryce, Space Foundation, ESPI)

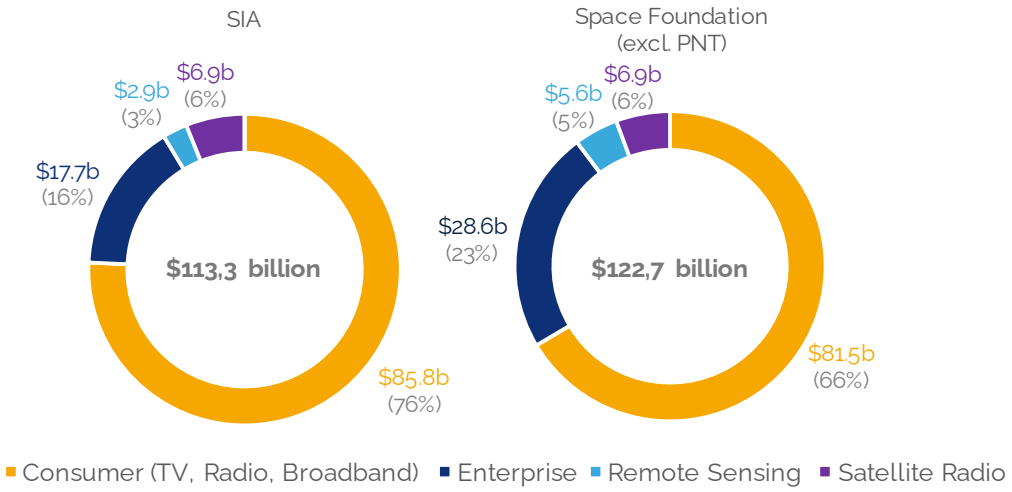


Figure 9: Space products and services split excluding PNT.

Excluding PNT services from the Space Foundation data, the estimated 2022 revenues from space products and services reveal a $9.4 billion between the two reports, $113.3 by the SIA/Bryce and $122.7 by the Space Foundation. Doing so, a significant difference in revenue estimates for the enterprise segment is uncovered.

3.1.6 Space insurance sector

Space insurance landscape

Space activities involve inherently risky operations, and the insurance sector provides space actors with solutions to help mitigate financial setbacks that can arise from activities undertaken in the phases ranging from pre-launch to in-orbit operations. Insurers usually compete on coverage terms, capacity and most often on premium prices. While they are typically packaged together in most insurance solutions, there is a distinction between property insurance (first party) and liability insurance (third party). While the property insurance insures against the failure of a satellite during launch or operation and will typically cover the cost of the satellite, the liability insurance of a satellite insures against damage caused to a third-party by the launch or satellite operator.

First-party insurance covers the riskiest phase of the satellite's life cycle, with 34% of GEO satellite losses since 2000 occurring during launch, and usually represents the third-largest expenditure of commercial satellite ventures after launch and manufacturing. The third-party liability insurance, on the other hand, may be mandatory in some countries for obtaining a license, depending on their national legislations. For instance, in the U.S., while launchers need to have liability insurance covering launch personnel and operators, satellite operators are not required by law to procure it.[834]

There are currently approximately 30 insurers operating in the space industry across the world.[835] Just a few changes occurred from the previous year as some underwriters left the market (e.g., Allianz) or reduced their available capacity, and the market saw the acquisition of Occam Underwriting by Global Risk Partners (formerly known as Brown & Brown).[836]

From 2017 to 2023, approximately 50% of all orbital launches and all satellites (excluding Starlink) have been insured. However, there is a very large variation between orbits, as the percentage is only around 1% for LEO satellites and around 45% for GEO satellites.

The decision to insure a spacecraft is often taken in relation to the overall costs and risks associated with the mission. The price of insurance premiums for a single spacecraft may vary depending on its size, cost, and the type of mission it will carry. GEO satellites thus often incur higher premium prices, as they are in many cases the most expensive private commercial satellites to produce, assemble and launch. The high costs associated with these types of satellites throughout their development stage and operational lifespan are typically the main reason driving customers and operators to be more risk-averse than with other types of satellites such as those in LEO and CubeSats.

Therefore, whereas a large telecommunications satellite operator may choose a more comprehensive insurance to cover the risk of loss of their investment, operators of smaller satellites may seek more basic insurance to reduce costs or decide to not pursue insurance at all.

Operators of satellite constellations such a SpaceX with Starlink tend to be less risk averse and launch and operate their constellations without first-party insurance, basing their risk reduction strategy on redundancy, by launching more satellites than needed. These operators are likely to view the entire constellation as the asset rather than a single satellite.[837]

[834] Space Insurance Update, AXA XL, 2019; Third Party Liability and Insurance Innovation in the Smallsat Era, Mathieu Luinaud, Virgile Salmon, December 2020; The Space Insurance Landscape, Payload, October 2022
[835] Connecting the Dots | Double whammy for space insurance - SpaceNews, October 2023
[836] Space Insurers wither from 'worst year' in over twenty years as claims get close to US$1 billion (Updated and corrected), Seradata, Decembre 2023; AGCS exits space market and puts portfolio into run-off, The Insurer, January 2023; Brown and Brown Europe set to snap up MGA in first acquisition since rebranding, Insurance Times, September 2023
[837] Space insurance premiums rose by 2x-3x in late 2019 and the increase is holding — so far, Space Intel Report, March 2020.

Still, **space insurance companies are trying to adapt their business practices to New Space companies**. Indeed, for smaller companies that are backed by venture capital or that are public, insuring their space assets can be important to keep the confidence of their investors.[838]

Claims growth causes biggest losses in decades

In recent years the space insurance business faced difficult results, culminating in 2019, while at the same time seeing premium rates settle at historical lows.

In 2023, space insurance companies interrupted the trend of returning to profitability, with $557.3 million in premiums and $995.2 million in claims. This would represent one of the worst performing years since 2014, on par with 2019. Importantly, the market shows no sign of relief as there are already some claims being filled for 2024, including the loss of the first O3b mPower satellites, which can lead to an insurance claim of $472 million, the biggest to date in the space insurance sector.

Blue Origin's self-insurance

Even third-party liability insurance, required for launch in the U.S., is not safe from new approaches. Starting from 2021, Blue Origin's New Shepard received an updated launch licence where the company essentially insures itself through an agreement with a "parent guarantor" setting up a fund held in escrow exclusively intended to cover any losses, instead of buying insurance from an insurance company. This alternative approach could be seen as a method of avoiding paying premiums for third-party liability insurance that would otherwise be required.

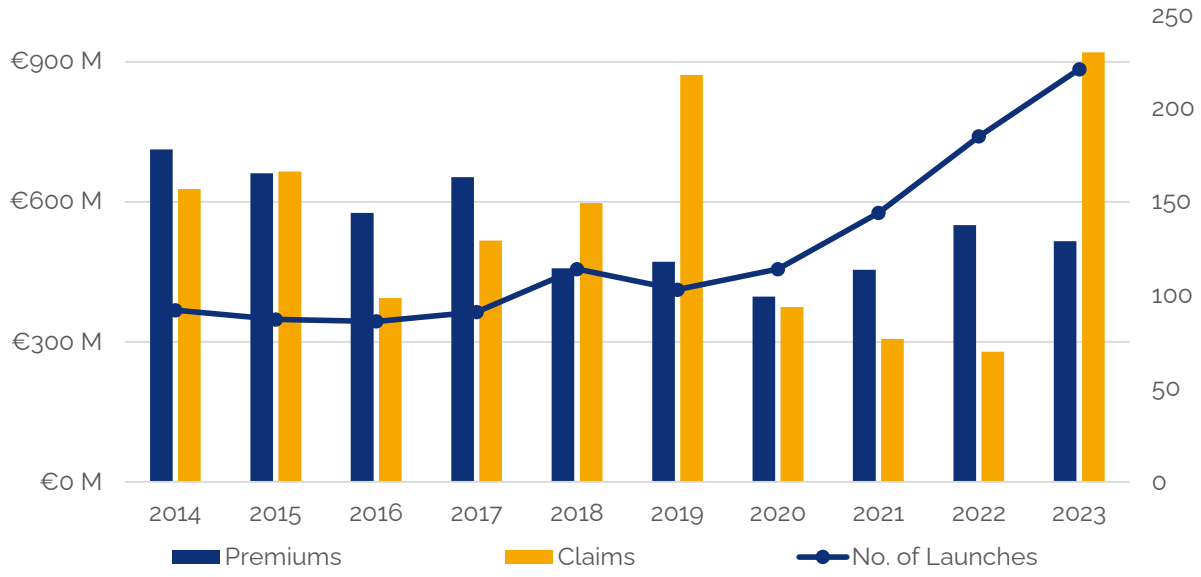


Figure 10: Insurance premiums and claims 2014-2023 (Seradata, AXA XL, ESPI)

In previous years the space insurance market has seen a decrease in insurance rates due to newcomers (increased competition) and the "vertical marketing system". The system, which has been gradually adopted by the space insurance market, is effectively a blind auction where various insurance companies propose a different premium rate to their potential clients. The excess of underwriters in conjunction with this system saturates the market, keeping insurance rates low.

[838] Insurers to New Space: Be patient with us as we adapt and learn to price your risk, Space Intel Report, December 2021.; Space insurers just might book 2020 as a gross profit, but with the lowest premium volume, Space Intel Report, May 2021.

However, starting from the second half of 2023 the market was characterised by a resurgence in insurance rates due to a high number of claims, a trend that is expected to continue also in 2024.[839]

2019		
Falcon Eye-1	$415 million	Launch failure
ChinaSat-18	$250 million	Post-launch anomaly
Eutelsat 5 West B	$192 million	Partial failure
2020		
Thaicom 5	$26 million	On-orbit anomaly
Express AM-6	$39 million	Payload failure
Palapa-N1	$252 million	Launch failure
2021		
SXM-7	$225 million	Payload failure
Measat-3	Under dispute	In-orbit failure
Pléiades Neo 3	$62 million	Partial in-orbit failure
2022		
Pléiades Neo 5 and 6	$222 million	Launch failure
2023		
Viasat-3 F1	$421 million	Payload failure
Inmarsat-6 (I-6) F2	$349 million	Post-launch anomaly
Arcturus	$40 million	Payload failure
Azersky/Spot-7	$26.5 million	In-orbit failure
Al Yah 3	Under dispute	In-orbit failure
MEV-1 and 2	$50 million	In-orbit failure

Table 11: Major insurance claims in the space sector 2019-2022 (ESPI compilation)

But not all is doom and gloom, there are also some notable positive developments for space underwriters. The public push towards new space sustainability policies could be good news for the insurance market. If LEO satellites would be required to have a 90% chance of deorbiting and disintegrating upon re-entry, failing to do so could lead to a task-order for an active-debris-removal spacecraft, in a mission paid by a blanket insurance policy paid by public actors. Consequently. this new programme could provide a steady stream of revenues to the insurance market.[840]

[839] More space insurers head for the exit: Allianz & Aspen Re (Corrected), Seradata, September 2022; Space Insurers wither from 'worst year' in over twenty years as claims get close to US$1 billion (Updated and corrected), Seradata, December 2023; More woes for space insurers as O3b mPOWER claim runs to US$472 million, Seradata, February 2024; The Space Insurance Landscape, Payload, October 2022

[840] Space insurance underwriter sees a turnaround in premiums starting this year, Space Intel Report, October 2022.

Other legislative changes in the sector see the possible extension of U.S. government-provided insurance to the space sector and the UK's review of its third-party liability cover cap (that is currently set at €60 million per satellite).[841]

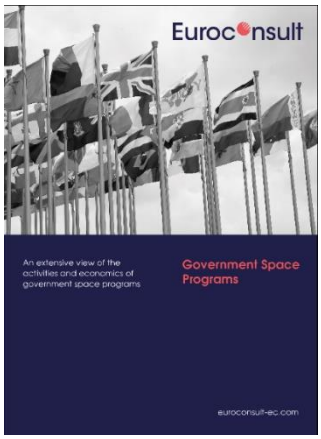
Additionally, important news for the sector could come from both changes in insurance policy structures and the exploration of new potential markets. In the first case, space insurers are working on insurance policies where the premium includes the different risk of collision in specific orbits: recent examples include Axa XL's collaboration with orbital debris removal company Astroscale, and Hiscox's with situational awareness company Aldoria.[842]

Commercial human spaceflight and insurance for Moon assets could also emerge as interesting opportunities within the sector, as the first space travel insurance products emerged on the market over the last years[843].

Notwithstanding the risks involved, insurance companies see these developments as opportunities where their services can be provided, especially regarding commercial space stations and lunar exploration. Notably, in 2022, the Japanese company ispace reached an agreement on the first commercial Lunar insurance with Mitsui Sumitomo Insurance, which "comprehensively covers risks arising from ispace's Mission 1, from the launch of the rocket to the lunar landing". The failure of ispace's lander in April, was followed by a claim of around $26 million.[844]

[841] New DoD commercial space strategy opens door to military, financial protection for contractors, Breaking Defense, April 2024; Space needs a sustainable insurance industry, Financial Times, September 2023
[842] Space insurers creating policies that assess collision risk even as they face their worst year ever for losses, Space Intel Report, November 2023; Insurance Premiums are Being Hit Hard by Space Debris I Infosys BPM, ; Hiscox and Share My Space Unite to Mitigate Collision Risks, SpaceWatch.Global, July 2023
[843] To the Moon and Back: Space Tourism and Insurance, insurancejournal.com, March 2023
[844] The Space Report 2023 (Q2), Space Foundation, April 2023; ispace Reaches Agreement with Mitsui Sumitomo to Become World's First User of Commercial Lunar Insurance, ispace, November 2022; Mitsui Sumitomo pays out US$26m to ispace in lunar insurance claims, Insurance News, August 2023

3.2 Institutional Space Budgets



The following section makes use of national space budget data from Novaspace, a merger of Euroconsult and SpaceTec Partners, with their permission.

Data are extracted from the Novaspace Government Space Programs report which provides a comprehensive assessment and analysis of national space programmes and space budgets. Various sources of information are collected by Novaspace on government space programmes and budgets from government agencies' primary information, public sources, and estimates. This information is harmonised and processed to form a coherent set of data.

The report provides an in-depth profile for each country, through country factsheets: high-level key figures on an individual country's space program, including top 3 applications, high-profile space missions, total space budget, world ranking, space spending per capita, 5-year CAGR, etc.

- Analysis of government space strategy and space policy documents, including key stakeholders
- Assessment of government budgets, split by application, civil/defence, and 10-year historical data and 10-year forecast
- Breakdown and analysis of government space program by application (satcom, satnav, EO, exploration, etc.)
- Roadmap of all satellites and space missions launched by that country (10-year historical and 10-year forecast)

The complete Novaspace report is available **here**.

3.2.1 Global overview and evolution

The total governmental budget for space programmes in 2022 is estimated to be $101.8 billion by SIA/Bryce, $118.6 billion by the Space Foundation, and $103 billion by Novaspace. Out of the three data suppliers, only Bryce reports a reduction in government budgets of -5% between 2022 and 2021. Both, Space Foundation and Novaspace, report an increase of 11%. Novaspace reports the highest 5-years CAGR of 7.8%. Although in 2021 the Bryce and Space Foundation estimates were very similar, this year reveals a significant disparity between the two providers. While Novaspace and Bryce converge, SF estimates are EUR >$15 billion higher.

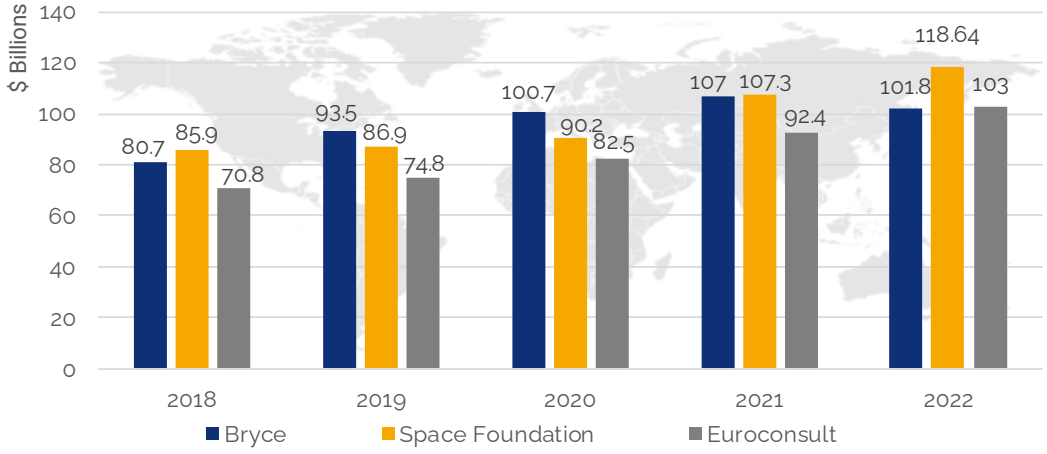


Figure 11: Global institutional space budget evolution (Source: SIA/Bryce, Space Foundation, Novaspace)

It is important to note that institutional budgets provide an incomplete perspective on governments' respective investments in the space sector and cannot be directly compared. The influence of currency exchange rates and purchase power differences should not be overlooked. Governments may also invest in the space sector through classified military spending or programmes in adjacent sectors.

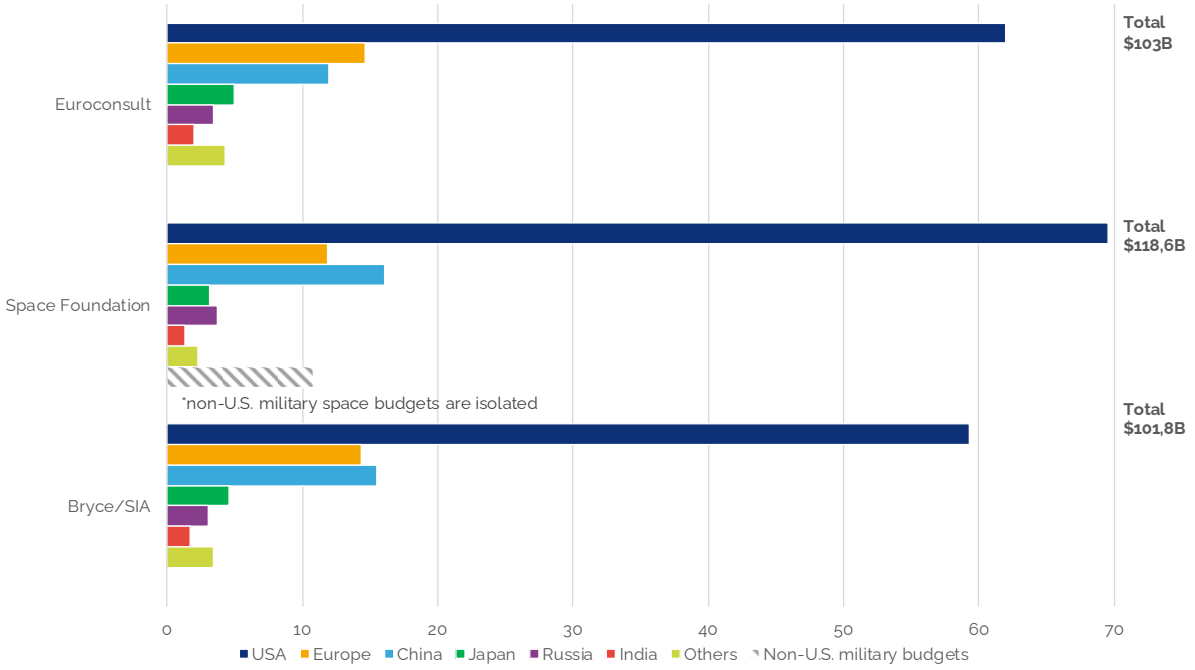


Figure 12: Institutional space budgets in 2022 (Source: Space Foundation, Novaspace)

When comparing the specifics of institutional space budgets, **Novaspace diverges from the Space Foundation and Bryce in their estimation of Chinese and European space budgets, considering Europe's budget to be significantly larger than China's by 22% or $2.6 billion. This is inverted to both SF and Bryce's estimates of the European budgets, considered to be 36% and 8% smaller, respectively.** This divergence can be caused by multiple factors, including the fact that China's real budget is unknown. Less obvious is the divergence in Japan's reported budgets. SF reports it to be smaller by 19% than Russia's, while both Novaspace and Bryce flip the estimates at 43% and 53% larger than Russia's respectively.

Regarding the world military space budget, the Space Foundation indicates significant growth from $42.6 billion to $53.8 billion between 2021 and 2022, a $11.2 billion increase driven primarily by U.S. budgets, which represent 80% of global investment in military space, but also a change in the methodology used. At the same time SFs estimate of the world civil budget increased from $60.3 billion to $64.8 billion between 2021 and 2022. This increase in civil budget is a result of increased civil expenditure in most of the countries with the largest budgets, such as the U.S. and China.

Novaspace has slightly lower figures in total; however, it highlights a 23% increase in military budgets in 2022, reaching a total of $48 billion in comparison with $38.9 billion in 2021. Novaspace also shows a growth in the global civil budget growing from $53.5 billion in 2021 to $55 billion in 2022. Both sources report a similar almost even split between civil and military space budgets globally, with Novaspace reporting 47% of global spending going to the military, and SF reporting 45%.[845]

[845] New record in Government Space Defense spendings driven by investments in Space Security and Early Warning (Link)

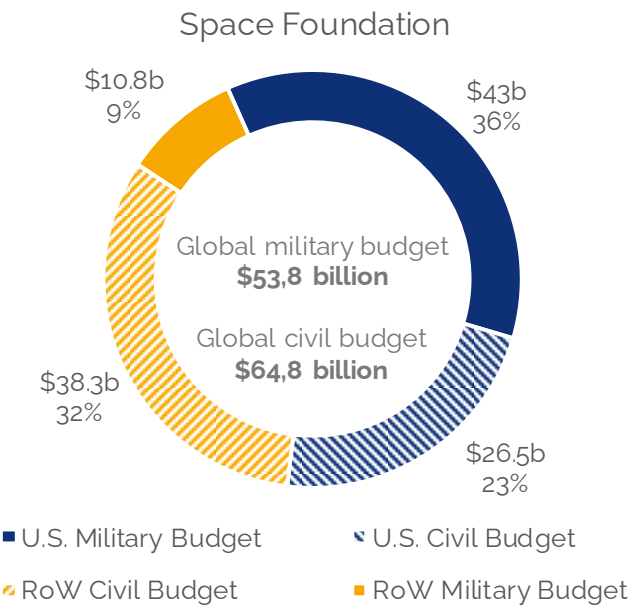


Figure 13: Civil vs Military budgets in the U.S. and Rest of the World in 2022 (Source: Space Foundation)

In 2022 the United States share of the global space budgets was around 60%, the share looks to be consistent despite increasing budgets of non-US counterparts year-on-year. The U.S. military budget is the main driver behind the growth of the overall U.S. space budget, representing 62% of the total and increasing by 26% in 2022. In comparison, the U.S. civil budget only increased by 3%.

Moreover, only 22% of the space budget for the rest of the world goes to military budgets, notably up from 20.2% in 2021. This makes the U.S. military budget approx. 4 times larger than that of the rest of the world's militaries. Regarding civilian space budgets in the rest of the world, they increased 26% in 2022 ($59.8 billion in 2021 to $64.8 billion in 2022) and military budgets are up 13%, ($42.6 billion in 2021 to $53.8 billion in 2022).

3.2.2 Space budget per country

Nominal space budgets

In 2022 Novaspace estimated the total global institutional space budget at $102.96 billion. As in the previous years, in 2022 the U.S. budget is larger than all the other combined. The second largest single-country spender is China, whose budget is estimated at $11.94 billion. The next largest contributors are France, and Japan, of which the latter has switched places in the ranking with Russia. These top five largest space budgets represent 84% of the global total.

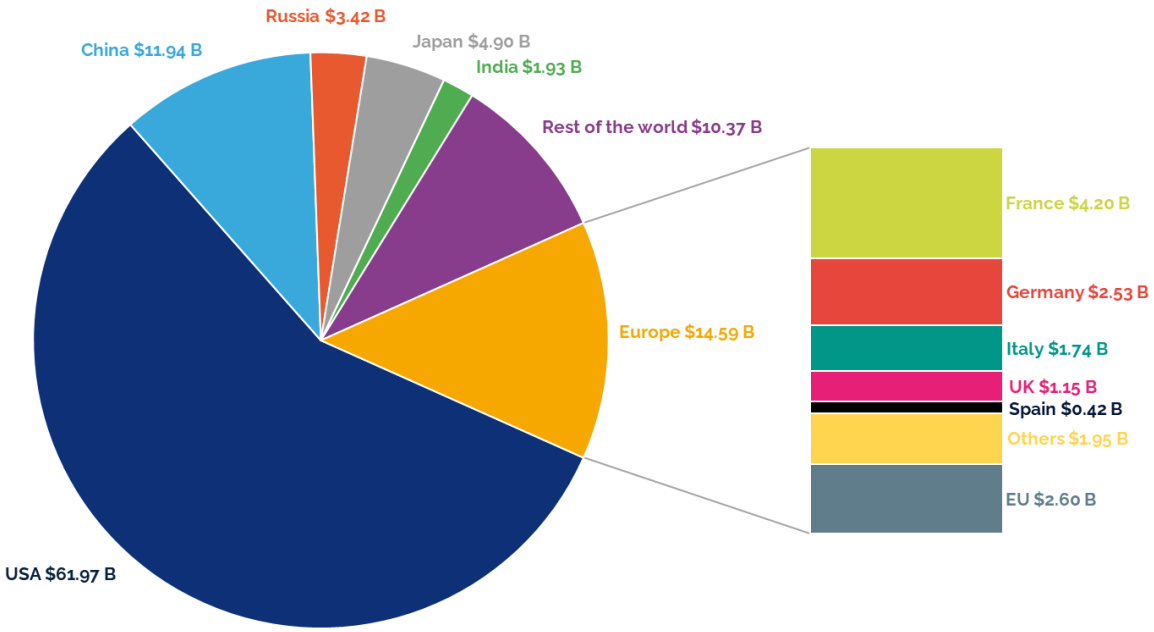


Figure 14: Institutional space budget per country in 2022 in USD (Source: Novaspace)

The U.S. institutional space budget grew by 14% to $61.97 billion between 2021 and 2022. The Space Foundation reports higher numbers than Novaspace at $69.5 billion, keeping the year-on-year growth at 14%. Novaspace estimates China's space budget to have reached $11.94 billion in 2022, up from $10.29 billion in 2021, achieving a yearly growth of 16%. However, estimates of the Chinese space budget vary between providers. The Space Foundation estimates it to be $4.2 billion higher than Novaspace and $0.6 billion higher than Bryce/SIA. The Space Foundation estimation is higher than the one provided by Novaspace, even with military budgets removed.

Such a large discrepancy may come from the fact that the information on the Chinese space budget is not based on official figures and is more speculative due to China's policy of opacity towards its space programme. Another challenge is posed by the Chinese monetary policy, which causes difficulties in evaluating the real value of the Yuan. Consequently, Chinese space budget estimations do not necessarily reflect the level and growth of space activity in the country.

Japan continues to hold the spot of the third largest single-country space budget at $4.9 billion, however, its spending growth decreased from 27.6% in 2021 to 16% in 2022. In turn, France has the fourth largest budget in the world in 2022 at $4.2 billion and shifted trends by increasing its budget by 6% YoY compared to a 1.25% reduction the prior year. Regarding Russia, its spending is estimated at $3.42 billion, continuing the downward trend from 3.7 billion in 2021 and $3.6 billion in 2020.

The European space budget, understood here as the sum of ESA and EU member states budgets (excluding Canada), reached $14.6 billion according to Novaspace. The French budget accounts for

almost 30% of the total European space budget. The EU spends the second largest sum at $2.6 billion, representing 18% of the European total. In third comes Germany, with an estimated institutional spending of $2.5 billion, accounting for 17% of the total. Other European countries with significant space budgets are Italy ($1.74 billion, 12% of total) which also increased its budget by 17% YoY, the United Kingdom ($1.415 billion, 7.9%) decreased its budget by 21%, and Spain ($420 million, 2.9%).

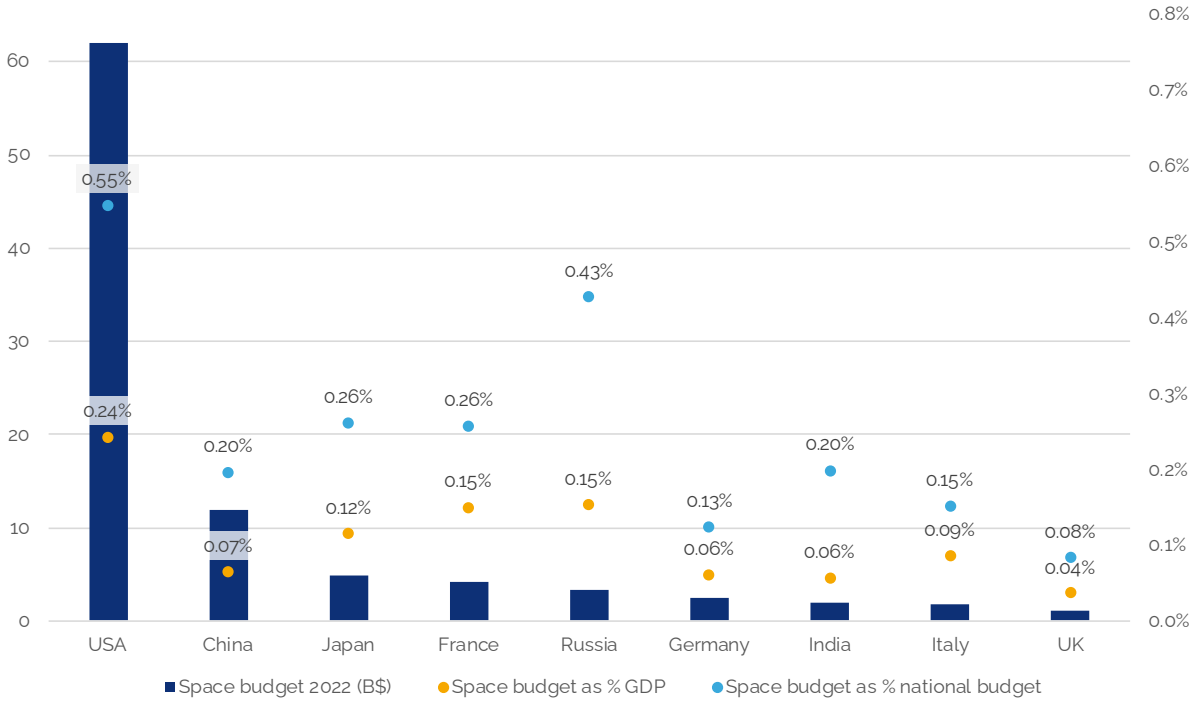


Figure 15: Space budgets as % of GDP and as % of total government expenditure in 2022 (Source: Novaspace, IMF, ESPI)

The figure above focuses on the relation between national space budgets, total government expenditure and GDP. It presents the national space budgets as a share of the total national budgets and as a share of the GDP. Countries are ranked in descending order by their nominal space budgets, which are represented by the bar chart.

When it comes to presenting the national space budgets as a share of the total national expenditure, the U.S. comes first spending 0.55% of the national budget on space-related initiatives. The second highest result is obtained by Russia, which allocates 0.43% of the budget on space programmes. The third place is shared by France and Japan, which each allocate 0.26%, followed by China and India allocating 0.20% of their budget for space endeavours respectively. Among the nine analysed countries, the UK and Germany's space budgets represent the lowest share in the national expenditures, at 0,08% and 0.13% respectively.

If national space budgets are compared as a share of total GDP, the U.S. comes first again. The U.S. space budget represents 0.24% of the GDP. Russia has a lower ratio of 0.15%, now shared with France. The third place is taken by Japan, whose space budget value is equal to 0.12% of the Japanese GDP. All the other countries' space budgets represent somewhat between 0.09% of the total GDP (Italy) and 0.04% (the UK).

2022 was an exceptional year of growth for the Japanese space sector. The country has grown its space budget share of GDP by 37% leading the next largest grower, Italy with 23% YoY. As a percentage of the national budget, Japan leads with a 17% increase between 2021 and 2022 compared to the next largest leader, China, with a 16% increase. The UK has decreased its space

budget as a percentage of GDP by 21%, the same cut as Russia. As a percentage of the national budget, the UK has slashed its budget between 2021 and 2022 by 34%.

The differences between countries are not as clear as they might seem if only nominal budgets were taken into consideration. Although the U.S. obtained the highest results in every analysed metric, an important conclusion can be drawn from the comparison of the national space budgets with the total national budgets and the GDP. The U.S and Russia follow one another in lockstep, reducing their space expenditure as a percentage of the national budget by 34% and 26% respectively, and also reducing their budgets as percentage of GDP by 21% YoY. Though their respective economies differ in size, the provision of national expenditure on space remains synchronised over the years.

PPP-adjusted space budgets

Another perspective can be provided by adjusting the national space budgets for purchasing power parity. Purchasing power parity is an approach which allows to level the price differences between countries. For instance, the cost of labour in nominal prices varies substantially across different countries and purchasing power parity helps to remove this factor so that the adjusted values are easier to compare with each other. Purchasing power parity is often used to study GDPs.

This metric emphasises a perhaps undervalued potential of the emerging economies, which do not spend as much as developed countries in terms of nominal values but may catch up thanks to lower operational and labour costs.

However, adjusting the space budgets for purchasing power parity may have stronger limitations than usual, since the prices on the space goods market are less elastic than on the consumer goods market. Nevertheless, the purchasing power parity approach enriches the scope of the analysis and emphasises the fact that intermediate and labour costs are significantly lower in some world economies such as China, Russia, and India.

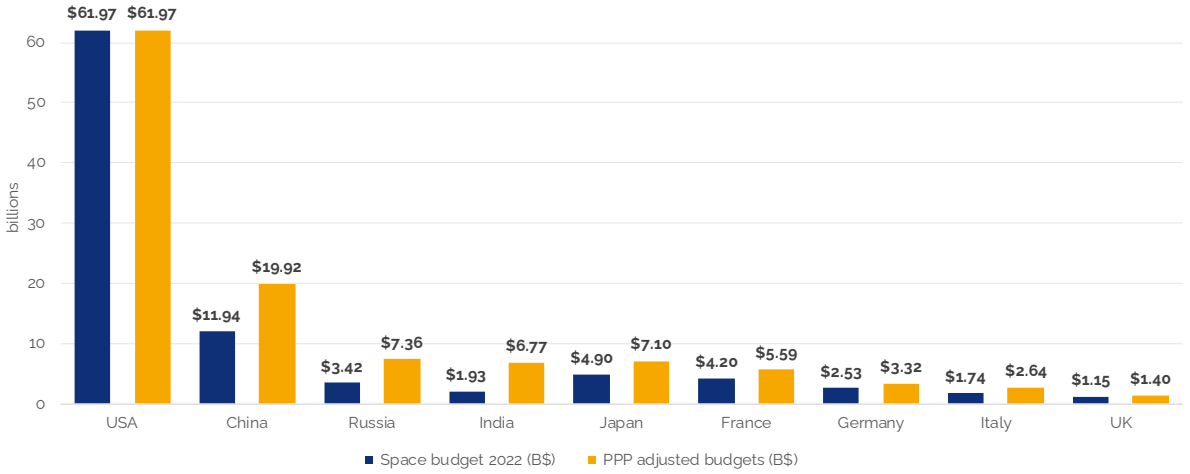


Figure 16: National budgets per capita adjusted for PPP (Source: Novaspace, IMF, ESPI)

Purchasing power parity approach uses the U.S. Dollars as a reference point; thus, the U.S. budget remains unchanged after the adjustment. Adjusted Chinese budget is over 54% larger than the nominal one. The largest growth after adjustment was observed for India and Russia, whose adjusted budgets tripled compared to the former and increased by 2.5x for the latter. Overall, the developed countries' adjusted space budgets have seen much less increase than those of the emerging economies. Consequently, the ranking of the largest space budgets is shuffled. Russia reclaims its 3rd position and India the 4th, overtaking Japan, France, Germany, Italy, and the UK.

Space budgets per capita

The U.S. government spends $186 per capita, which allows the U.S. to confirm its primacy in the metric. **The second largest result of $62 per capita is obtained by France.** The third place is taken by Japan which spends $39 per capita. Chinese and Indian budgets per capita are the lowest $8 and $1 respectively.

Concerning **PPP adjusted space budgets per capita,** the U.S. results remain unchanged. Second and third come France and Japan with PPP adjusted space budget per capita of $82 and $57 respectively. Japan has overtaken the number three spot from Russia by this metric in 2022. The fourth largest result is obtained by Russia ($51) followed by Italy ($45) and Germany ($40). China and India take again the last two positions with PPP adjusted space budgets per capita of $14 and $5 respectively.

The most significant change occurs when it comes to the position taken by China. Although China has the second largest national space budget, per capita takes the eighth place, spending as little as $8 per capita in nominal values and $14 in the PPP adjusted. Similarly, even though India took sixth place in terms of nominal budget, it comes eighth in both nominal space budget per capita ($1) and PPP adjusted space budget per capita ($5).

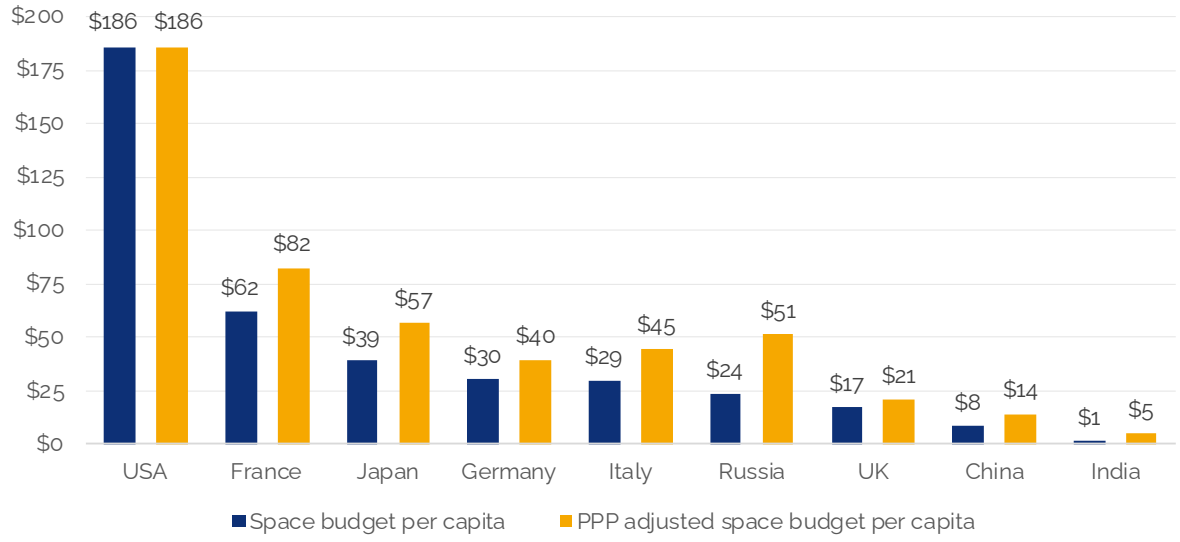


Figure 17: Space budget per capita in 2021 (Source: Novaspace, World Bank, ESPI)

3.3 European space budgets

3.3.1 Consolidated European space budget

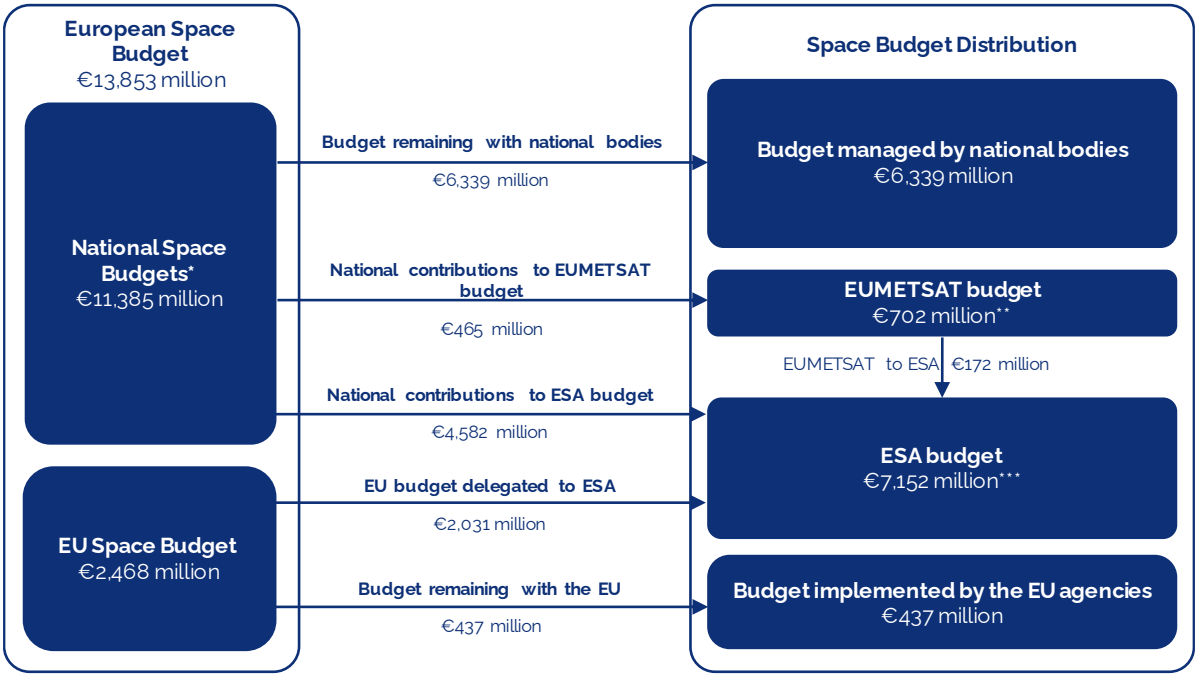
Space budgets in Europe are intertwined with a variety of budget transfers (delegations, contributions) between different national, intergovernmental and supranational actors. Overall, and after consolidation, ESPI estimates the consolidated European space budget was around €13,853 million in 2022.

This includes two main sources of public funding:

- National space budgets are the primary source of public funding in Europe. In 2022, the total space budget of European countries (ESA and EU member states) was around €11,385 million. This budget includes:
  - National contributions to the ESA budget of €4,582 million
  - National contributions to the EUMETSAT budget of €465 million
  - Budget remaining with national bodies for developing national space programmes and other space projects outside ESA and EUMETSAT of €6,339 million.
- The European Union space budget is the second source of public funding in Europe. This budget is financed through Member States contributions to the budget of the Union but managed as a supranational budget complementing national budgets. In 2022, the EU space budget represented an additional public investment of €2,468 million.

In 2021, the budget of the European Space Agency (ESA) was €7,152 million, including income from the EU of €2,031 million EUMETSAT of around €172 million.

Consolidated European Space Budget 2022



*National Space Budgets include all budgets of EU and ESA member states excluding Canada

** EUMETSAT budget includes €237 million from other sources including the contribution from Turkey

*** ESA budget includes €367 million from other sources including the contribution from Canada

Figure 18: Consolidated European space budget 2022 (ESA, EUMETSAT, Novaspace, ESPI)

3.3.2 National space budgets

European countries delegate approximately half of their national space budget to ESA and EUMETSAT and contribute primarily to European space programmes. Most of the countries implement more than half of their national space budget through ESA. The table below shows the estimated national space budget (civil and military) for European ESA Member States in 2022. Worth noting, on the 21st of May 2021 Lithuania became an ESA Associate Member State.

Country	National space budgets in 2022 (€M)	ESA contribution (€M)	National activities (€M)
Austria	34.2	49.8	84.0
Belgium	82.3	238.7	321.0
Czech Republic	35.6	45.4	81.0
Denmark	20.2	33.8	54.0
Estonia	2.4	2.0	4.4
Finland	41.3	28.7	70.0
France	3,025.8	1,178.2	4,204.0
Germany	1,509.5	1,017.5	2,527.0
Greece	19.0	20.0	39.0
Hungary	20.8	21.2	42.0
Ireland	14.1	22.9	37.0
Italy	1,055.8	680.2	1,736.0
Latvia	-	1.1	-
Lithuania	-	3.0	-
Luxembourg	146.5	47.5	194.0
Netherlands	87.4	99.6	187.0
Norway	103.2	71.8	175.0
Poland	91.2	44.8	136.0
Portugal	31.8	25.2	57.0
Romania	19.6	39.4	59.0
Slovenia	8.3	2.7	11.0
Spain	199.3	220.7	420.0
Sweden	58.0	75.0	133.0
Switzerland	88.3	174.7	263.0
United Kingdom	716.1	437.9	1,154.0

Table 12: National space budgets of European countries in 2022 (Source: Novaspace, ESA, ESPI)

3.3.3 European Space Agency

The ESA budget saw an overall growth trajectory. In **2023**, ESA budget reached €7078 million which is a 1.04% decrease compared to the 2022 budget of €7152 million. **It is important to note that these figures do not yet reflect the significantly increased subscriptions approved at the ESA CM 2022 that will only be reflected in the years to come.**

In terms of programmes, the Earth Observation budget remains the largest budget allocation at ESA accounting for €1768 million which represents 25% of the total ESA budget, growing 9.67% as compared to the EO budget in 2022. The second biggest programme in terms of budget allocation is Navigation. The Navigation programme saw a 25.93% decrease year over year, going from €1534 million in 2022 to €1136 million in 2023. It now upholds 16% of the total ESA budget. Both EO and Nav represented together in 2023 41% of the total ESA budget.

The space transportation programme budget decreased in 2023, going from €1006 million or 14.1% of the total budget in 2022 to €892 million in 2023 or 12.6% of the total budget, representing a considerable decrease of 11.3%.

Following Space transportation, the biggest programmes in terms of budget allocation are Human Spaceflight at 12.5%, Telecommunications and Integrated Applications at 8.7%. and finally Scientific Programmes at 8.4%

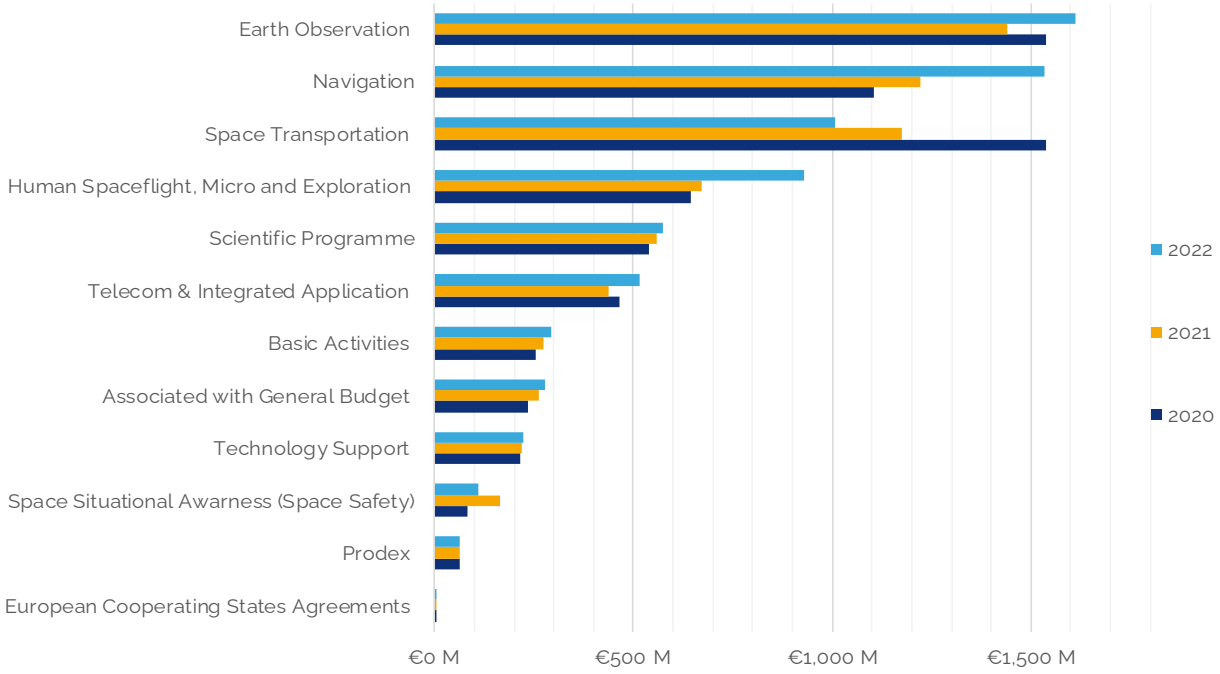


Figure 19: ESA programmatic budget allocations from 2020 to 2022 (Source: ESA)

The increase in the total budget was a result of the increased national contributions, which grew from €4596 million in 2022 to €4686 million in 2023, a change of 2% compared with 2022. The majority of member states increased their contributions to ESA, although among the top five contributors only Germany, the UK and Spain did so. The total increase of these 19 countries sums up to 378.6 million, of which 70% comes from the UK and Germany

Thanks to an increase of 2.9% its ESA contributions, Germany is now the largest contributor as it allocated €1047 million in 2023 thus accounting for 22% of the total. Due to a decrease of 15%, France now holds the second position with €1001 million or 21% of the total member states

contribution. The third largest contributor the UK (€610 million) and the fourth Italy (€580 million) followed the trend and respectively increased their contributions by 39% and reduced it by 15%. Spain overtook the fifth position substantially increasing its contribution by 30% and thus reaching €286 million, despite Belgium (€260 million) increasing its share of funding by nearly 9% year over year. The other countries which increased their contribution are Estonia, Romania, Finland, Austria, Slovenia, Portugal, Hungary, Sweden, Belgium, Czech Republic, Switzerland, Norway, Greece and Denmark. However, it should be underlined that France, Italy, Luxembourg, Ireland and Poland had reduced their funding in 2023.

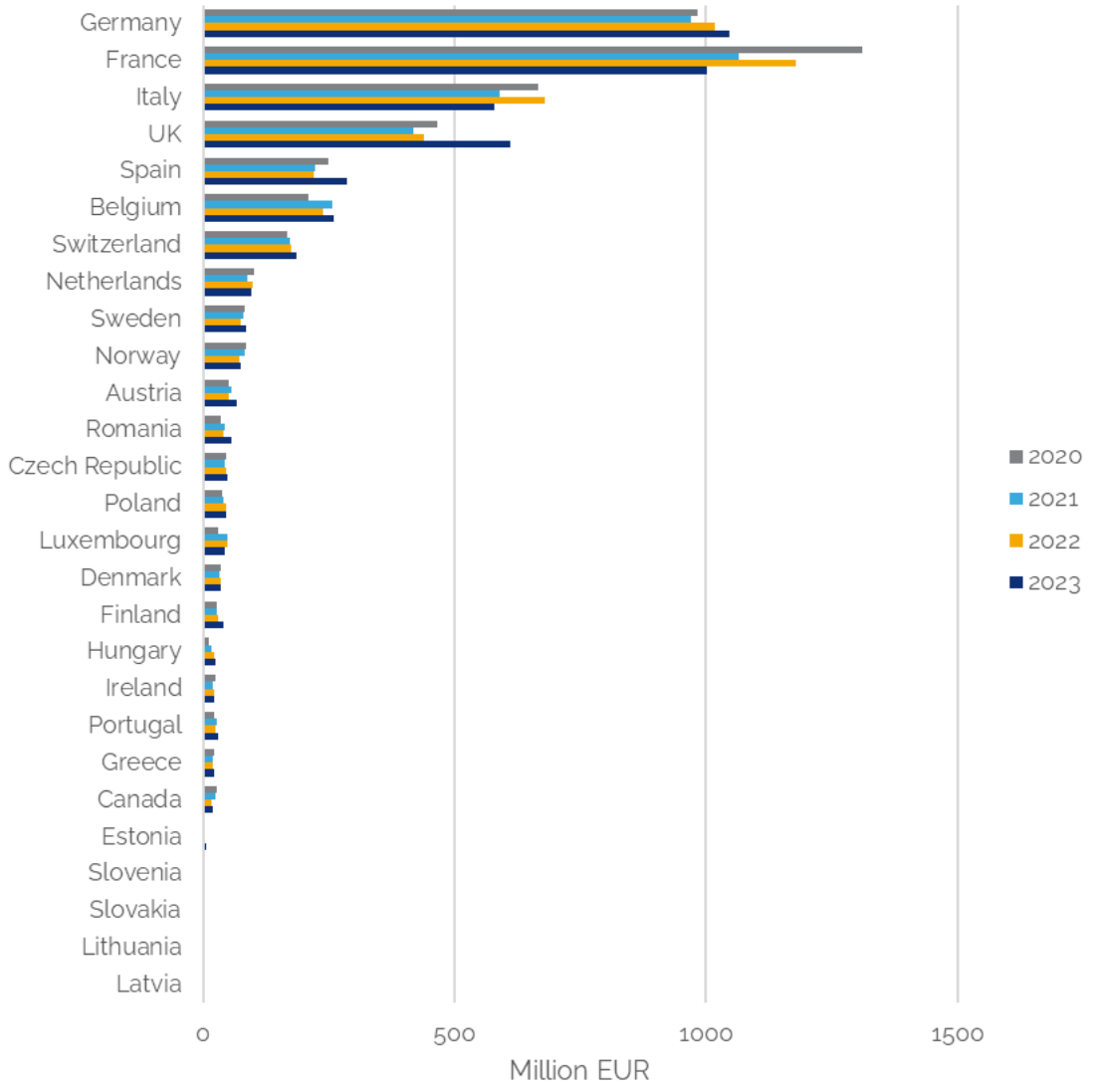


Figure 20: Member states contributions to ESA budget from 2020 to 2023 (Source: ESA)

The figure below illustrates the distribution between national budgets and the national contributions to the ESA budget. Roughly half the MS keep more than 50% of their national space budget under national management, however, interestingly, the two largest ESA contributors France and Germany are also among those. Belgium contributes the largest proportion of its space budget to ESA (74%).[846]

[846] Barring Latvia, Lithuania, and Slovakia as their national space budgets for 2022 could not be reliably verified.

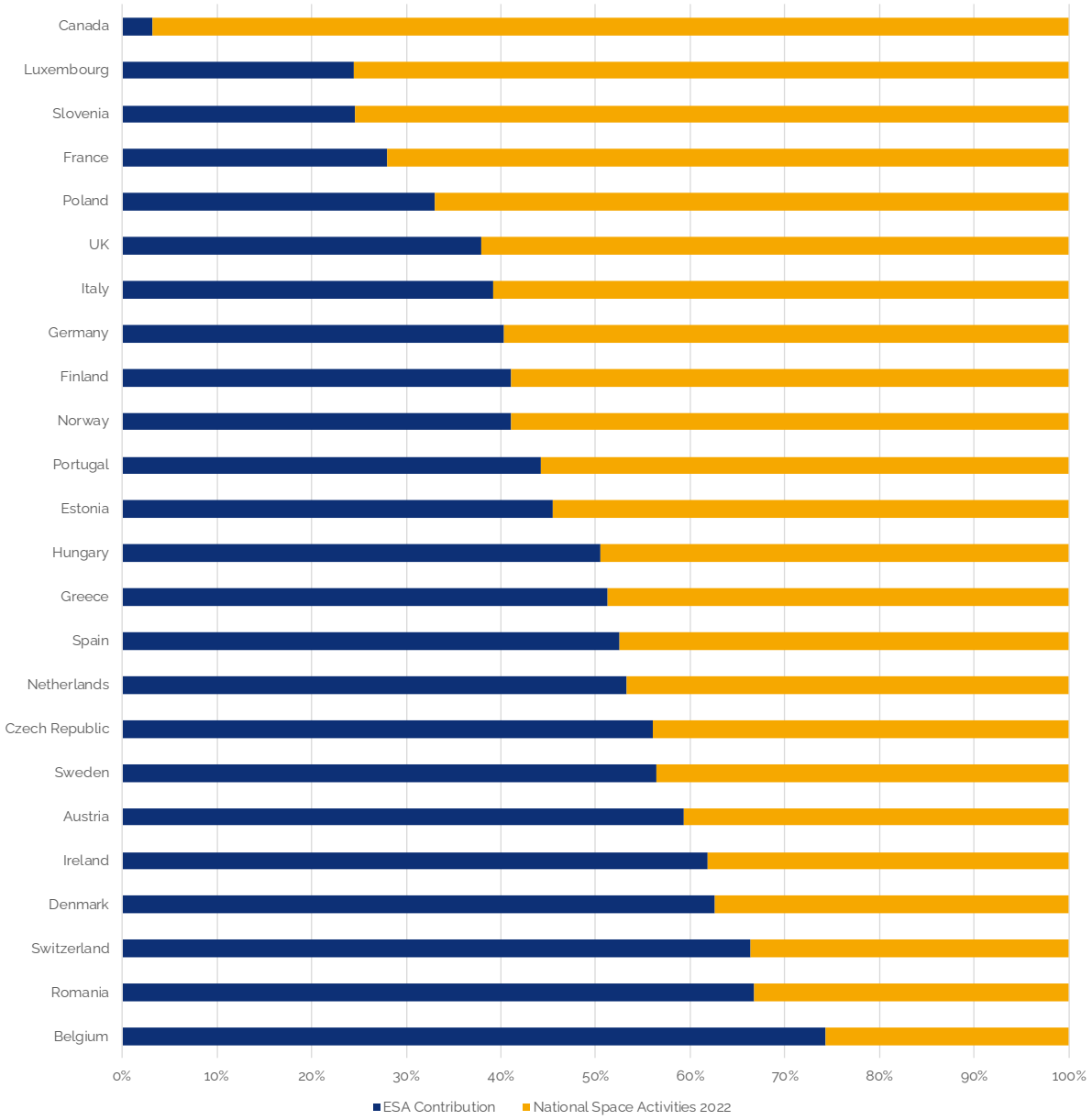


Figure 21: Member states budget allocation comparison in 2022 (Source: ESA, Novaspace, ESPI)

Inflation adjusted ESA contributions

Adjusting the national contributions from ESA Member States by this year's latest inflation data (February 2024, annual inflation 2.6%) reveals that since 2020 real national contributions have consistently fallen until 2023. Only in 2024, when Eurozone inflation was reigned back in towards the 2% target by tightening monetary policy, did the real value of contributions begin to reverse the trend. The real values reveal a drop in purchasing power from 2020 of 10% for the agency.

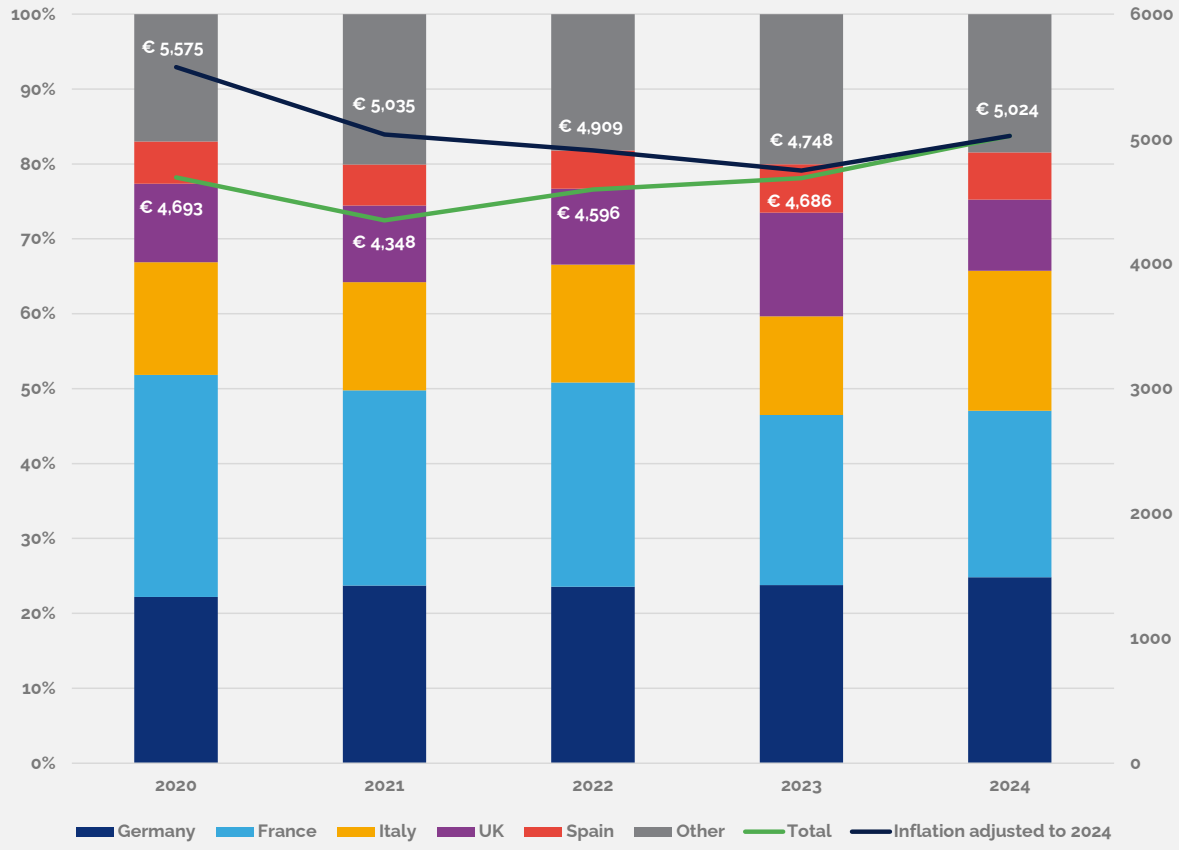


Figure 22: ESA national contributions and total contributions adjusted with inflation (Source: ESA)[1]

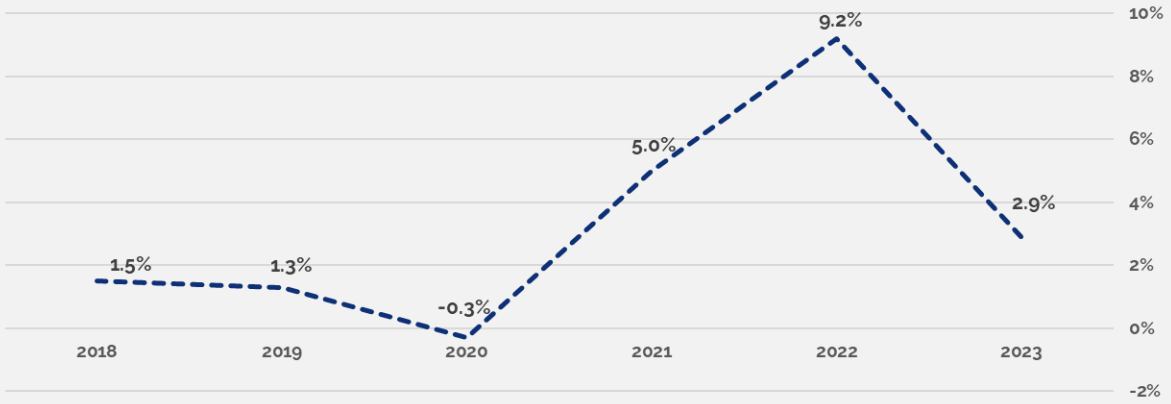


Figure 23: Eurozone inflation rate (Source: ECB)

[1] Other refers to countries with national contributions of less than EUR 100 million in 2024.

3.3.4 European Union

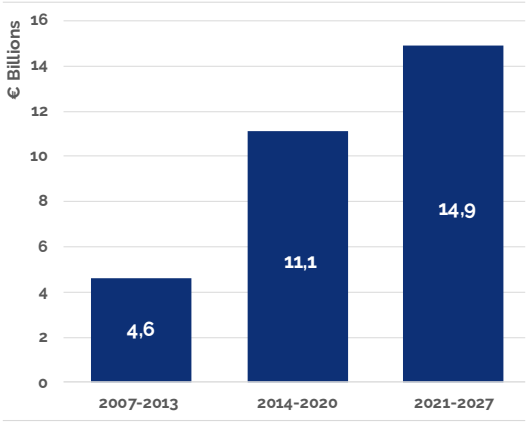
The European Union conducts various space activities that are implemented and managed by different executive bodies and agencies including the European Commission, the European Union Agency for the Space Programme (EUSPA), the European Defence Agency, EU SatCen, the EU Joint Research Centre, the European Health and Digital Executive Agency, the European Innovation Council, as well as the separate European Space Agency.

The 2021-2027 Multiannual Financial Framework defines the budget of the EU for the next 7 years, including for the EU space programme. In 2020 the European Union approved its space programme for the MFF 2021-2027, which significantly increased its space budget and navigated more towards security-related activities. In 2023, the 'mid-term revisions' were proposed following increased inflationary pressures and Russia's war on Ukraine.

In 2023, the European Union space budget stood at €2,276 million an increase of 7.2% over 2022. €2,045 million is dedicated to the European Union Space Programme, which covers several flagship programmes of the EU:

- **Galileo and EGNOS** are Europe's GNSS and SBAS programmes providing improved positioning and timing information.
- **Copernicus** is the European Union Earth Observation flagship programme.
- **GOVSATCOM and SSA**.
- **Other space activities** implemented by the European Commission, the European External Action Service, the EU Satellite Centre, the EU Joint Research Centre and other European bodies.

Moreover, the EU also has other budget instruments with allocations for the space sector such as **Horizon Europe, InvestEU, European Defence Fund.**



Galileo and EGNOS

In 2023, the European Union committed 1.25 billion to the Galileo/EGNOS programme, representing an approx. 8 % increase from 1.15 billion in the previous year. This sets budgets back to 2021 levels. The EU has committed €9.01 billion to Galileo and EGNOS as part of the new MFF, which represents a 31.8% increase compared to the budget committed to the two components in the previous period. With the new budget, the EU mainly projects to provide additional resources for continuity in operations and infrastructure for the components. It also expects to enhance the current capabilities as well as the development of the next generation of Galileo and EGNOS services, and drive for deeper integration of satellite navigation data in other policy areas and economic sectors.

Copernicus

In 2023, the European Union dedicated about €750 million to Copernicus, which represents an increase of 7% compared to the €700 million committed in 2022. As part of the MFF 2021-2027, the EU has committed approx. €5.4 billion to the Copernicus Earth Observation programme, an increase of roughly 26% compared to the €4.3 billion commitment under the previous MFF. The increased budget attributed to Copernicus in the new MFF will provide resources for the continuity of operations as well as for the enhancement of capabilities for the programme.

GOVSATCOM / SSA

The committed appropriation for the GOVSATCOM/SSA saw a substantial 73% reduction from €150million in 2022 to €40.3 million in 2023. As part of the MFF 2021-2027, the EU has committed €442 million to SSA and GOVSATCOM. Up until 2021, these programmes were under a preparatory action with a budget of €10 million for the period of 2019-2020.

Although the two components have a relatively smaller budget compared to both Galileo/EGNOS and Copernicus, the increased budget as well as their inclusion in the new MFF underlines the growing importance of the security and defence dimension of EU engagement in space.

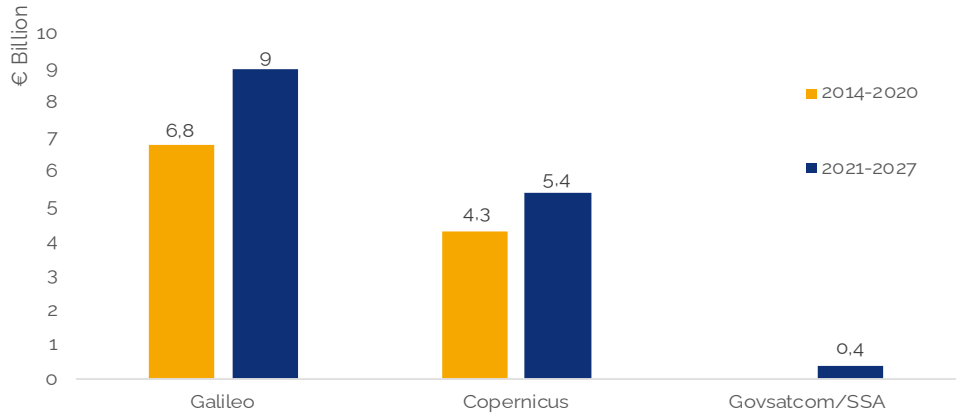


Figure 22:: Evolution of budgets Galileo, Copernicus and Govsatcom/SSA between MFF 2014-2020 and MFF 2021-2027

Horizon Europe

The Horizon Europe research and innovation funding programme was established in April 2021, with a budget of €95.5 billion for the period of 2021-2027 (including €5.5 billion from NextGenerationEU). Its support for space technologies and applications will be under Cluster 4 named "Digital, Industry and Space", with a total budget of €13.5 billion for the duration of the Horizon Europe, plus an additional €1.35 billion from NextGenerationEU.

The support provided through Horizon Europe is thematically linked with the development of Copernicus and Galileo services, SSA and GOVSATCOM-related activities, as well as other strategic innovation areas such as reusable launchers, European technology non-dependence and space science. It will thus be used in support of the overlapping objectives set by the EU Space Programme.

In addition, the **European Innovation Council** has been established under Horizon Europe with a total budget of €10 billion for the current MFF period. In order to enable the support of selected start-ups and SMEs, the European Commission and the EIB Group have established that approx. €3 billion will be attributed to the **European Innovation Council Equity Fund**. The EIC Fund is an innovative instrument through which the European Commission can make direct and quasi-direct equity investments in funded companies. In 2023, the EC has adopted the 2023 work programme of the EIC providing €1.6 billion in funding opportunities beyond the initial budgets.

The EIC will support research and innovation on the continent through three main instruments, which include:

- The **EIC Accelerator**, with a budget of €1.13 billion in 2023, to support European companies to scale up and develop their disruptive, high risk and high impact technologies. Within it, €525 million are earmarked for next generation technologies in strategic areas or Europe, including

space technologies and services. Among others, in 2023 companies involved in spacecraft manufacturing, satellite laser manufacturers and debris detection located in Italy, Belgium, UK and France were supported through either blended finance tools from €0.5 to €15 million or grants up to €2.5 million.

- The **EIC Pathfinder**, with a budget of €343 million in 2023, to support research in breakthrough and highly disruptive technologies. Regarding space applications, this specific programme has supported projects on solar and microwave energy harvesting in space from companies in Spain, France, Italy and Sweden.
- The **EIC Transition**, with a budget of €128.3 million in 2023, to support the transition between research and real innovation opportunities.

Overall, in 2023 a total of €97.7 million was allocated across the three instruments to the space sector. €32.7 million across the three instruments was allocated to in-space solar energy harvesting and novel propulsion concepts, while €65 million was allocated to space technologies and services.InvestEU Programme

The **InvestEU programme** is the EU's main investment instrument to stimulate innovation and facilitate access to finance. With a total budget of €9.49 billion for the MFF period 2021-2027, it aims to mobilise over €372 billion of additional investment, through a €26.2 billion guarantee from the EU budget.

A portion of this investment is aimed at supporting European start-ups and SMEs, in particular in the space sector. In this context, the Competitive Space Start-ups for Innovation (**CASSINI**) initiative has been launched as part of the InvestEU programme. Launched in January 2022, CASSINI is managed by the Directorate-General for Defence, Industry and Space in partnership with the European Investment Bank (EIB) and the European Investment Fund (EIF).

CASSINI has two main vectors to attribute funding:

- **Access to finance:** With a budget of around €1 billion, the CASSINI facility provides capital to venture capital funds to invest in EU-based companies that develop and commercialise space technologies and digital services using space data.
- **Prizes and competitions**: The Cassini Challenges serve as a gateway to the space industry. Participants use Galileo and Copernicus satellite data to address pressing societal issues, with a €1 million prize pool for winning solutions.

By integrating these initiatives under the InvestEU framework, the EU aims to create a more coherent and supportive environment for space.

European Defence Fund (EDF)

The European Defence Fund, which has been established with a budget of approx. €8 billion for the period 2021-2027, is a grant programme from the European Commission to strengthen defence research and development and promote an innovative and competitive industrial base. The EC has allocated to the EDF a budget of €945.7 million in 2023.

The calls for proposals are distributed among 17 thematic categories, and space is one of these categories, under which a call for projects was placed by the EDF in 2023 with a total budget of €125 million.

Managed under the Strategic Technologies for Europe Platform (STEP), following the 2023 mid-term revision, an additional €1.5 billion was proposed to be allocated to the EDF which reached a provisional agreement in February 2024.

The European Commission directly manages the EDF and, although since 2022 the European Defence Agency (EDA) became eligible as an implementing partner for the indirect management of EDF actions, the Commission remains responsible for selection and award procedures, including ethics screening and assessment. Accordingly, the indirect management of EDF actions may be entrusted to the EDA by the European Commission, for example at the request of Member States. As the granting authority, the EDA carries out tasks such as preparing and signing grant agreements, monitoring their implementation, managing amendments, approving reports and deliverables, making payments to project coordinators, and reporting to the European Commission (DG DEFIS).

Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS2).

In February 2022 the European Commission proposed the Secure Connectivity Initiative to establish a secure satellite communication system for the EU and its Member States' governmental entities through a public-private partnership.

The programme is funded via €1.65 billion for the period 2023-2027 through the existing 2021-2027 MFF. Considering that the MFF did not foresee this new programme, its budget is sourced from reductions in other programmes, including €500 million from the EDF, €1 billion on the Single Market, Innovation and Digital programme heading, and €150 million from the Neighbourhood and the World programme heading.

An additional envelope of €750 million would serve as a contribution to the Secure Connectivity System, to be implemented under the Horizon Europe (€380 million), the Union Space Programme (€220 million) and the Neighbourhood, Development, and International Cooperation Instrument (€150 million).

3.3.5 EUMETSAT

EUMETSAT is an intergovernmental organisation supplying climate and weather satellite data to European Member States' national meteorological services since 1986. EUMETSAT activities are primarily funded through Member States' contributions. In 2022, MS contributions amounted to €486,3 million (roughly 70% of the total budget), compared with €487 million in 2021, representing a year-on-year decrease of 0.3%. Member States contributions are calculated on the basis of their Gross National Income (GNI).[847]

[847] Annual Report 2022, EUMETSAT, 2022.

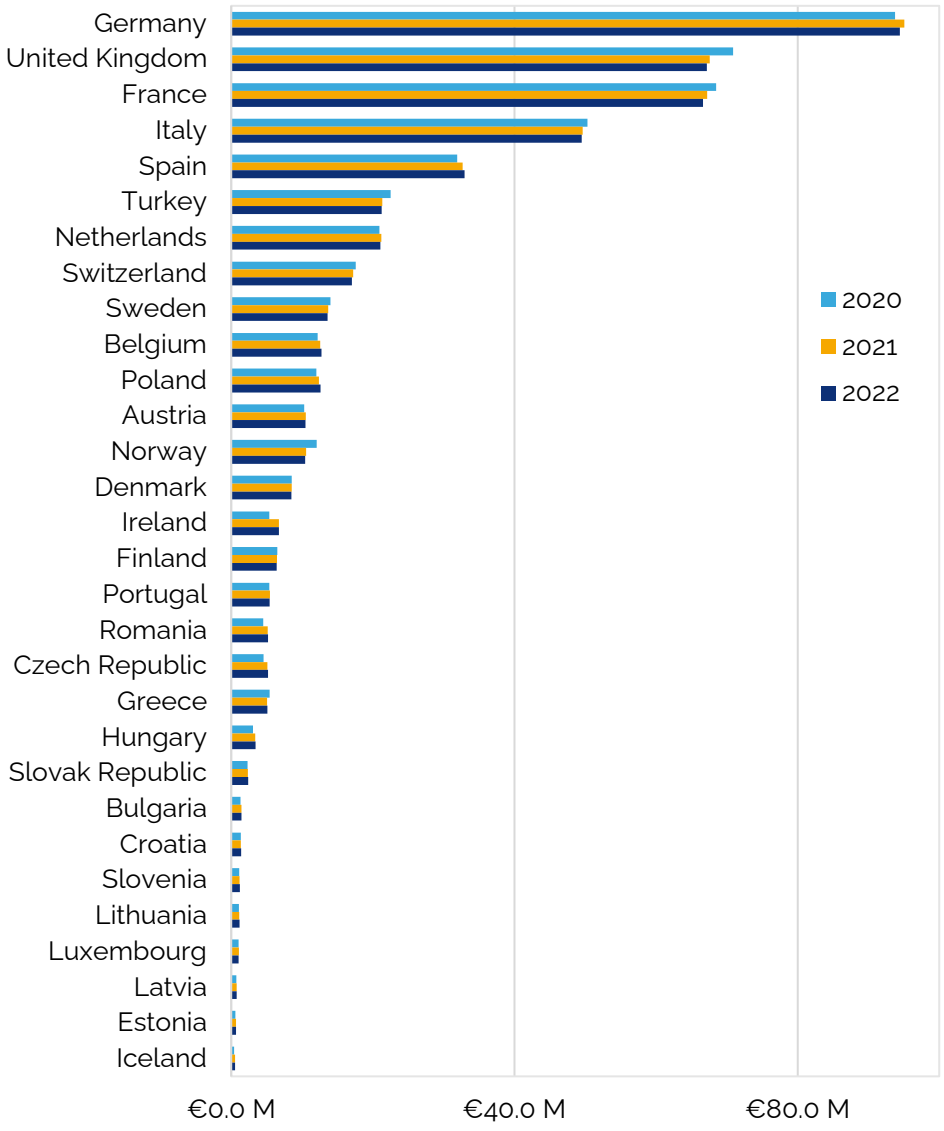


Figure 23:: Member states contributions comparison for 2018/2019/2020 (Source: EUMETSAT, ESPI)

Germany remained the largest contributor to the EUMETSAT budget with €94.4 million, it reduced its contribution by €0.6 million, the largest reduction. Spain provided the largest increase YoY with €0.3 million. Beyond Member States contributions, other sources of revenues for EUMETSAT originated from product sales and other contributions and revenue totalling €620 million of its income.

3.4 European space economy statistics

3.4.1 European space manufacturing industry

Main indicators

ASD-Eurospace, the trade association of the European space industry, provides robust and detailed insights on the state of the industry in its *Facts & Figures* annual report. This edition highlights the results achieved by the space sector globally, despite the consequences of the war in Ukraine, with the disruption of economic activity in the European space industry that followed.[848]

Accordingly, the numerous dependencies that the European space industry had on Russian and Ukrainian space systems led to lower revenues and loss of supplies. The final sales of the European space manufacturing industry thus decreased by 4,1% to around €8.257 million, a level that is still higher than the one observed in 2020.

ASD-Eurospace underlined how the pressure on the labour market, driven mainly by new and emerging start-ups, is causing difficulties in filling vacant positions, especially among legacy companies, combined with existing inflationary pressures on critical supplies, could lead to a reduction in the competitiveness of the European space system.

Space industry employment grew to reach 57510 permanent staff (in Full-Time Equivalent - FTE), an increase of 8,2%. When including other personnel, not directly employed by space industry companies, the number of total staff increases by over 2000 to 59707.

Key figures employment (FTE) and sales (M€)	2020	2021	2022	Variation
Direct industry employment (FTE)	50317	52822	57510	8.2%
Other personnel working on site (FTE)	2402	2422	2197	-9.3%
Total space industry employment (FTE)	52720	55244	59707	7.4%
Final sales (M€ current e.c.)	7720	8620	8257	-4.1%

Table 13: Main industry facts

Industry sales by customer segments

The distribution of industry sales by customer segment shows that the European space industry addresses primarily domestic markets: in 2022, public and private European customers accounted for 82% of industry sales, the same share as in 2021. The European public sector (ESA, EUMETSAT, European Commission, national space agencies and other civil and military institutions) remains the principal source of revenues for the European space manufacturing industry, corresponding to 67% of final sales in 2022.

[848] Facts & figures – The European space industry in 2022, ASD-Eurospace, July 2023; As data are revised between different annual publications, we present here the revised data from the most recent publication.

European public programmes have become increasingly important over the past decade in terms of share of industry revenues, with sales to European public entities growing from approx. $3 billion in 2010 to roughly €5.5 billion in 2022. Accordingly, the pandemic-induced downturn of this market segment between 2019 and 2020 seems to be an outlier, with sales stabilizing to around previous levels. On the contrary, the commercial and export markets are still under a downward trend since its peak in 2017.

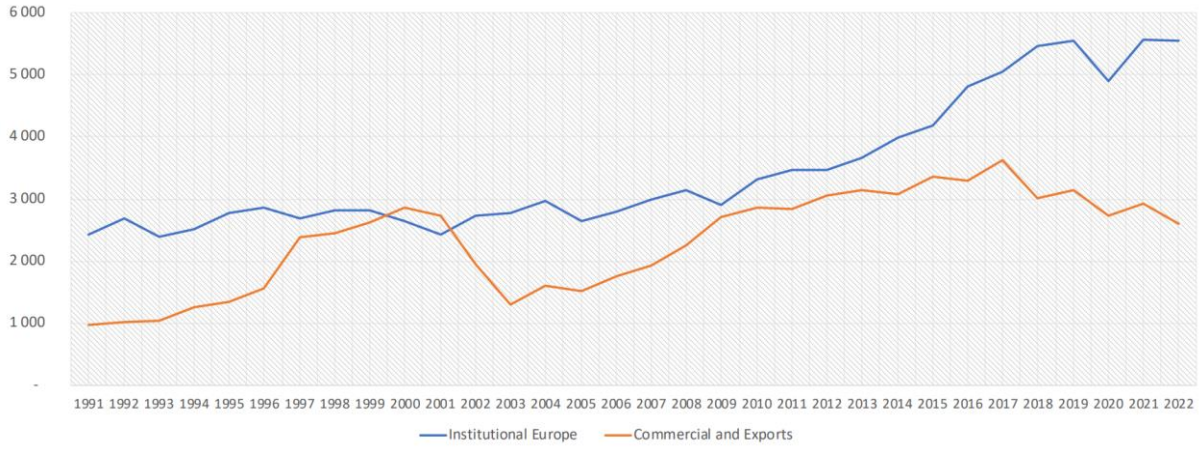


Figure 24: Sales by main market segment - type of system (M€)

Final sales by main customer segment (M€)	2020	2021	2022	Variation
European public customers	4900	5539	5556	0.0%
European private customers	1297	1367	1073	-19.5%
Other European customers	99	117	104	-10.9%
Public customers RoW	457	458	363	-20.9%
Private customers RoW	941	1084	1132	4.1%
Other customers RoW	25	54	28	-47.6%

Table 14: Final sales by main customer segment (M€)

Industry sales by product segments

The distribution of industry sales by product segment shows that satellite application systems, including the development and production of telecommunication, Earth observation and navigation systems, are the main market of the European space industry, representing 44% of sales.

This segment grew steadily peaking in 2017 at around €5 billion, to then fluctuate during the next two years until Covid-19 struck the sector between 2019 and 2020. After the dip, the segment continued to fluctuate above the 2020 levels.

Ground systems and services, including electric and mechanical ground segment equipment (EGSE & MGSE) as well as engineering and other specialised services, are the second source of revenue, representing 21.2% of the total sales by macro segment.

Scientific systems, including human spaceflight, exploration, Earth and space science programmes, surpassed launcher systems for the first time in 2021 and reached an all-time high of revenue in 2022, accounting for 16.9% of the total sales.

Traditionally the second product segment with the most sales, launcher systems has been downgraded to the third position since 2021. Thanks also to the relevant growth in 2022, it's worth noting that programmes under the Other & Unknown label reached levels analogous to the previous peak of 2017. Also note that, contrary to the 2021 edition, Support activities have been separated from Other & Unknown activities.

The irregular evolution of final sales over time, characterised by sudden changes in trends, is explained by ASD Eurospace by the strong influence of sales to commercial customers.

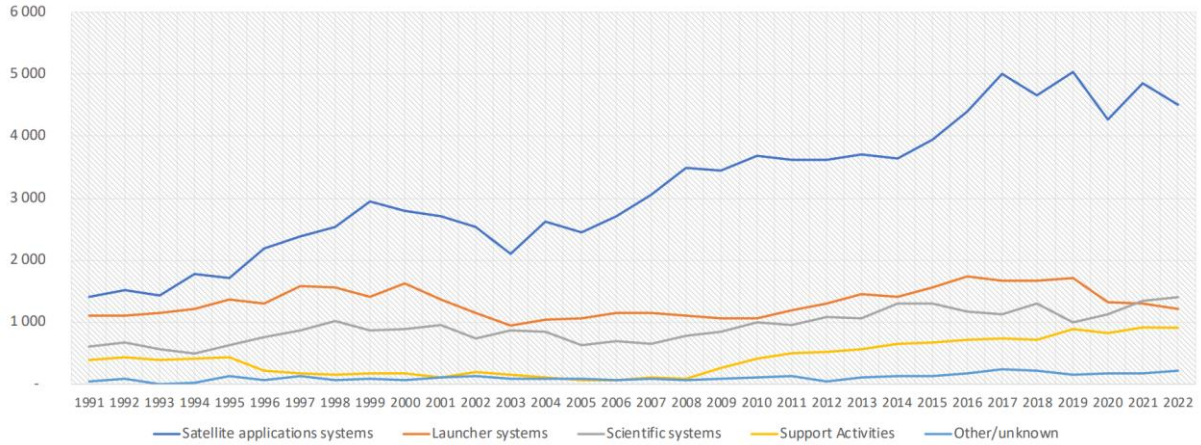


Figure 25: Sales by main market segment - type of system (M€) (Copyright by Eurospace - all right reserved, used with permission, reproduction forbidden)

Final sales - main product segment (M€)	2020	2021	2022	Variation
Launcher systems	1316	1338	1214	-6.8%
Satellite applications systems	3525	3959	3657	-8.0%
Scientific systems	1129	1341	1403	4.2%
Ground systems and services	1567	1806	1750	-3.1%
Other & Unknown	183	175	232	32.3%

Table 15: Final sales by main product segment (M€)

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3.4.2 European GNSS and EO sector

In the latest edition of the **EO & GNSS Market Report 2023, the European Union Agency for the Space Programme (EUSPA)** emphasises the growth of the EO and GNSS markets and how these industries contribute to innovation.

Earth Observation (EO)

According to the report, the EO global market turnover will grow from €3.4 billion in 2023 to €6 billion in 2033. The sales of this market mainly come from EO value-added services, amounting to €2.8 billion in 2023 and €5 billion in 2033.

Currently, almost half of global revenues (45%) come from the top three market segments: Climate, Environment and Biodiversity (22%), Urban Development and Cultural Heritage (13%) and Energy and Raw Materials (10%).

The forecasts suggest that the growth of EO data and services revenues is due to different drivers in different segments, but it is important to note that, unlike the other segments, we don't yet have information on the use of EO data in the insurance and finance segment with an analogous level of accuracy and update frequency.

Distributing the revenues of the EO market according to the companies' headquarters, in 2021 over 87% of the global market was concentrated in Europe and the U.S., with 44% and 43%, respectively. This represents an increase of 4% from the previously estimated 83% share of the global market in 2019 by these two players. On the other hand, in 2021, China had 6%, Canada 3%, and Japan 2%.

Among the categories comprising the industry's value chain, Europe is particularly prevalent in the global Analysis, Insights, and Decision market, with 50% of the global market share. Moreover, Europe's leadership in the Analysis market translates into a share above 80% in Aviation and Drones as well as in the Insurance and Finance segments of the market.

	2023		2033	
	EU27	Share of World	EU27	Share of World
Data revenues (€)	100 million	17%	195 million	20%
Value-added service revenues (€)	415 million	15%	760 million	15%

Table 161: EU27 EO market demand in 2023 and forecast in 2033 (Source: EUSPA)

Global Navigation Satellite Systems (GNSS)

According to the report, the global GNSS market was worth €260 billion in 2023, with an installed base of GNSS devices of 5.6 billion units worldwide. It is projected that this value will more than double over the next decade with annual revenues reaching €580 billion by 2033 for an installed base of 9.0 billion units.

The growing installed base is driven mainly by the Consumer Solutions, Tourism and Health segments, as between 2023 and 2033 approx. 90% of the GNSS receivers will be bought as smartphones and other devices.

In terms of revenues, the majority of the GNSS downstream market proceeds stem from services, which are comprised of added-value services and augmentation services. Accordingly, in 2023, its revenues are projected to increase to €463 billion in 2033, representing almost 80% of the market.

Particularly regarding added-value services, it constitutes the largest portion of the revenues. Accordingly, this industry is the main driver of the growth of the global GNSS market revenues. Due to a widespread digitalisation of daily-life activities, also revenues from smartphone apps are a relevant component of over 60% of added-value services and over 40% of total revenues.

From a geographical standpoint, the global market is concentrated mainly in companies with headquarters in the U.S. and Europe. In 2021, they represented 31% and 24% of the revenues, respectively. Still, the share of the European industry in the global market shrunk by 3%, from 27% in 2017 to 24% in 2021. On the other hand, the U.S. continues to lead the global GNSS market, having increased its share of revenues from 28% in 2017 to 31% in 2021.

This continues a trend highlighted in the previous 2022 GNSS market report, which highlighted a widening gap between the European and American industries. Moreover, Japanese, Chinese and South Korean companies accounted for 31% of the global market in 2021.

Regarding market segments, the ones where the European industry holds a larger share are Insurance and Finance (70%), Maritime (45%) and Fisheries (45%). In contrast, the European industry had a smaller market share in Forestry (15%), Urban Development and Cultural Heritage (5%) and Consumer Solutions, Tourism and Health (5%).

	2023		2033	
	EU27	Share of World	EU27	Share of World
Devices revenues (€)	16 billion	23%	27 billion	23%
Services Revenues (€)	32 billion	17%	54 billion	12%

Table 17: EU27 GNSS market demand in 2023 and forecast in 2033 (Source: EUSPA)

Many other key statistics are publicly available in the EO & GNSS Market Report.

3.5 Global Private Space Investment

In 2021 the ESPI Investment Database was expanded to cover global investment in space start-ups since 2019. In similar fashion to European deals, information on foreign deals is sourced from a combination of online public resources, financial databases such as Crunchbase and Pitchbook and private information sources. All deals are reported in euros using World Bank exchange rates averaged on a monthly basis.

For the purposes of ESPI's analyses on private investment, a space company is defined as a company providing analytics originating primarily from space-based systems, or manufacturing ground and or upstream equipment and provides services that rely on such systems.

To provide comparable metrics with already established sources such as BryceTech and Seraphim capital, ESPI uses a **broader "New Space" perimeter in the context of global private investment** compared to its detailed analysis of the European landscape, and therefore features a less stringent definition of "start-ups", broadly speaking, meaning a company that has received venture capital investment

3.5.1 Global investment dynamics

Global investment in space ventures in 2023 totalled **€6 billion**, which represents a **32% decline from the previous year's peak of €8 billion**. Moreover, comparing with the peak of €12.3 billion reached in 2021, it represents a drop of 51%. However, it is important to note that 2021 was an exceptional year and should be seen as an outlier. The difference in volume between 2021 and 2023 can **largely be attributed to the SPAC boom/bust phenomenon and the decrease in VC funding**. Underpinning these dynamics are **significant geopolitical and macroeconomic changes**, further explored in ESPI's "Bridging the Financing Gap in the European Space Sector" report.[849]

Despite the year-on-year downturn, the industry has maintained a healthy growth rate of 3% CAGR since 2019. Furthermore, the number of deals increased from 272 in 2021 to 266 in 2023.

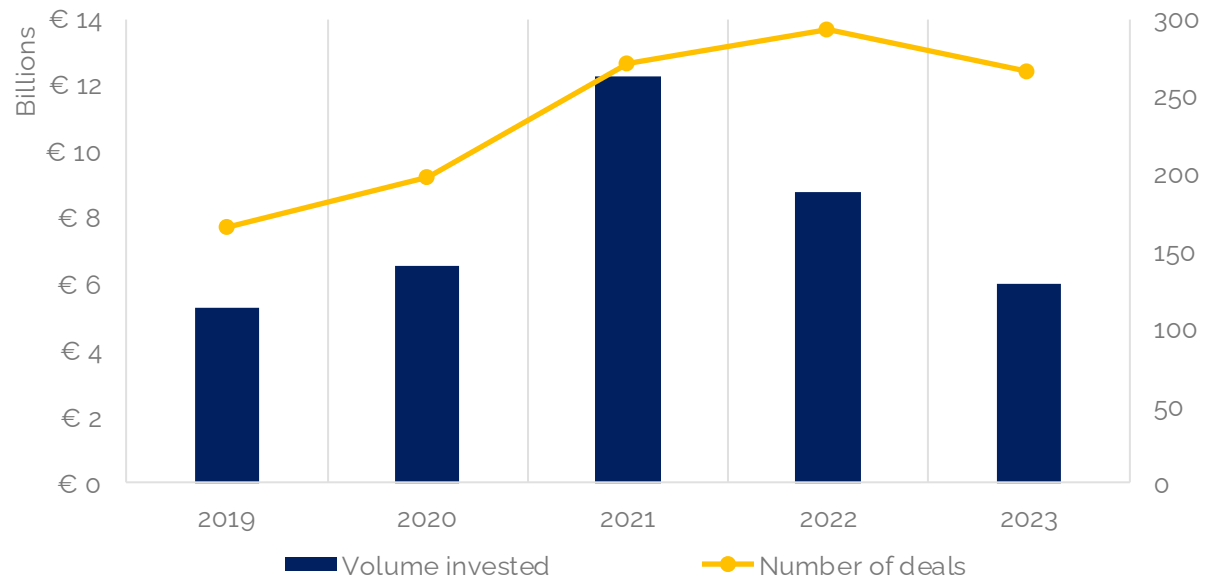


Figure 26: Global Investment & Deals

[849] Bridging the Financing Gap in the European Space Sector, ESPI, (link)

Venture Capital accounts for the largest share of private space startup financing worldwide. In 2019 this share was 45%, slightly decreasing in 2020 to 31%. Since 2021, its share has been increasing consistently, reaching a remarkable 71% of investment in 2023. The most notable difference between 2022 and 2023 is the absence of major acquisitions. This investment type accounted for €1.8 billion in 2022 and decreased to €43 million in 2023. The investment value of acquisitions is often not disclosed, but even when looking at number of recorded deals, 2023 saw only 20 deals, far less than the heights recorded in the previous year (39) and slightly under 2021 (22).

ESPI also accounts for the self-capitalization into Blue Origin from Jeff Bezos which is approximately $1 billion per year and is included as an "Angel" investment.

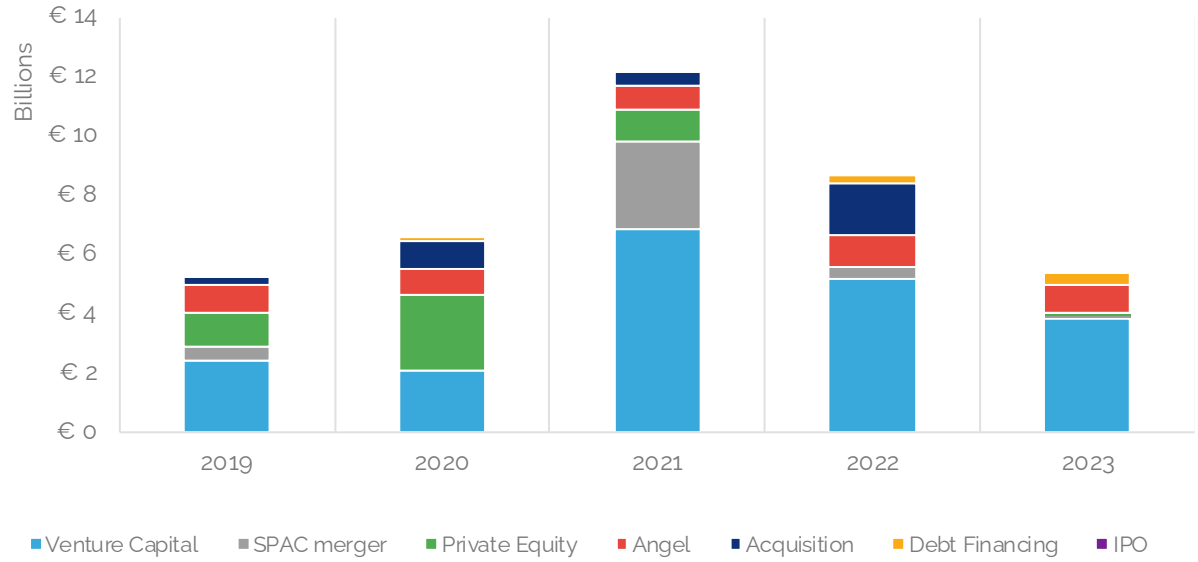
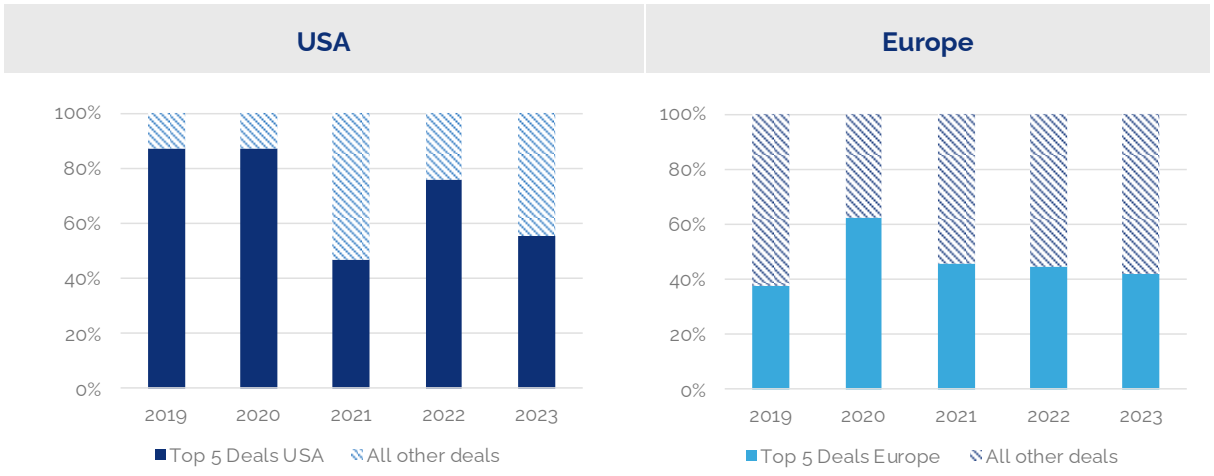


Figure 27: Investment type for global New Space ventures

Another interesting index to analyse is the share of the top five deals with regard to total investment. The fundraising environment in the USA is more concentrated in the top five deals, whose share has fluctuated since 2020, but nonetheless **represent on average 70% of the total raised in the country**. In Europe, this average is considerably lower are more stable, with the **top five deals only representing on average about 47% of the total since 2019.**



3.5.2 Global distribution of investment

The U.S. has historically been the most active country for New Space investment and ventures. Between 2019 and 2021 it experienced significant growth. Since then, investment has decreased significantly from a peak of €9 billion in 2021 to €3.2 billion in 2023, effectively returning to 2019 levels and leading to a **0% CAGR**.

Europe remains the second region attracting the most investment into New Space ventures. China has seen steady growth, with an increase of 63% between 2019 and 2023.

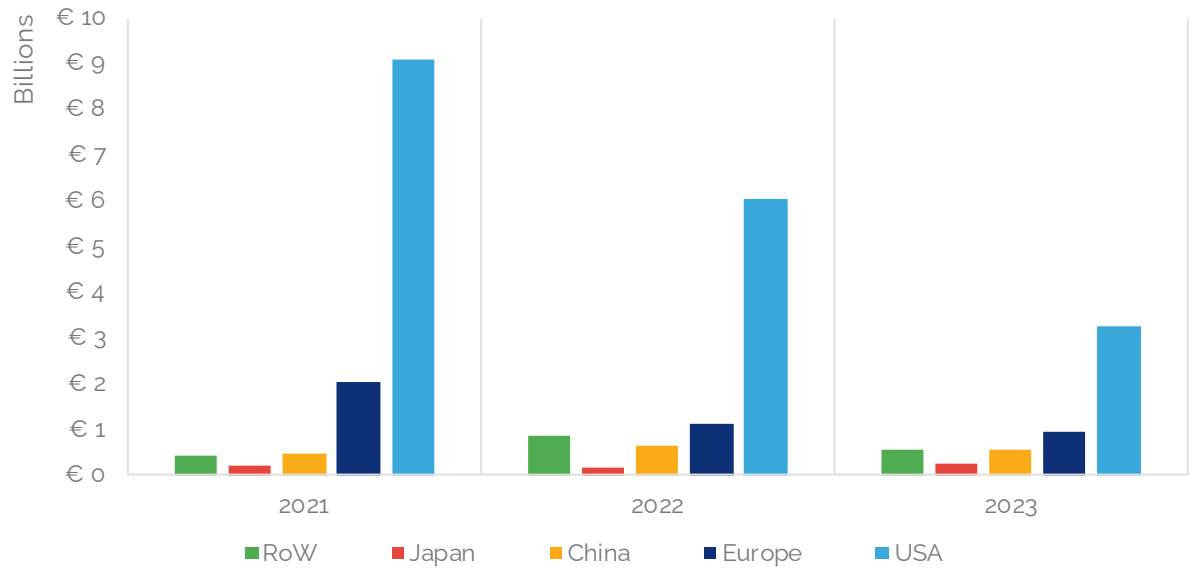


Figure 28: Investment volume per region

The biggest growth in investment over the past years has been seen throughout the rest of the world (RoW). Outside of the United States, European countries, China, and Japan, the total investment in space in the rest of the World has increased **€163 million in 2020 to €566 million in 2023** (majority originating from Canada, India, Israel and Australia). This represents an incredible **247%** growth over three years.

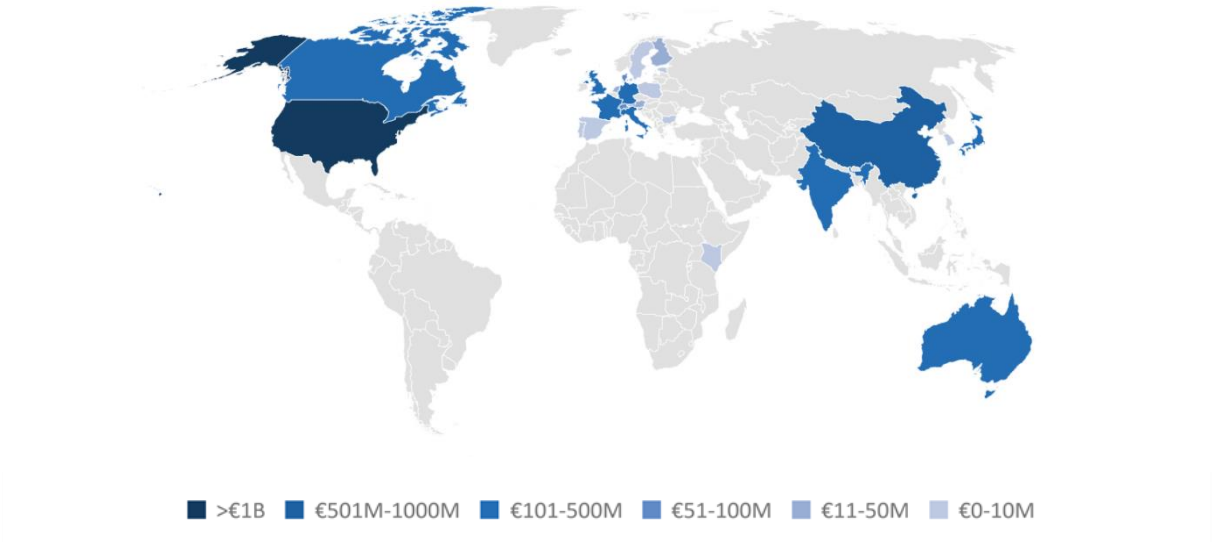


Figure 29: 2023 investment map

Europe has averaged 96 deals over the past 3 years compared to 114 for the U.S. As such, **while there is only a 16% difference in deal number between the EU and the U.S., there is a 78% difference in investment volume** between both regions (Europe has averaged €1.4 billion over 3 years as compared to €6.3 billion for the U.S.).

The U.S. saw 116 deals in 2023 for a total of €3.6 billion. This makes an average deal size of €31 million. In comparison, Europe saw a total of 83 deals totalling approx. €978 million, which makes an average deal size of €12 million. The size of certain US deals can affect this average significantly.

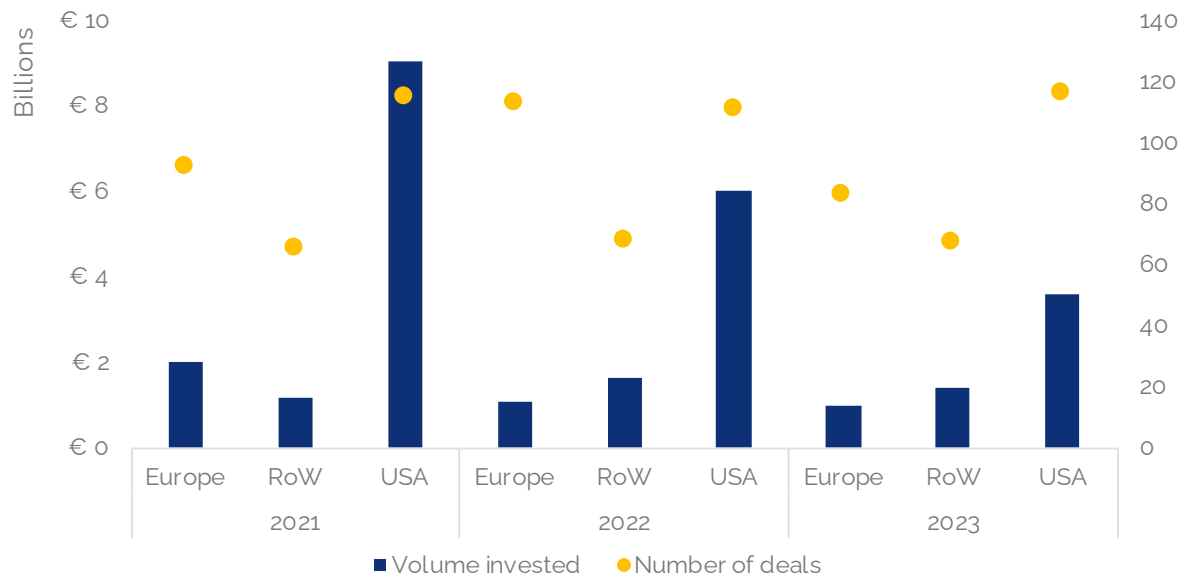


Figure 30: Volume and deals per region

4 LAUNCHES & SATELLITES

4.1 Global space activity evolution 2010-2023

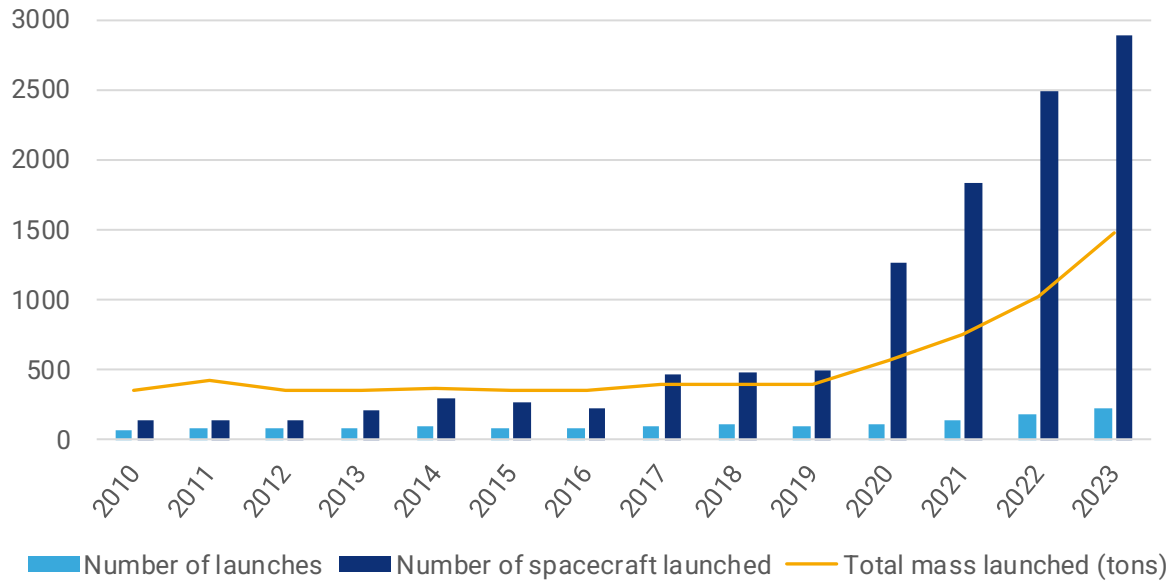


Figure 31: Evolution of launch activity over time (2010-2023)

Once again, the **global space activity broke all records in 2023** reaching new heights in terms of total mass, number of launches and number of spacecraft launched. With **221 launches being carried out** in the world, 2023 is a new landmark, **19%** higher than the previous one set in 2022 with 185 launches. Confirming the trend started in 2020, a new record high of **2889 satellites were launched** in a single year (**16% more** than in 2022). While the number of launches and spacecraft launched still rises significantly, a relative slowdown compared to the growth rates in 2022 (+28% launches and +35% spacecraft) can be observed. A large part of the activities in 2023 is caused by the launch of the Starlink connectivity constellation by SpaceX, and to a lesser extent OneWeb. As a result, the total mass launched also went up drastically, increasing from 1021 tonnes in 2022 to 1477 tonnes which translates to an increase of 45%. It is noteworthy that, as opposed to the relative slowdown in the growth of the number of launches and spacecraft**, the increase in mass is up almost 20 percentage points** compared to the growth between 2021 and 2022. This increase is largely attributed to SpaceX starting to launch its heavier Starlink V2 satellites. This deviates from previous years (2020-2022), where we observed the strongest rise in the number of spacecraft launched.

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Number of launches	92	87	86	91	114	103	114	144	185	221
Spacecraft launched	298	266	223	471	477	490	1266	1843	2491	2889
Mass launched (tonnes)	363	360	359	401	389	385	564	756	1021	1477

Table 18: Evolution of launch activity over time (2014-2023)

4.1.1 Launch activity evolution by country

The evolution of activities in top space launch countries (United States, China Russia, Europe,) shows very different profiles. Furthermore, it has to be noted that **India (7 launches) surpassed Europe (4 launches) for the first time in 2023.**

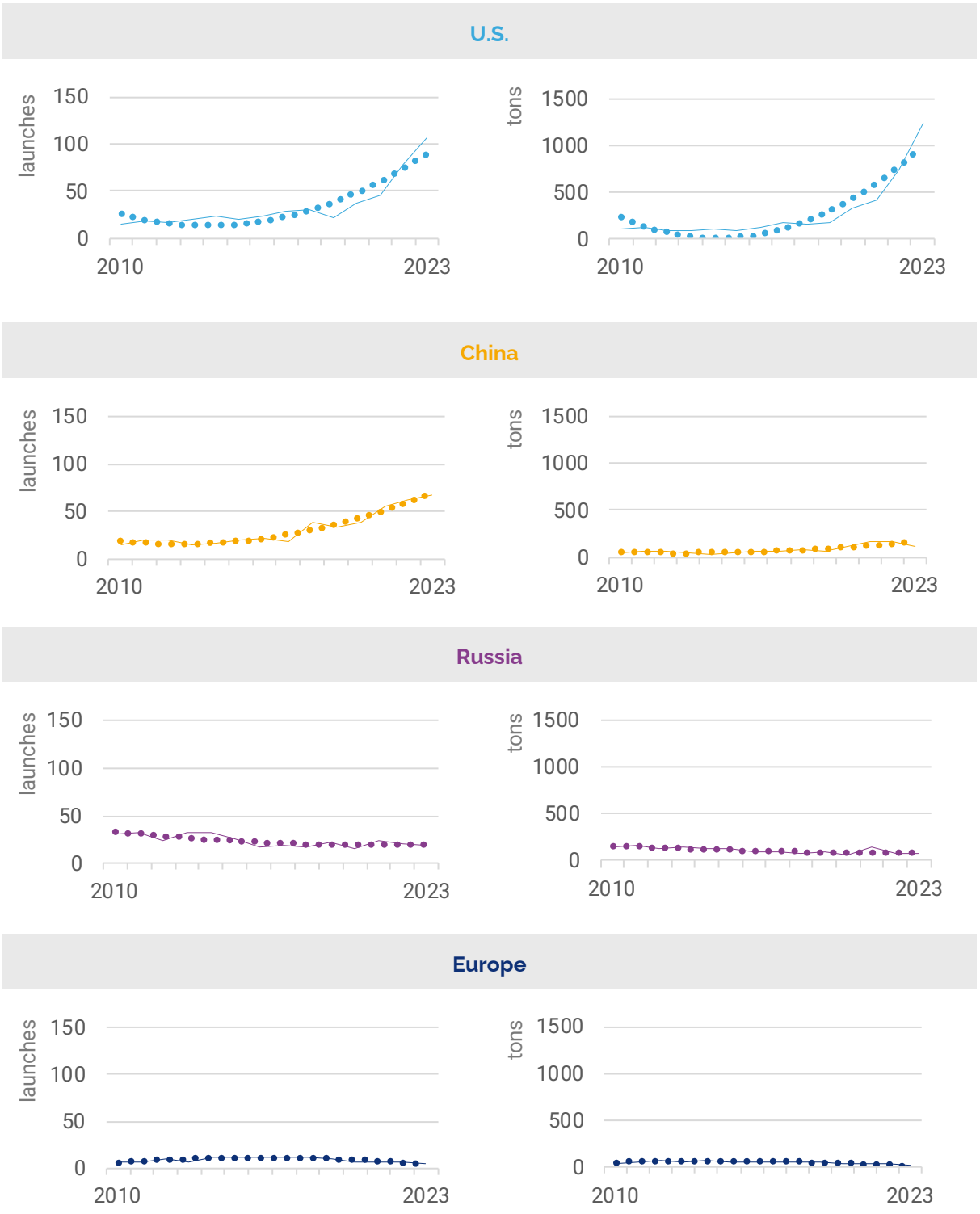


Figure 326: Evolution of the number of launches (left) and total mass launched (in tons, right) per country (2010-2023), with trendline

- **United States:** U.S. activity is experiencing steep growth, which continued through 2023 (107 launches). This trend is largely driven by a single launch service provider, SpaceX, its Starlink constellation, and by the capacity to service the ISS, for both cargo and crew missions. **The role of SpaceX in the increase of 2020-2023 is predominant (80% of the U.S. launches and almost one-third of the total number of launches over the three years).** The rollout of the Starlink constellation is a major driver behind this high level of launches, representing 62% of SpaceX launches in the period.
- **China:** the Chinese launch activity has skyrocketed since 2010 and China has now become a serious contender in terms of the number of launches (67 in 2023). While the institutional launch service provider CASC remains the dominant actor, 2023 also saw a diversification of Chinese launch service providers including commercial actors. However, the strong growth in institutional demand from Chinese authorities remains the main driver, as almost all payloads launched by China are domestic and **almost 90% of the mass is launched for governmental actors** (civil and military).
- **Russia:** along with the rest of its space sector, the launch activity of the historical (co)leader has experienced a steady decrease over time, both in the number of launches and mass launched. This **decrease continued in 2023 with only 19 launches**. Mass launched has also been decreasing over the past years, although a small peak was reached in 2021 (138 tons put in orbit). This increase was due to the launch of two modules for the International Space Station. In 2023, the total mass launched decreased to 73 tons, again resembling a steady decrease over time.
- **Europe:** similar to Russia**, launch activity in Europe is also decreasing**. While in the period of 2015-2019, Europe on average conducted 11 launches per year, this number fell to only 6 launches in the 2020-2023 timeframe. In 2023, only 4 launches were conducted from European soil, which is the lowest number since 2004.

Summarising recent shifts in the landscape of launch activity, Table 19 below compares the top launch service providers from the 2015-2019 and 2020-2023 timeframes by their share of launch activity.

2015-2019			2020-2023		
Top 10	**Country/ region**	**% of launches**	**Top 10**	**Country/ region**	**% of launches**
CASC	China	26%	SpaceX	US	32%
SpaceX	US	14%	CASC	China	27%
Starsem	**Europe/Russia**	**13%**	Roscosmos	Russia	7%
Arianespace	**Europe**	**11%**	**Arianespace**	**Europe**	**5%**
ULA	US	9%	Rocket Lab	US	5%
Antrix	India	5%	RAF	Russia	5%
MHI	Japan	4%	ULA	US	3%
Roscosmos	Russia	3%	ExPace	China	3%
ILS	Russia/US	2%	ISRO	India	2%
Rocket Lab	US	2%	Galactic Energy	China	2%
Total		**89%**	**Total**		**91%**

Table 19: Share of launches by service provider 2015-2019 vs. 2020-2023

Furthermore, it can be noted that in the 2015-2019 timeframe 16% of spacecraft for European customers have been launched by European launch service providers, this number decreased in 2020-2023, only accounting for 5.4%.

4.1.2 Spacecraft orbit and mass

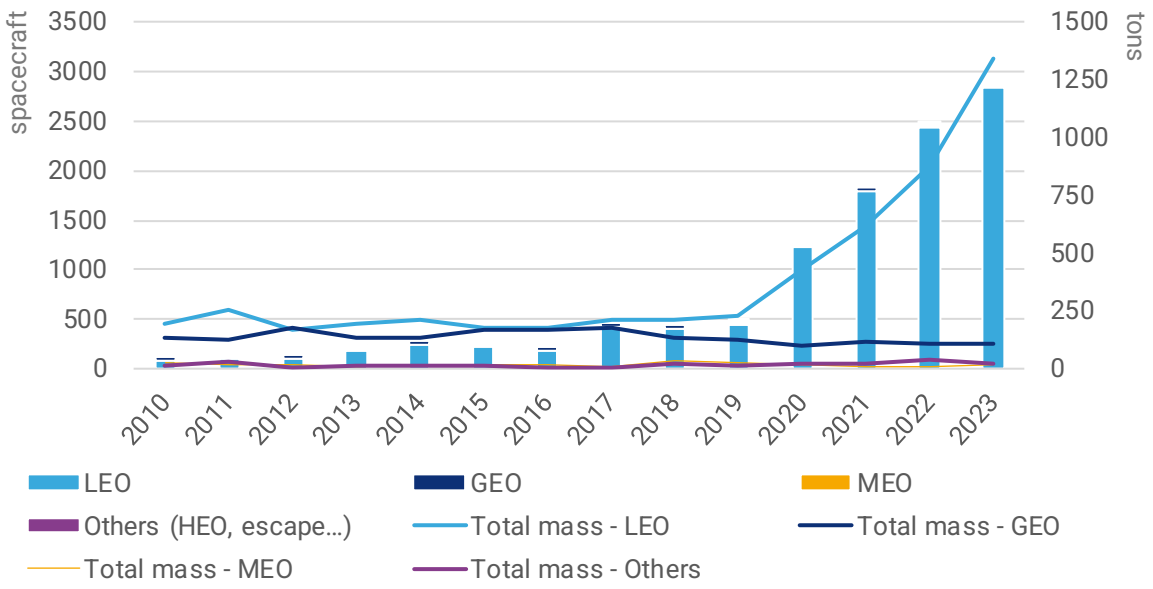


Figure 327: Evolution of the number and mass of spacecraft launched per orbit (2010-2023)

From 2020 onwards, LEO dominates both the number of spacecraft launched as well as the overall mass to orbit. This remains true even when excluding human spaceflight activities, which traditionally accrue more mass and could bias the calculations. Traditionally (pre-2020), this orbit used to dominate "only" in terms of number of spacecraft. However, **the predominance of LEO spacecraft in terms of number is not fully mirrored when focusing on the mass launched**. While spacecraft launched to LEO accounted for 97.8% of all spacecraft in 2020-2023, they represented 82% of the total mass sent to orbit (excluding human spaceflight activities). In comparison, spacecraft launched to GEO (mostly telecommunication satellites) accounted for only 1.6% of all spacecraft launched but 16% of the total mass (when excluding human spaceflight activities). This latter share is nonetheless decreasing as well, due to the quick absolute and relative growth of LEO activities.

Over the past ten years, the number of satellites launched to GEO has remained rather stable, with a maximum of 45 in 2014 and a minimum of 24 in 2020. In line with this trend, **32 satellites were launched to geostationary orbit in 2023.** By contrast, an overwhelming majority of satellites are deployed in LEO, mainly due to the launch of small spacecraft in the context of large constellations (for telecommunication or Earth observation). During the period 2017-2019, LEO was the destination of 88% of all satellites launched but, in 2020-2023, this rate reached 97.8%. This remarkable increase is mostly due to the launch of Starlink (and to a lesser extend OneWeb) satellites; yet, even when excluding them, still 92% of all spacecraft launched in 2020-2023 were for LEO.

Other orbits such as MEO, HEO or escape are negligible in comparison (only 16 spacecraft combined in 2023). Activity in MEO remains to be limited in the 2020-2023 period with on average 5.5 spacecraft. This is especially pronounced compared to 2018 (31 spacecraft) and 2019 (16 spacecraft), which saw record numbers. The completion of GNSS constellations (e.g. Galileo, Beidou) and the development of LEO satcom constellations may explain the low numbers of spacecraft launched to MEO since 2020.

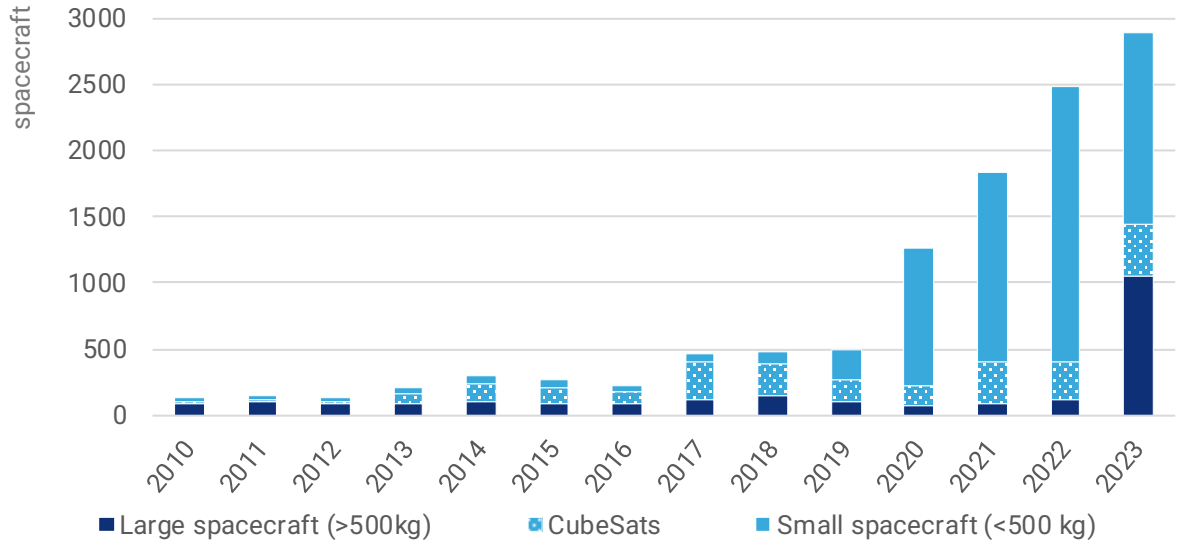


Figure 34: Evolution of the number of spacecraft launched per mass category (2010-2023)

Since 2019, small spacecraft (below 500 kg) have been the dominant type of system launched. In 2022, small spacecraft represented 20 times the number of large spacecraft. This was mostly linked to the rise in the number of Starlink version 1 & 1.5 satellites since 2020.

However, while small spacecraft remain the dominant type of system, their share significantly reduced in 2023, only accounting for 50% of spacecraft launched. At the same time, the number of large spacecraft almost multiplied by ten, growing from 118 in 2022 to 1056 in 2023. Again, these developments are mostly caused by SpaceX, which switched to launching the heavier Starlink V2 satellites (800 kg vs 295 kg for V1.5) in the second quarter of 2023.

Figure 35 below, exemplifies this even further, showcasing that the increase in large spacecraft is entirely due to the rise of medium-class satellites (500-2000 kg), with the number of heavy class (2000-8000 kg) and extra heavy class (over 8000 kg) spacecraft being stationary.

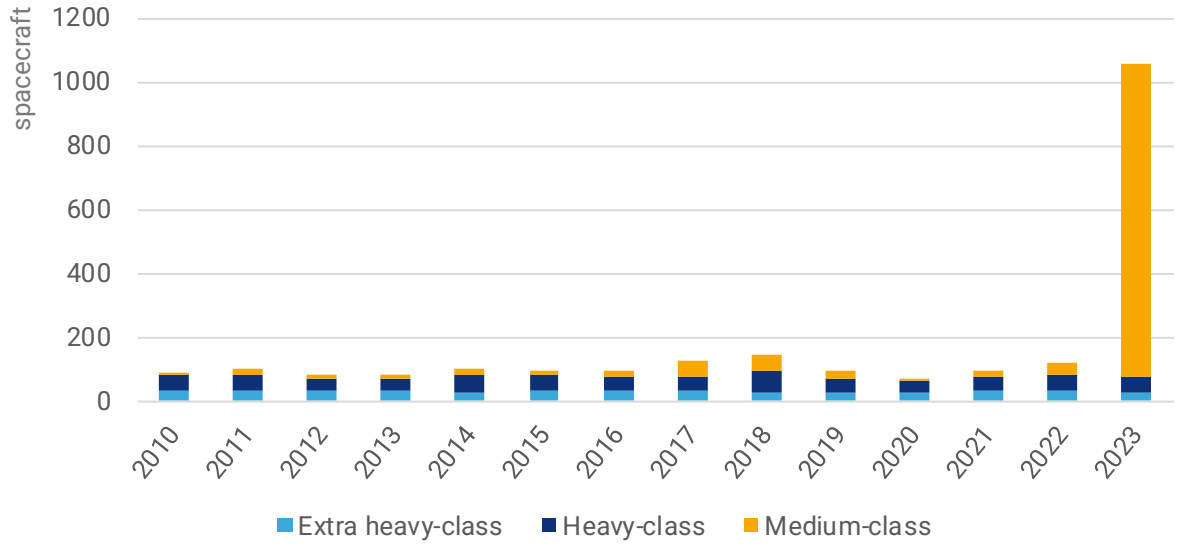


Figure 35: Evolution of the number of large spacecraft launched per mass category (2010-2023)

4.1.3 Space missions and markets

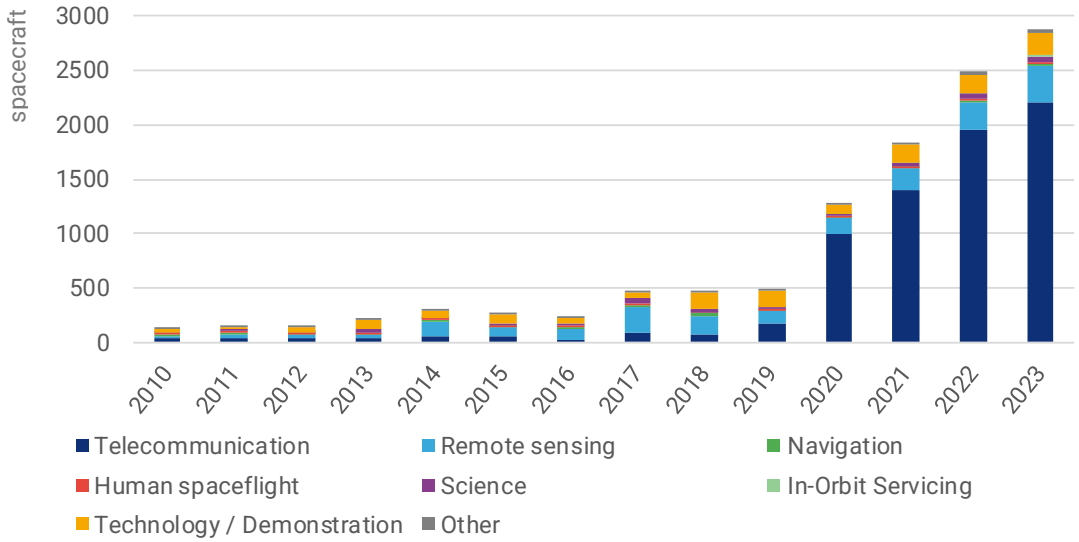


Figure 36: Evolution of the number of spacecraft launched, per mission (2010-2023)

In the past four years, the majority of spacecraft have been launched for telecommunication missions. While traditionally heavy GEO satcom accounted for the bulk of this mass, years 2020-2023 saw a switch to small spacecraft in LEO. The large majority of satcom spacecraft is also launched to LEO in 2023 (99%). However, due to the aforementioned switch to Starlink V2, a large chunk of those LEO telecom satellites have been large spacecraft (43.2%).

Overall, **telecommunication spacecraft account for 77.6% of the total mass launched in 2023** (while this share was 60.6% in 2022), compared to 10.2% for human spaceflight and 6.8% for remote sensing. The share of technology/demonstration spacecraft represents 2.3% of the total mass launched in 2023. **Telecommunication applications increasingly dominate the use of space**, with all other major application types losing shares to the former.

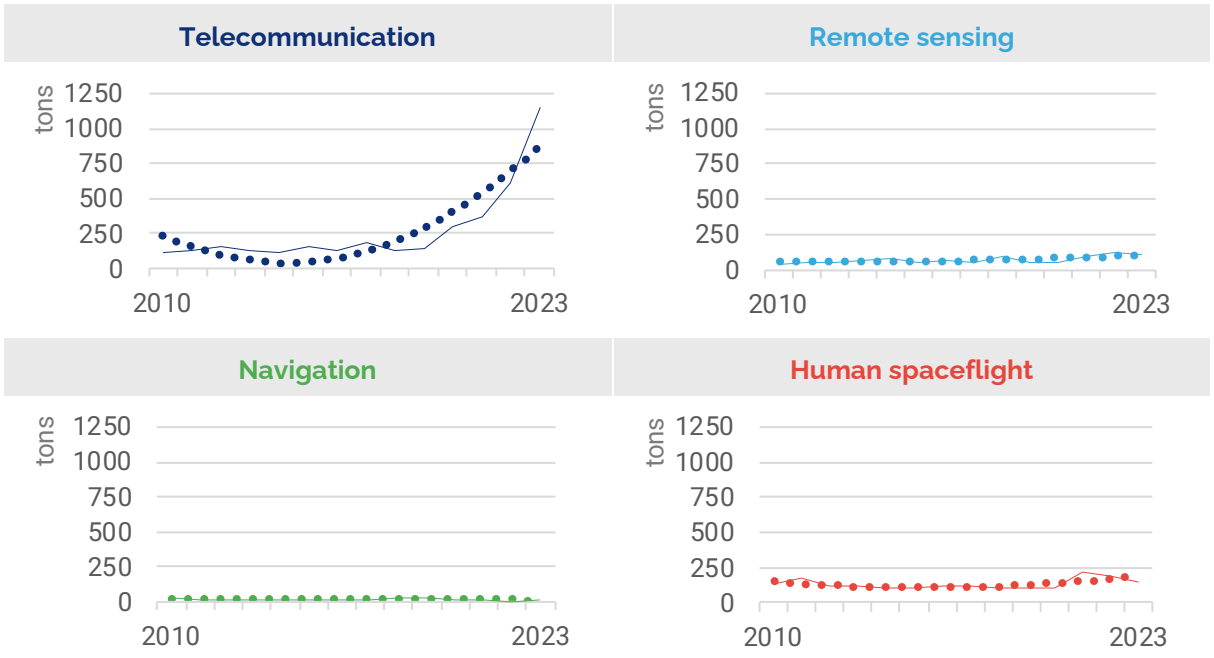


Figure 328: Evolution of the total mass launched (in tons) per mission (2010-2023) with trendline

Telecommunication is the main type of mission contributing to the total mass launched. The high number of telecommunication satellites launched in recent years is mostly due to the launch of constellations, in particular Starlink. From 2010 onwards, the total mass launched for telecommunication missions has increased and 130 to 150 tons in average were launched every year until 2019. While new record highs of 300 tons (2020), 375 tons (2021) and 620 tons (2022) were achieved, **2023 outweighs them with more than 1140 tons launched for telecommunication applications**. After a strong increase in the mass of remote sensing between 2020 and 2021 (from 47 to 99 tons), numbers remain stable since 2021 with an average of 105 tons for 2021-2023.

The number of **technology/demonstration satellites continues to increase since 2017, reaching a record number of 207 spacecraft in 2023**. A noticeable outlier is the year 2020, which can be attributed to the start of the Covid-19 pandemic, which caused a halt to many projects in development. From 2021 to 2023 demonstration or technology missions represented 7.4% of all spacecraft launched (26.2% without Starlink and OneWeb).

Finally, the number of **human spaceflight missions, mostly comprising the servicing of the ISS and Tiangong**, remained rather steady with 12 to 20 missions per year. However, the past years have seen a slight increase for this category, with on average 20 launches in 2021-2023, which can be explained by the establishment and servicing of the Chinese Tiangong space station as well as private missions to the ISS conducted by Axiom Space. Corresponding to the number of launches, the mass of human spaceflight missions has increased as well in those years but on a more significant level. 2021 marks a record year, as more than 200 tons were launched for human spaceflight activities. Since then, the mass is decreasing with 195 tons in 2022 and 150 in 2023 but remain far above the pre-2021 period. This is in large parts due to the delivery of the Tiangong space station modules to LEO in 2021 and 2022.

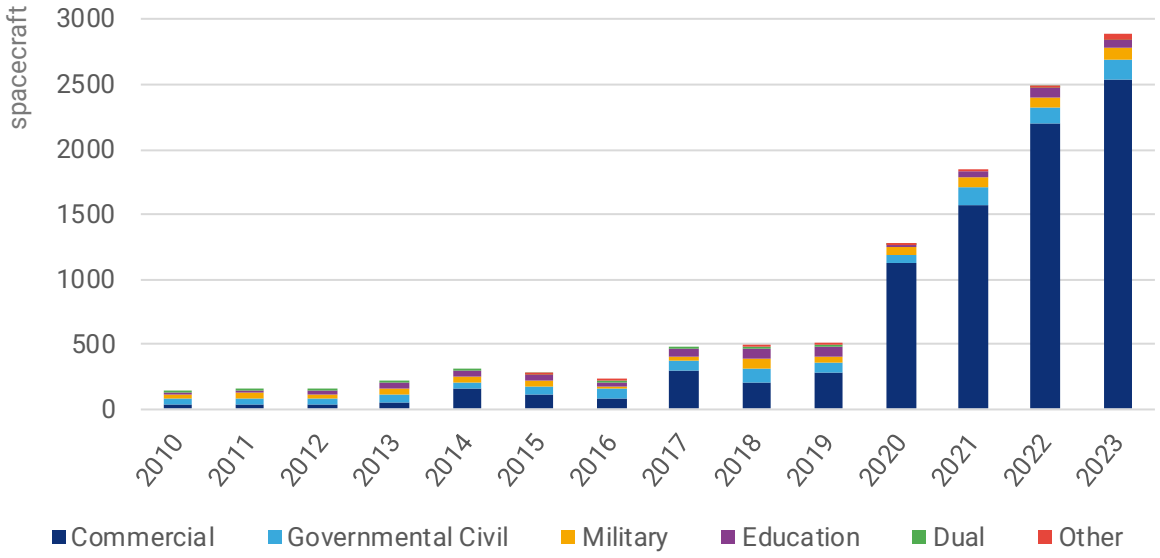


Figure 38: Evolution of the number of spacecraft launched per market (2010-2023)

The data showcases that **the year 2020 marks a change of scale, continued in the years 2021-2023.** While more than 200 spacecraft were launched each year to provide commercial services between 2017 and 2019, representing between 40% and 60% of the total number of satellites launched, 1120 commercial satellites were launched in 2020, 1576 in 2021 and 2196 in 2022 (that is, on average over the three years, 87.4% of all spacecraft).

In 2023, 2543 commercial spacecraft were launched, that is, 88% of all satellites sent to orbit that year. Even with Starlink and OneWeb satellites excluded from the calculation, commercial

satellites still account for 55.6% of the spacecraft launched in 2020-2023. The total mass of commercial satellites also grew over time, this mass being multiplied by almost 10 between 2019 and 2023 and undergoing an increase of 81% only between 2022 and 2023. In 2023, commercial satellites accounted for 78.5% of mass. These figures illustrate the growing momentum in commercial space activities and the emergence of new entrants, services, and markets.

While traditionally making up a large share of the mass, spacecraft used for institutional purposes (civil and military), have increasingly been relegated to smaller shares of the overall mass launched to space. Between 2015 and 2019 civil and military markets accounted for two-thirds of launched mass, this share significantly decreased to an average of 44.4% in the period between 2020 and 2022. In line with this trend, **2023 marks a record low as only 21.3% of the mass launched served institutional actors.** This trend is even more visible when investigating the number of spacecraft launched in a given year. While in 2019, institutional markets represented 25.3% of spacecraft launched, this share shrunk to just 8.4% in 2023. However, it has to be noted, that even when institutional markets lose relative shares in terms of the number of spacecraft and mass, both indicators steadily increase in absolute numbers. The **number of spacecraft launches for institutional customers doubled between 2019 and 2023**, indicating a growing interest of government-affiliated actors in space, which is nevertheless outpaced by the rise of commercial interest as displayed above. Furthermore, many commercial solutions being launched target institutional markets for selling space-based services.

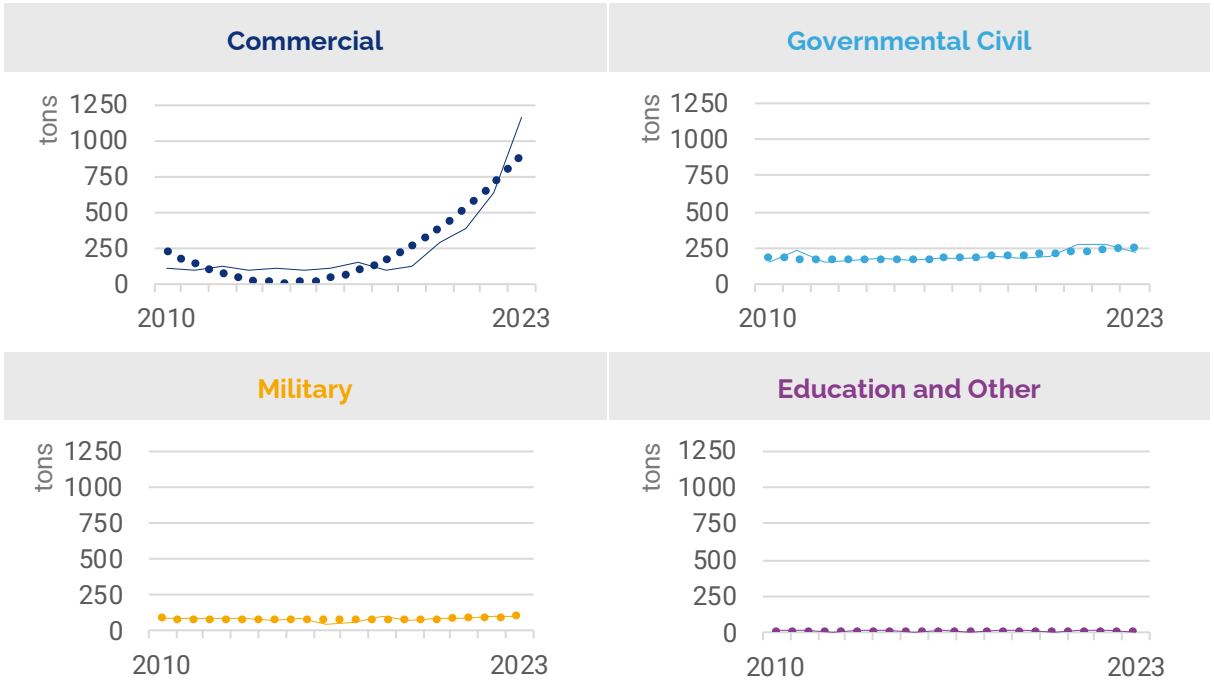


Figure 3929: Evolution of total mass launched (in tons) per market (2010-2023) with trendline

4.1.4 Spacecraft manufacturing and procurement by country

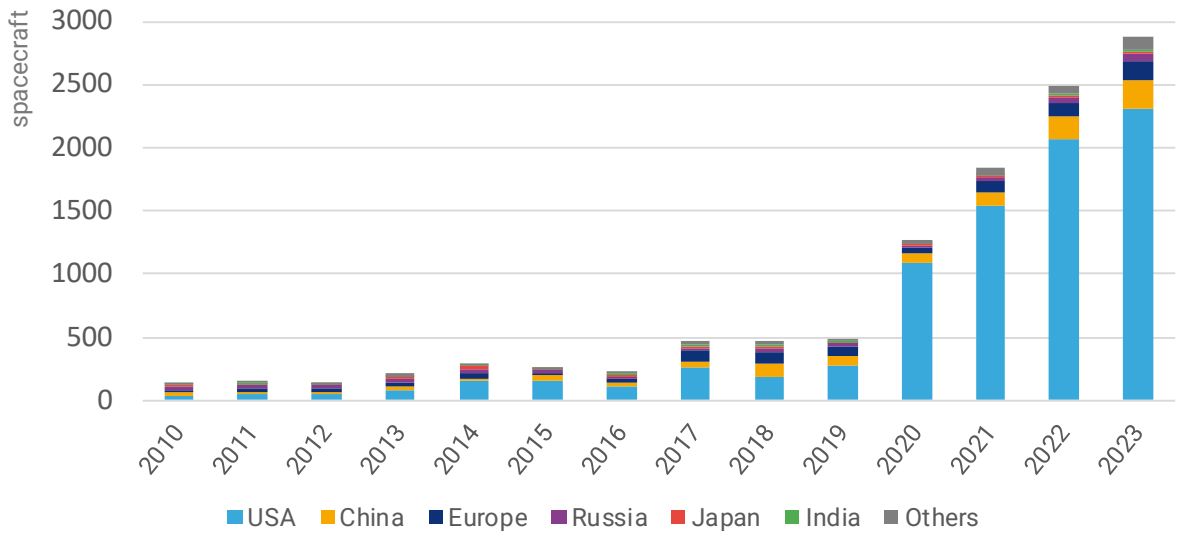


Figure 40: Evolution of the number of spacecraft per manufacturing country (2010-2023)

The **manufacturing activity in the United States sharply increased over the last decade**. Between 2017 and 2019, 51% of all spacecraft launched worldwide were integrated in the U.S., corresponding to 38% of the total mass. **In 2020-2023, these shares respectively reached 82.6% and 71.9%,** again largely boosted by SpaceX/Starlink (and to a lesser extend OneWeb).[850]

Spacecraft manufacturing in China also experienced a massive growth in absolute numbers, almost tripling the number of spacecraft manufactured between 2019 and 2023. However, **while China's growth in absolute number of spacecraft and mass in recent years has been significant, it gets dwarfed by the developments in the U.S.**, especially due to SpaceX. Since the first launch of the LEO satcom constellation in 2019, China's share is steadily decreasing. Its space activity amounts to 7% of spacecraft launched in 2023 (down from 21% in 2018) and 8% of the total mass (down from 18% in 2018).

The activity of Russia remained stable for many years with even a slight decrease in total mass. A vast majority of its output concerns human spaceflight vehicles (Soyuz, Progress) and military applications, especially since 2022. Yet, the surge in the number of spacecraft launched which appeared in 2022 continued in 2023. As in the previous year this trend was driven by CubeSats manufactured and launched for commercial or educational entities.

European output, measured in number of spacecraft and total mass, is declining both in absolute and relative metrics. In the period 2017-2019, Europe manufactured 18% of all spacecraft put in orbit and accounted for about 17% of the mass launched. This downward trend started in 2020-2022 with Europe accounting for 4% of spacecraft and 4.4% of mass launched. In 2023 the respective metrics represent 5.4% of spacecraft and 3.1% of mass.

[850] OneWeb spacecraft are produced by OneWeb Satellites, a joint venture between OneWeb and Airbus. Although these two companies are European, the main production line for its first generation of satellites was located in Florida, hence ESPI considers the satellites as a U.S. output.

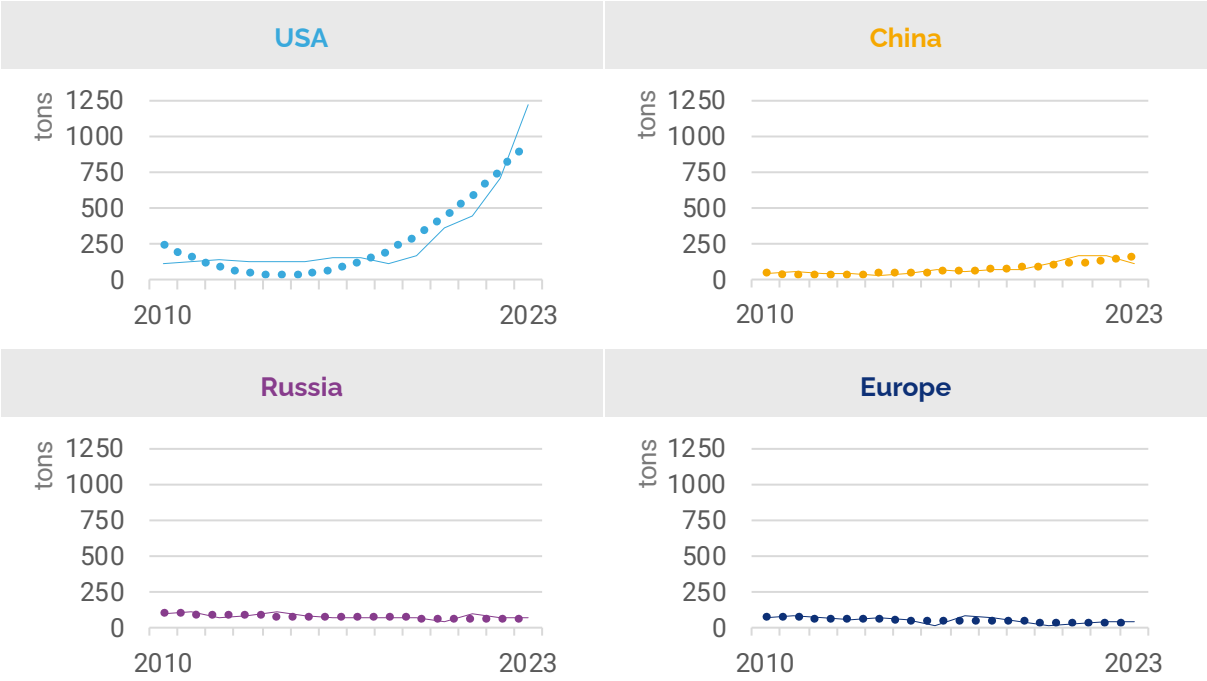


Figure 30: Evolution of spacecraft mass (in tons) per manufacturing country (2010-2023) with trendline

With the popularisation of the CubeSat standard, a growing number of countries and organisations have already developed a spacecraft. Since 2018, more than 540 organisations have produced a satellite, including agencies, governmental bodies, universities, research institutes and others. Nevertheless, **the spacecraft manufacturing activity is still highly concentrated in a few countries but also in a few organisations. Over the last 5 years, the top 10 manufacturers produced 80% of the total mass put in orbit.**

This concentration is even more visible in the commercial market (mostly for telecommunications). A few companies and organisations compete on the international commercial satellite market and capture most of the related activity. **The top 10 manufacturers produced 95% of commercial satellite mass during the period 2015-2019 and even 97.8% in 2020-2023.** U.S. companies, including Boeing, Northrop Grumman, Maxar Technologies and, above all, SpaceX, are the main actors on the market followed by Chinese actors (CAST and Chang Guang) as well as the two traditional European OEMs **Thales Alenia Space** and **Airbus**.

SpaceX manufactured and put into orbit 1943 operational Starlink satellites in 2023, breaking its previous record of 1727 in 2022. **The company alone was responsible for 84.1% of the mass manufactured in 2023.** giving way to one of the first large-scale fully vertically integrated activities: the company is the manufacturer, operator and launch service provider of its constellation. In parallel, the deployment of OneWeb's constellation allowed this company to quickly become one of the leading actors in terms of mass launched in the 2020-2023 timeframe.

2015-2019			2020-2023		
Top 10	**Country/region**	**% commercial mass**	**Top 10**	**Country/region**	**% commercial mass**
SSL/Maxar	US	26.1%	SpaceX	US	84.1%
TAS	**Europe**	**19.9%**	OneWeb Satellites	US	3.8%
Boeing	US	15.1%	Maxar	US	2.3%
Airbus	**Europe**	**12.8%**	CAST	China	2.0%
CASC	China	6.8%	**TAS**	**Europe**	**1.8%**
SpaceX	US	5.5%	**Airbus**	**Europe**	**1.7%**
Orbital ATK/NG	US	3.4%	Boeing	US	0.8%
Lockheed Martin	US	2.7%	Northrop Grumman	US	0.7%
Mitsubishi Electric	Japan	1.8%	ISS Reshetnev	Russia	0.4%
NEC	Japan	0.9%	Chang Guang	China	0.4%
Total		95%	Total		97.8%

Table 20: Share of the mass launched (in tons) for the commercial market by the top 10 manufacturers

European companies Airbus and Thales Alenia Space, which used to be in a market-leading position, have been relegated to smaller shares, in particular due to difficulties on the GEO satcom market as well as the dynamics of the US market. In the period 2015-2019, the two European companies delivered 32.7% of the mass of commercial satellites. **However, in 2020-2023, they delivered only 3.5% of the mass launched (excluding the satellites produced by OneWeb Satellites).**

The commercial activity of the China Aerospace Science and Technology Corporation (CASC), including through its subsidiaries (for example CAST), remains rather limited because of difficulties to enter large segments of the market, for example due to export control restrictions.

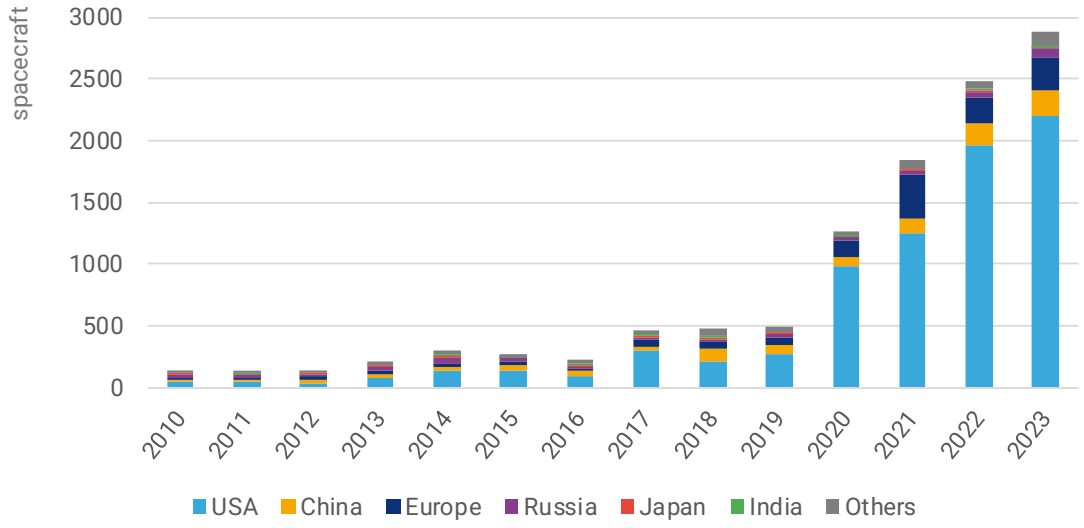


Figure 31: Evolution of the number of spacecraft per procuring country (2010-2023)

A large majority of spacecraft is procured domestically. For this reason, the distribution of spacecraft per manufacturing and procuring country is almost identical, with a slight variation related to import/export of commercial satellites. This is the case both for the number of spacecraft and the corresponding mass. As a result, it is not surprising that most of the spacecraft launched during a year are also procured by U.S. organisations and companies. During the period 2017-2019, 55% of spacecraft launched worldwide were for U.S. customers, corresponding to 36% of the total mass. **This share reached 75% of spacecraft and 70% of the total mass launched in 2020-2023**.

In China, a significant share of the activity serves domestic needs. Therefore, China's growth comes primarily from an increase of public investment in space. The number and mass of satellites ordered by Chinese organisations and operators has multiplied by more than 10 since 2000, exceeding 116 tons in 2023. 2021 (163 tons) and 2022 (171 tons) have been outliers because of the launch of the Tiangong space station modules, which took place during these years.

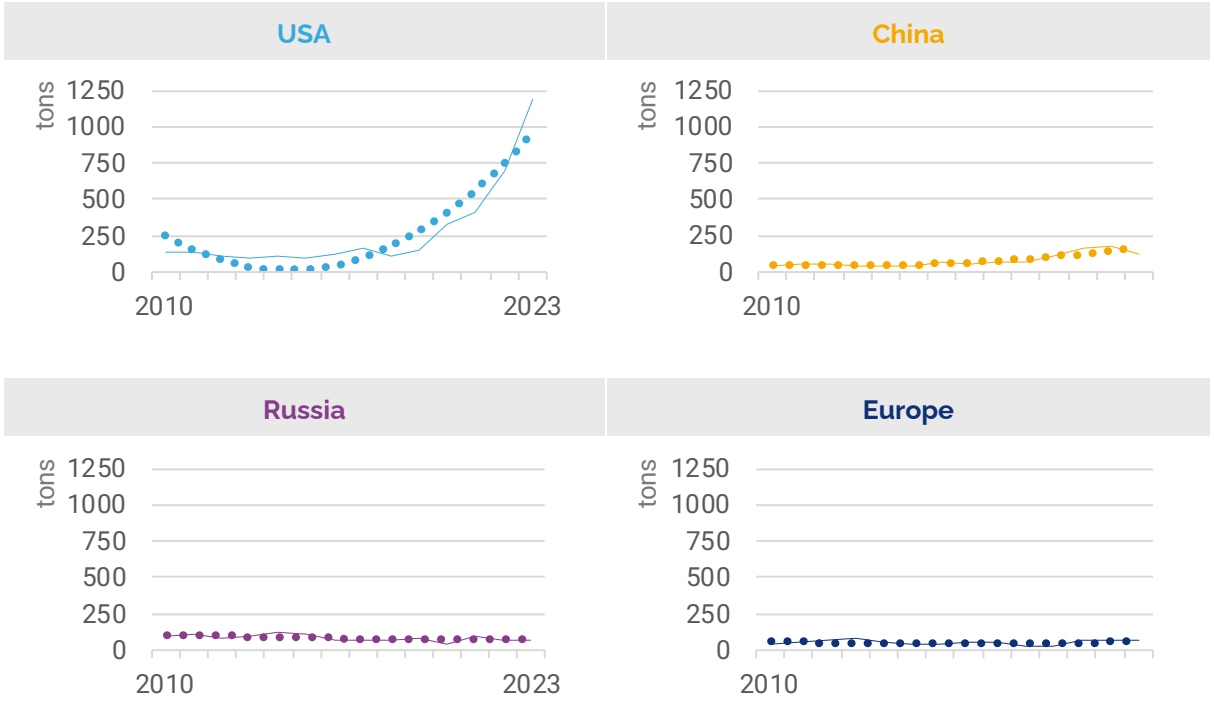


Figure 43: Evolution of total mass launched (in tons) per customer country (2010-2023) with trendline

Europe is the only region where the manufacturing output used to be much higher than the domestic demand, underlining the importance of export markets for European companies. For instance, **in 2023, the number of spacecraft launched for European customers was only half of the number of satellites launched that were built by European manufacturers (157 vs 273).** However, in terms of mass, this trend is starting to reverse. Indeed, since 2020, the industry output is lower than the mass launched for European customers. Thus, is in large part due to OneWeb spacecraft, which have been produced in the United States.

On the commercial market, leading satellite operators and customers are more diverse and include European, American, Chinese, Japanese, Canadian and Middle Eastern companies. Over the period 2015-2019, shares of top operators were relatively well spread and represented slightly more than half of the mass launched for the commercial market. However, in 2020-2023, the top 10 operators represented 93.8% of this mass. This remarkable increase is strongly driven by SpaceX and its Starlink constellation, which accounts for 82% of the total mass launched for the commercial market during these 3 years.

In the future, the distribution of mass could become more balanced again, as several operators are contemplating constellations of smaller satellites in LEO (e.g. Chinas Guowang and G60 LEO megaconstellations). Over these 3 years, the geographical distribution was also more restricted, as American, European and Chinese operators clearly dominated the sector.

2015-2019			2020-2023		
Top 10	**Country/region**	**% commercial mass**	**Top 10**	**Country/region**	**% commercial mass**
Iridium	US	11.7%	SpaceX	US	82%
Intelsat	US	10.2%	**OneWeb**	**Europe**	**3,8%**
SES	**Europe**	**5.8%**	Intelsat	US	1.4%
Eutelsat	**Europe**	**5.5%**	China Satcom	China	1.3%
SpaceX	US	5.5%	**Eutelsat**	**Europe**	**1.1%**
Inmarsat	Europe	4.9%	**SES**	**Europe**	**1.0%**
SKY Perfect JSAT	Japan	4.4%	Axiom Space	US	1.0%
Telesat	Canada	3.4%	SiriusXM	US	0.6%
Arabsat	Saudi Arabia	3.3%	Private individuals	US	0.5%
DirecTV	US	2.7%	**Inmarsat**	**Europe**	**0.4%**
Total		**57.4%**	**Total**		**93.8%**

Table 21: Share of the mass launched (in tons) for the top 10 operators on the commercial market

Global Space Activity in 2023

Overview

221 Launches

+19% compared to 2022

10 Failures

4.5% of all launches
19 spacecraft

8.4% of payloads were institutional,
-16.9% from 2019

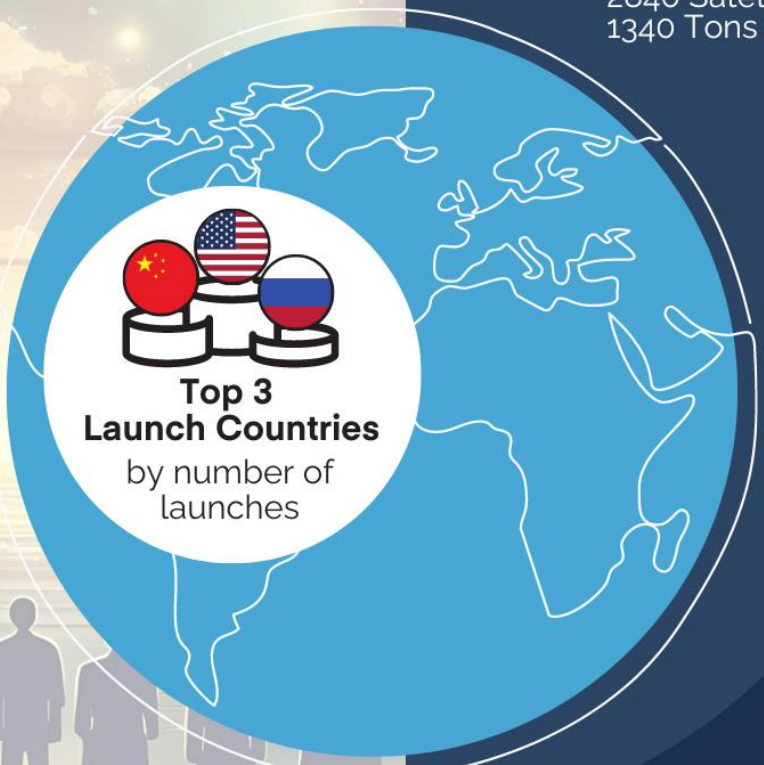
248 institutional payloads were recorded,
double the amount from 2019

GEO
32 Satellites
103 Tons

MEO
7 Satellites
13Tons

LEO
2840 Satellites
1340 Tons

Others
19 Satellites
35.6 Tons



Top 3 Launch Countries
by number of launches

2889 Satellites
Launched

+16% compared to 2022

1477 Tons
Launched

+44.7% compared to 2022

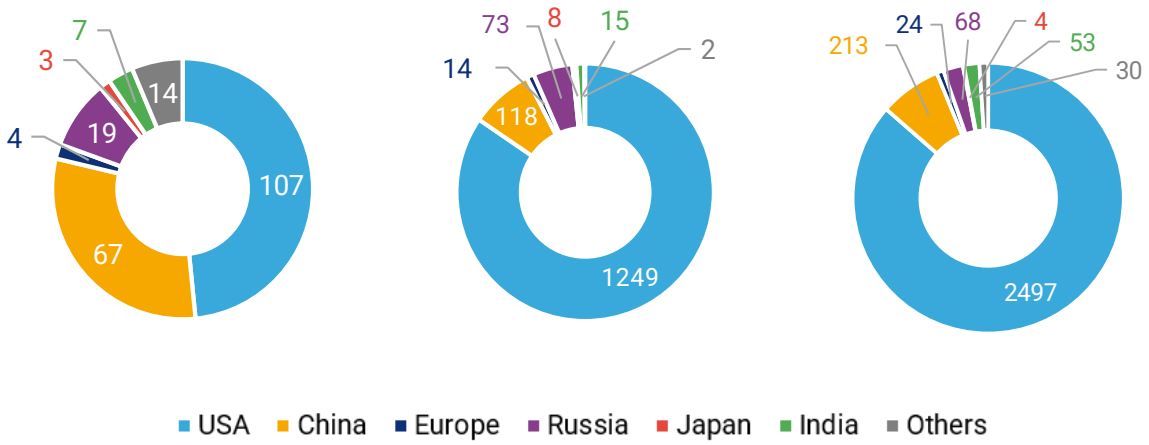
Top Application

Telecommunications

76.2% of all satellites launched
77.7% of the mass launched

4.1.6 Launch activity in 2023

Number of launches per country in 2023	Mass launched (in tons) per country in 2023	Number of spacecraft launched per country in 2023



Launches: 221	Mass launched: 1477 tons	Spacecraft: 2889

Figure 44: Number of launches, spacecraft and mass launched in 2023 per launch country

In 2023, eleven countries (United States, China, France (for Europe), Russia, Japan, India, New Zealand, South Korea, Iran, North Korea and Israel) launched 2889 spacecraft belonging to 58 nations. Among these nations, Oman, the Vatican, Djibouti and Ireland had their first satellite launched, joining the more than 100 countries involved in outer space activities.

These figures and the numbers given below also include failed launch attempts, which represent 4.5% of all launches carried out this year **(10 failures out of 221 launches).**

The United States keeps the top spot for number of launches. It launched 107 times, an increase of 37% compared to its previous record of 2022. China came again in second place with 67 launches, representing 30% of all launches. The third traditional main launch country, Russia, lags behind with only 19 launches (8.6% of the total), a smaller number than what was performed in 2022 (21).

Compared to the previous years, the number of satellites that it put into orbit is lower than China's, likely due to the loss of OneWeb launches following the severing of ties between Arianespace and Russia after the start of the war in Ukraine. At the same time, the number of spacecrafts launched for commercial customers in China has seen a strong increase in recent years.

In terms of mass launched, the United States holds the first place (81% of total mass launched; 1249t), primarily due to the launch of Starlink satellites (88.4% of the total mass launched by the United States) and its human spaceflight activities.

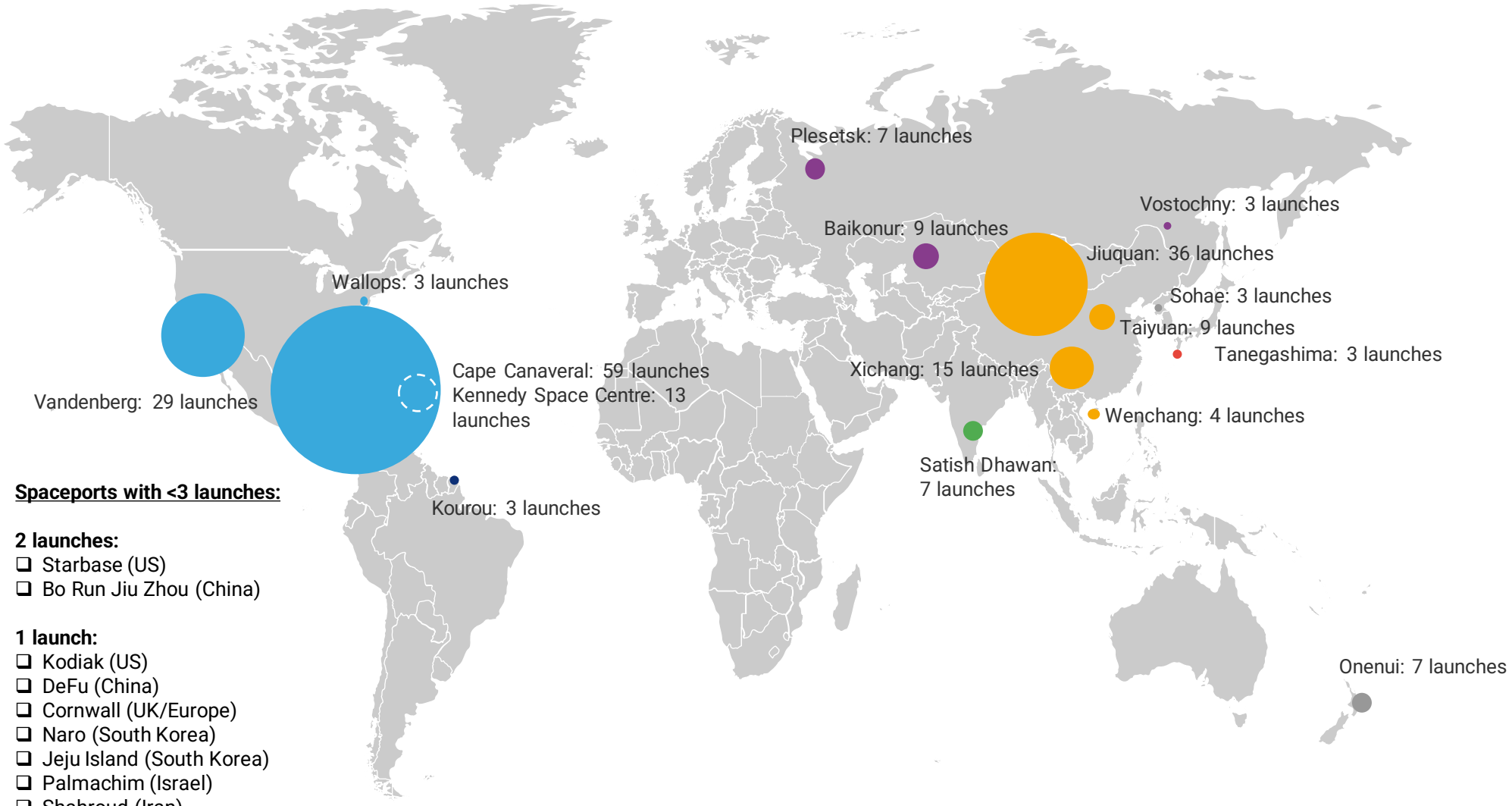
The total mass launched by China (118t) is 1.5 times the one of Russia (73t), despite the role of the latter in bringing crew and cargo to the ISS (accounting for 59% of the total mass launched by Russia, comparable to previous years).

In China the mass is more evenly distributed between crew and cargo missions to Tiangong (26%), Earth Observation (25%), and Technology/Demonstrations (14%). With 4 launches, **European activity reached its lowest level since 2004**.

Only 13.7 tons were launched from Europe, which can be explained by delays in the Ariane 6 programme as well as the impossibility for Arianespace to operate Soyuz rockets since the start of the war in Ukraine.

In terms of number of launches, **Cape Canaveral defends its position as the most active spaceport of the planet**, after having regained it from the Jiuquan Satellite Launch Center in 2022. 59 launches were conducted from the Cape, followed by Jiuquan (36 launches) and the Vandenberg Space Force Base (29 launches).

Vandenberg replaced the Kennedy Space Center (13 launches in 2023) as the third place, mainly due to launches related to Starlink. In terms of mass launched, Cape Canaveral is also the major spaceport, with 787 tons, that is, more than double the mass of the second (Vandenberg Space Force Base, with 323 tons) and more than fifteen times the mass launched from the first non-U.S. spaceport (Baikonur, 4th position with 50 tons). In total, **more mass was launched from Cape Canaveral than from all other spaceports combined** (53%).

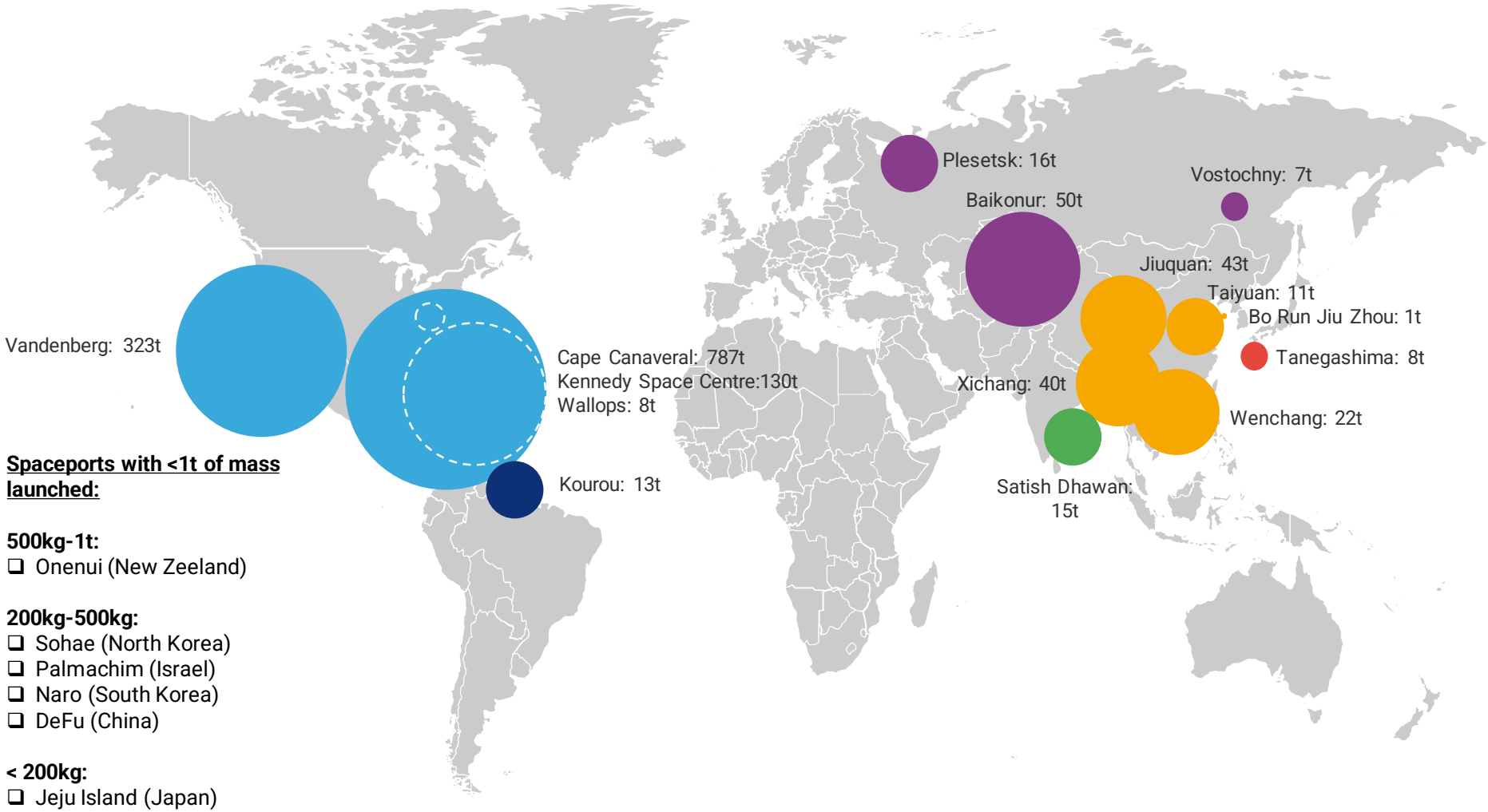


Spaceports with <3 launches:

2 launches:
- ❑ Starbase (US)
- ❑ Bo Run Jiu Zhou (China)

1 launch:
- ❑ Kodiak (US)
- ❑ DeFu (China)
- ❑ Cornwall (UK/Europe)
- ❑ Naro (South Korea)
- ❑ Jeju Island (South Korea)
- ❑ Palmachim (Israel)
- ❑ Shahroud (Iran)

Figure 45: Number of launches per spaceport in 2023



Spaceports with <1t of mass launched:

500kg-1t:
- ❑ Onenui (New Zeeland)

200kg-500kg:
- ❑ Sohae (North Korea)
- ❑ Palmachim (Israel)
- ❑ Naro (South Korea)
- ❑ DeFu (China)

< 200kg:
- ❑ Jeju Island (Japan)
- ❑ Cornwall (UK/Europe)
- ❑ Shahroud (Iran)
- ❑ Kodiak (US)
- ❑ Starbase (US)

Figure 32: Total mass launched per spaceport in 2023

4.1.7 Spacecraft launched in 2023: customers and manufacturers

Spacecraft per operating country in 2023	Mass (in tons) per operating country in 2023

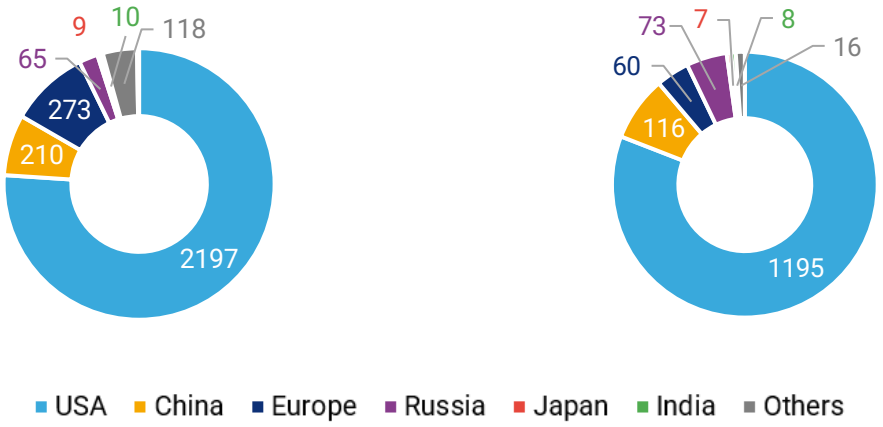


Figure 33: Number and mass of spacecraft per operating country in 2023

The United States were the top customer country in 2023 with 2316 satellites launched for U.S. operators, accounting for almost 1200 tons. 76% of the spacecraft launched in 2023 were American. In terms of mass, satellites operated by U.S. organisations account for 81% of the mass launched, and those for China for 7.8%, while the number of satellites operated by Chinese organisations is almost 10 times lower than the American one.

While in the last years, the average mass for Chinese spacecraft was much higher than US ones, they are now almost equal (555 kg vs. 544 kg). This can be attributed to the launch of the Chinese space station modules in 2021 and 2022 and the switch to heavier Starlink V2 satellites.

The dynamics of Russia and Europe are also interesting, as the total mass launched for Russian organisations is slightly above the mass for European customers, while European entities procured more than four times more satellites.

Spacecraft per manufacturing country (2023)	Mass (tons) per manufacturing country (2023)

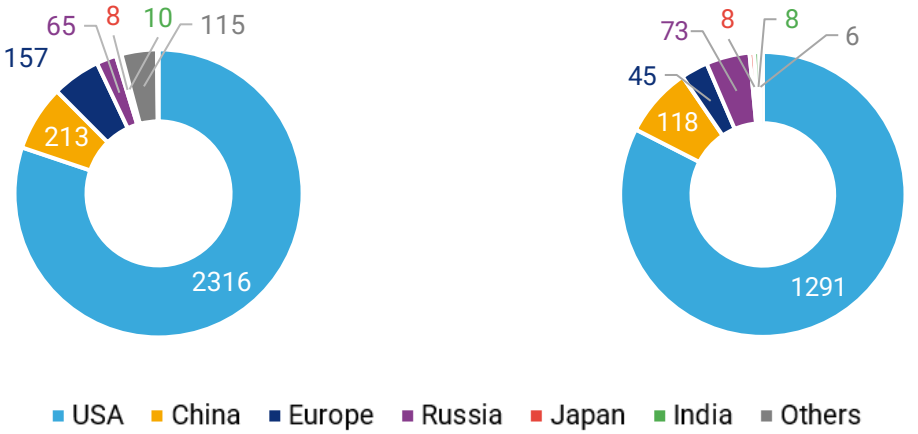


Figure 34: Number and mass of spacecraft per manufacturing country in 2023

From a manufacturing perspective, the United States has an even more prominent position, in particular in terms of number of spacecraft produced (80%) and in terms of satellite mass (83%). It shows that, even though most of the spacecraft built by U.S. companies are for U.S. customers, several satellites launched in 2023 were also the result of U.S. exports.

Of course, these high figures are primarily due to SpaceX's activity (Starlink and Dragons), as the company builds the spacecraft that it operates, following its vertical integration model.

Following the trend started in 2020 and continued in 2021 and 2022, the company played a pivotal role in 2023 launch activity, as it alone represented 91.7% of spacecraft and 75.7% of the mass manufactured respectively in the United States and globally, which was put in orbit that year. **Europe was the third biggest space systems manufacturer in 2023.**

4.1.8 Spacecraft launched in 2023: missions and markets

Number of spacecraft per mission in 2023	Spacecraft mass (in tons) per mission in 2023

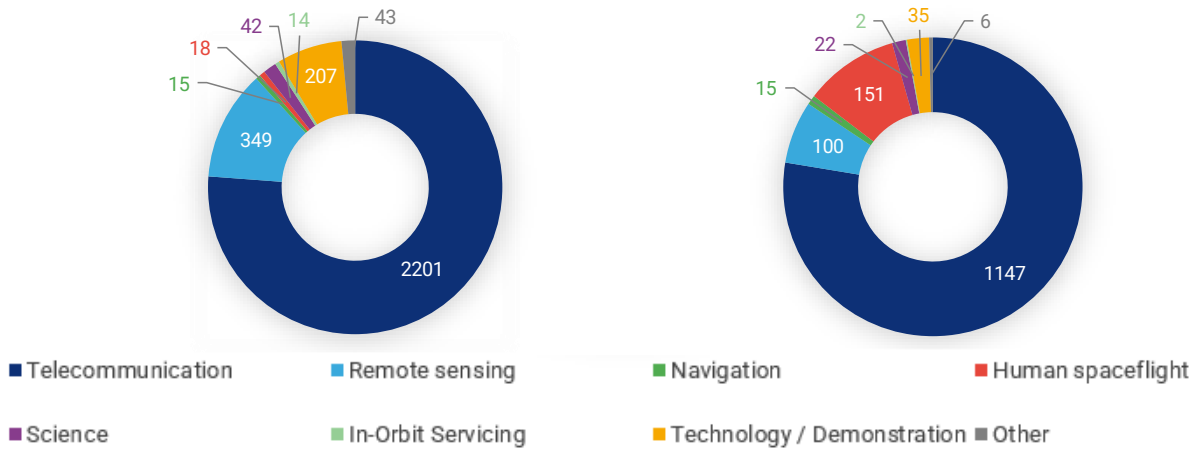


Figure 359: Number and mass of spacecraft per mission in 2023

Mainly as a result of the Starlink constellations, **an overwhelming majority (76.2%) of the satellites launched in 2023 serve telecommunication purposes**, followed to a much lesser extent by remote sensing (12%) and technology/demonstration spacecraft (7.2%). **Telecommunication satellites represent slightly more than 78% of the total mass launched,** followed by human spaceflight systems, which remain the second main category of mission in terms of mass launched (10.2%) even though the mass notably decreased compared to 2021 and 2022. The mass launched for remote sensing missions represents three times the one for technology/demonstration spacecraft, while only 70% more satellites were launched for the former compared to the latter.

Zooming in on Europe, it can be observed that in 2023, a majority of payloads and mass are launched for telecommunication applications (60%), again mostly because of the launch of 132 payloads for the OneWeb constellation (81% of telecommunication payloads). Additionally, there have been smaller payloads for remote sensing and technology demonstrations with limited mass. In terms of mass, a few heavy science missions (JUICE, Euclid) contributed a significant share.

Number of European spacecraft per mission in 2023	European Spacecraft mass (in tons) per mission in 2023

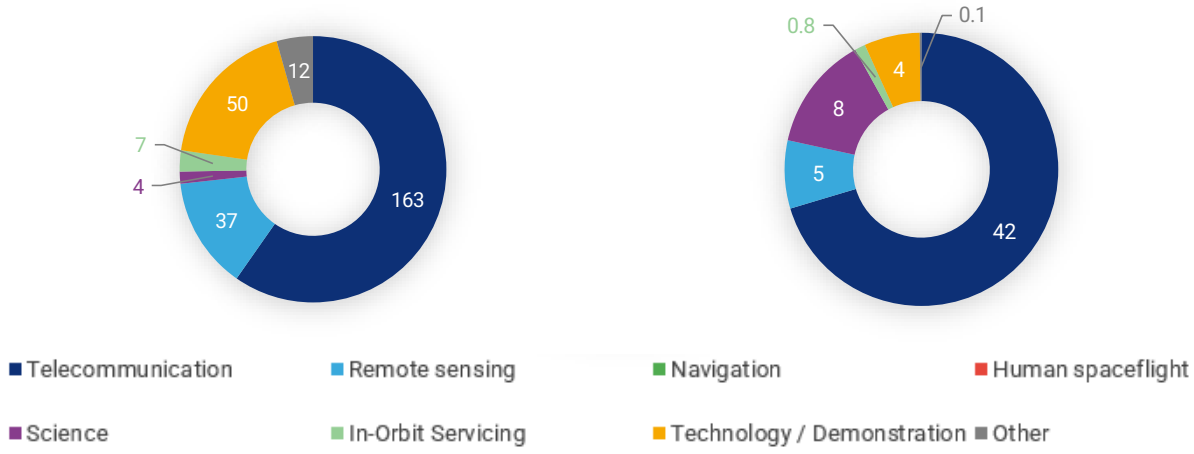


Figure 50: Number and mass of European spacecraft per mission in 2023

Commercial satellites account for 89% of the satellites launched in 2023, representing the fourth consecutive year that the majority of the mass launched is dedicated to the commercial market (78.5%). Slightly less than one sixths of the mass (14.5%) was launched for governmental (civil) purposes (64% of which for human spaceflight), a decrease of ten percentage points compared to 2022. 6.7% of the mass are dedicated to military activities, a slight decrease in comparison with the year before. As usual, other markets remain negligible in terms of mass launched.

Number of spacecraft per market in 2023	Spacecraft mass (in tons) per market in 2023

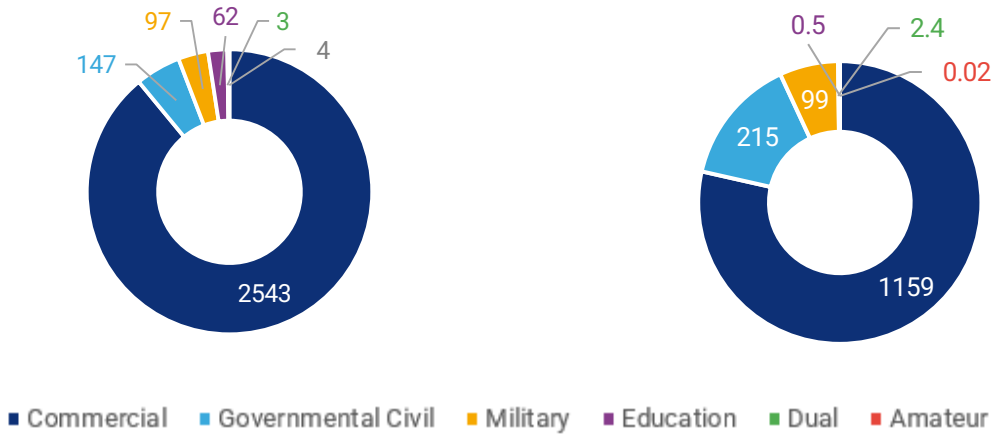


Figure 36: Number and mass of spacecraft per market in 2023

Taking a closer look at the distribution in Europe it can be seen that the distribution in terms of spacecrafts follows the global distribution. The main market in Europe is commercial (84%), with institutional actors only accounting for minor shares (9% for civil and 3.3% for military uses).

As previously mentioned, this is largely driven by the OneWeb constellation, but also to a lesser extent by the Finnish ICEYE and other constellations. In terms of mass, the distribution is less one-sided with commercial markets accounting for 68% of the mass launched. Civil (20%) and Military (12%) customers accounted for a significant share due to mostly the aforementioned heavy Science missions (JUICE, Euclid), as well as military payloads for telecommunication and remote sensing (e.g the French Syracuse and German SARah).

Number of European spacecraft per market in 2023	European Spacecraft mass (in tons) per market in 2023

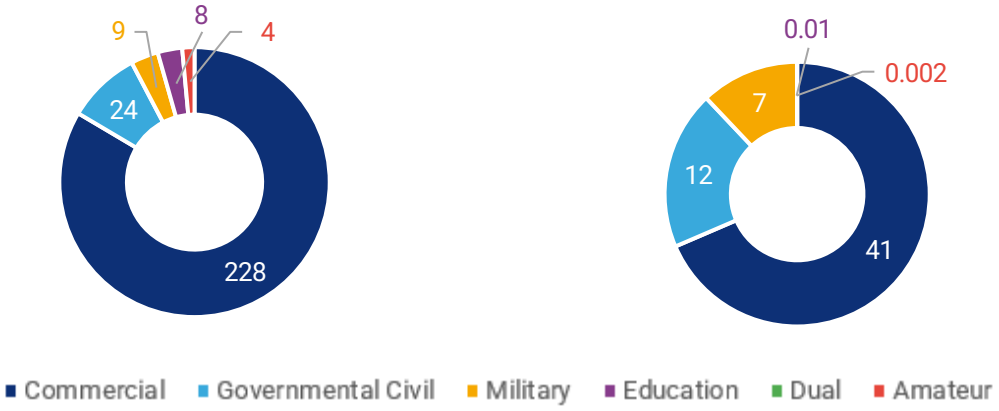


Figure 37: Number and mass of spacecraft per market in 2023

4.1.9 ESPI Database definitions

Launch outcome

- Success: launch attempt performed nominally, spacecraft injected in the intended orbit.
- Failure: launch attempt led to the loss of the payloads (destruction, unrecoverable orbit).
- Partial failure: launch attempt led to a recoverable harm for the payloads (damage, orbit).

System categories

- Satellite: standard spacecraft designed to orbit the Earth and comprised of a bus/platform and one or more payloads.
- Cubesat: spacecraft designed according to the cubesat standard and comprised of one or more units (U) of 10x10x10cm.
- Space Station Module: element of a space station including habitats, nodes, structure, external platforms and other permanent or temporary parts.
- Transfer Vehicle: spacecraft designed to transfer cargo or humans to a space station.
- Space Exploration System: specific spacecraft designed for space exploration purposes including probes, landers, rovers and other systems with a mission outside Earth orbit.
- Space Plane: reusable spacecraft with advanced manoeuvring capabilities including the capacity to land autonomously.
- Servicing Vehicle: spacecraft with advanced Rendezvous and Proximity Operations capabilities, designed to provide services to other satellites (e.g. life extension, refuelling, inspection).
- Dummy payload: passive object without operational payload (e.g. mockup, passive target…).
- Attached package: system remaining attached to the launcher upper stage.

Mass categories

- Large spacecraft (>500kg)
  - Extra heavy-class: More than 8,000kg
  - Heavy-class: Between 2,000 and 8,000kg
  - Medium-class: Between 500 and 2,000kg
- Small spacecraft (<500kg)
  - Mini-class: Between 100 and 500kg
  - Micro-class: Between 10 and 100kg
  - Nano-class: Less than 10kg

Orbits

- GEO: an orbit at an altitude of approximately 36 000 km from Earth.
- MEO: an orbit at an altitude between 2000 and 36 000 km from Earth.
- LEO: an orbit at an altitude between 100 and 2000 km from Earth.
- HEO: highly elliptical orbit, an elliptical orbit with a high eccentricity.
- Escape: an orbit beyond Earth orbit with an eccentricity higher than 1.

Missions

- Telecommunication
  - Telecommunication services by satellites
  - Automatic Identification System: detection and tracking of ships
  - Satellite Data Relay: telecommunication relay for other satellites
- Remote sensing
  - Earth Observation: observation of the Earth for an operational purpose (not scientific)
  - Meteorology: study of the Earth atmosphere with a focus on weather forecast (not scientific)
- Navigation
  - Navigation: Global Navigation Space Systems (GNSS) and Satellite-Based Augmentation Systems
- Human spaceflight
  - Cargo Transfer: transfer of supplies to a space station
  - Crew Transfer: transfer of astronauts to a space station
  - Space Station Infrastructure: supply of a space station's element
- Science
  - Astronomy: remote study of celestial bodies and phenomena
  - Biology: study of life and living organisms
  - Earth Science: study of the Earth
  - Planetary Science: study of planets, moons, asteroids, comets
  - Space Science: study of the space environment / the functioning of the Universe
- Military-specific
  - Early Warning: detection of missile launches through infrared observation
  - Signal Intelligence: interception of electronic signals
  - Space Situational Awareness: detection and tracking of objects in orbit
- Technology / Demonstration
  - Technology / Demonstration: testing of new systems or technologies
  - In-Orbit Servicing: provision of services to another spacecraft
- In-Orbit Servicing
  - Provision of services to another spacecraft
- Other
  - Radio Amateur: radiocommunication for amateur purpose
  - Other/Unknown: missions not falling in the above definitions

Markets

- Governmental civil: the spacecraft is primarily intended to serve the mission of an organisation providing a public service or having scientific research objectives.
- Military: the spacecraft is primarily intended to serve armed forces operational needs.
- Commercial: the spacecraft is primarily intended to serve commercial interests
- Education: the spacecraft is primarily intended to serve an academic or training purpose from system design to operation.
- Dual: the spacecraft is intended to serve both military and civil purposes.

4.1 Space activity highlights in 2023

4.1.1 Noticeable missions and payloads

Last two Ariane 5 launched delivered JUICE as well as German and French military satellites

Credit: ESA

The launch of the Jupiter Icy Moons Explorer (JUICE) mission to explore the three largest icy moons of Jupiter was carried out by teams from ESA and Arianespace. JUICE was launched on a trajectory that will lead to its arrival at the Jovian system in the summer of 2031. The launch took place on Friday, April 14th from pad ELA-3 at the Centre Spatial Guyanais (CSG) in Kourou, French Guiana.[851]

On July 5th, Arianespace conducted the last launch of an Ariane 5 rocket, from the Guyana Spaceport in Kourou. For this launch, Ariane 5 was transporting two governmental satellites: the Heinrich-Hertz satellite (H2SAT) for the German Aerospace Center (DLR); and the Syracuse 4B spacecraft for the French Defence Procurement Agency (DGA). It will be the last spacecraft for the Syracuse 4 constellation after the decision taken by France to give up the development of a third satellite and invest in IRIS2 instead.[852] Ariane 5, whose first launch occurred in 1996, performed 117 launches during its lifetime and became the iconic launcher of Europe. The rocket had a 95.7% success rate and launched major payloads such as the Rosetta probe, and the James Webb Space Telescope.

Increased launch activity towards the Moon in 2023

Credit: ISRO

On July 14th, ISRO used a GSLV Mk 3 rocket to launch the Indian mission Chandrayaan-3. This mission is the second attempt by India to send a lander and a rover to the Moon, after the failure of those that were onboard Chandrayaan-2 in 2019. According to ISRO, the objectives of Chandrayaan-3 are to "demonstrate safe and soft landing on the lunar surface, demonstrate rover roving on the moon and conduct in-situ scientific experiments" The landing was successfully conducted on August 23rd.[853]

August and September saw multiple space exploration missions launched towards both the moon and the sun. On August 10th, Russia launched its Luna 25 mission on a Soyuz-2.1b rocket from the Vostochny Cosmodrome.[854] The goal of the mission was to demonstrate landing technology in the lunar south pole region as well as investigating lunar regolith. On August 20th Roscosmos announced that Luna 25 has crashed into the surface of the Moon after an anomaly during an orbital maneuver had occurred. Additionally, Japan launched its SLIM moon lander and the XRISM space telescope855 on September 6th on the same H-2A rocket from the Tanegashima Space Center. While XRISM will stay in LEO, SLIM demonstrated a precision landing on the Moon in January 2024.

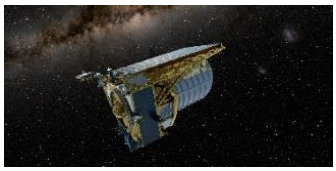
[851] ESA launches JUICE to Jupiter's icy moons atop Ariane 5, NASASpaceflight.com, April 2023
[852] A Franco-German success for the final Ariane 5 mission, Arianespace, July 2023
[853] Chandrayaan-3 is on its journey to the moon, ISRO, August 2023
[854] Luna 25: the first Russian spacecraft in 47 years heading to the moon. NASASpaceflight, August 2023
[855] Japan launches SLIM moon lander, XRISM X-ray telescope on space doubleheader, Space.com, September 2023

OneWeb completes its constellation; Amazon launches demonstrator for Kuiper

A Falcon 9 rocket was launched by SpaceX from Vandenberg Space Force Base on May 20th, carrying the last backup satellites for OneWeb's current, first-generation LEO network. OneWeb currently has 633 first-generation satellites in LEO, although only 588 are required for global coverage. OneWeb already surpassed this mark for operationality with a launch on March 25th. The launch May also carried a technology demonstration satellite, JoeySat, for OneWeb's second-generation broadband constellation, which could be launched as early as 2025.[856]

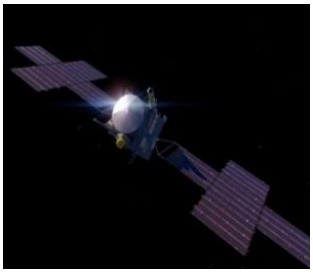
On October 6th, United Launch Alliance (ULA) successfully launched two prototypes for Project Kuiper, a planned broadband satellite constellation by Amazon. KuiperSat-1&2 serve the purpose of testing various aspects, including how the space-based systems connect with user terminals and the necessary ground infrastructure. To meet Federal Communication Commission (FCC) license requirements, Amazon needs to deploy at least half of its proposed 3236 satellites by July 2026, with the remaining satellites to be launched within three years after that date.[857]

SpaceX launches US and European Space Science missions



Credit: ESA

The Euclid telescope for ESA was successfully launched from on July 1st. The telescope's purpose is to observe the sky and delve into the ancient history of the universe to gain insights into the characteristics and distribution of dark matter and dark energy. The project has incurred a total expenditure of 1.4 billion euros, with 80 different European companies such as Thales Alenia Space, Airbus, Beyond Gravity, and OHB involved. Initially, Euclid was intended to launch on a Soyuz rocket from French Guiana, but due to the Russian invasion of Ukraine, ESA made the decision to switch to SpaceX's Falcon 9 launcher. [858]



Credit: NASA/JPL

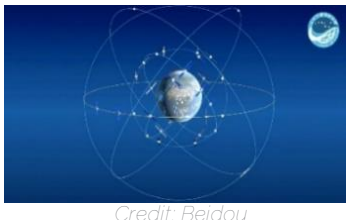
The Psyche spacecraft embarked on its journey to a metallic asteroid, also called Psyche, located in the main asteroid belt following a successful launch atop a SpaceX Falcon Heavy rocket from the Kennedy Space Center on October 13th. This launch marked the eighth mission for the Falcon Heavy, but the first time NASA had been the customer. The spacecraft will reach its destination in 2029 and spend 26 months in orbit around the asteroid, studying the largest solar system body made primarily of metal as part of NASA's Discovery Program.[859]

Vega makes launch return; successfully deploying 10 out of 12 payloads

On October 8th, the first Vega launch of this year took off from Europe's Spaceport in Kourou, French Guiana aiming to put 12 payloads into orbit. This launch marked the return of the standard Vega variant, the first since November 2021, with the upgraded variant Vega-C out of business after a failure in December 2022. The primary payloads included THEOS-2, an Earth-imaging satellite by the Thai government as well as FormoSat-7R/Triton, a GNSS satellite by the Taiwan Space Agency. In addition to these, the mission carried 10 other payloads for various customers. Later this month, on October 16th, Arianespace announced that two of the ten secondary payloads failed to be deployed.[860]

[856] SpaceX launches OneWeb Gen 2 technology demonstrator, SpaceNews, May 2023
[857] ULA Atlas 5 launches first Project Kuiper satellites, SpaceNews, October 2023
[858] SpaceX launches ESA's Euclid Telescope to explore the dark universe, NASASpaceflight, July 2023
[859] NASA launches Psyche mission to metal world, SpaceNews, October 2023
[860] Arianespace's Vega rocket launches 12 satellites to orbit, Space.com, October 2023

China and India launched satellites for their navigation systems


Credit: Beidou

China successfully deployed the 56th satellite of its Beidou navigation and positioning system into geostationary orbit on May 16th. The satellite serves as a backup for the system, which was already completed in 2020. The primary objective behind the launch, which was carried out by a Long March 3B lifted off from Xichang Satellite Launch Center, is to enhance the system's reliability, consistency, communication capabilities, and accuracy in positioning.[861] India also expanded its satellite navigation system NavIC by launching NVS-01, the first second-generation navigation satellite series of the constellation on May 28th. The system's first generation, launched between 2013 and 2019, consists of seven satellites in geosynchronous orbit.[862]

U.S. and China both launched classified spaceplanes

On December 28th, the X-37B Orbital Test Vehicle, operated by the Space Force, embarked on its seventh mission to space.[863] this time aboard a SpaceX Falcon Heavy rocket from the Kennedy Space Center. While specific details about the X-37B are limited, the Space Force has confirmed that the mission aims to explore new orbital patterns, trial space domain awareness technologies, and study the effects of radiation on NASA materials. Notably, each mission of the spacecraft has seen an increase in its duration in orbit, setting a record of 908 days during its previous return in November 2022. X-37B was launched shortly after China's spaceplane, named Shenlong, was sent to orbit on December 14th[864] on a Long March 2F for a third flight. Shenlong was observed to releasing six classified objects into orbit, some of which were transmitting signals. The US Space Force had initially scheduled the X-37B's launch for December 7, ahead of Shenlong's deployment, but faced multiple delays.

The Space Development Agency (SDA) started the deployment of its constellation

The Space Development Agency (SDA) announced the successful initial launch of Tranche 0 (T0) of the Proliferated Warfighter Space Architecture (PWSA) on April 2nd. The Transport and Tracking Layer satellites, launched on a SpaceX Falcon 9, are designed to demonstrate low-latency communication links for warfighters. This will include tracking advanced missile threats from LEO. A second tranche of both the Transport and Tracking layer was conducted on the 2nd of September, again by a Falcon 9 rocket. Trance 0 will be followed by Trance 1&2 which are planned to be launched by 2026 and consist of over 700 satellites.[865]

Falcon Heavy delivered the heaviest commercial satcom satellite ever launched

On July 29th, SpaceX performed the seventh launch of a Falcon Heavy to launch Jupiter 3, a GEO communications satellite for the company Hugues Network Systems, a subsidiary of EchoStar. The spacecraft, built by Maxar, is the largest commercial satellite ever sent to orbit: it weighs more than nine tons, is the size of a school bus and, when deployed, its solar arrays are as wide as a ten-floor building.[866]

[861] China launches new science probes, SAR sat and replacement Beidou satellite, SpaceNews, May 2023
[862] India launches new-generation navigation satellite aboard GSLV, NASASpaceflight, May 2023
[863] X-37 and Chinese Space Plane Both Launch: 'Two of the Most Watched Objects on Orbit', AirandSpaceForces.com, January 2024
[864] China launches mystery reusable spaceplane for third time, SpaceNews, December 2023
[865] SpaceX launches initial satellites for Space Development Agency, NASASpaceflight, April 2023
West Coast Falcon 9 launches 13 demonstration satellites for military mega-constellation, SpaceflightNow.com, September 2023
[866] Hughes JUPITER 3 Satellite Successfully Launches, Heralds the Start of a New Era of Connectivity, Echostar, July 2023

Responsive space mission "Victus Nox" launched on a Firefly rocket

The U.S. Space Force has confirmed the successful launch of a Millennium Space small satellite on September 14 by Firefly Aerospace using their Firefly Alpha rocket. This mission called "Victus Nox" was specifically designed to showcase the ability to launch on a significantly shorter timeline than what is typically required for national security missions. Upon receiving the alert, both companies had a 60-hour window to transport the payload to Firefly's launch site at the Vandenberg Space Force Base, complete fuelling procedures, and integrate it with the Alpha rocket's payload adapter. The responsive space program is overseen by the Space Systems Command's Space Safari Program Office and the Rocket Systems Launch Program. The last responsive space mission was launched in June 2021 using a Northrop Grumman Pegasus rocket.[867]

SES satellites launched by SpaceX to qualify for a fiscal incentive from the FCC

Credit: SES

On March 17th, SpaceX successfully launched the final two SES satellites that the Luxembourg-based company requires to receive approximately $4 billion in proceeds from the U.S. Federal Communications Commission for clearing their share of the C-band spectrum in due time. The clearing was necessary after the FCC decided in 2019 to transition parts of the C-band spectrum from satellite operations to 5G mobile applications and promised the satellite operators reimbursement for relocation costs.[868] On November 12th, SpaceX also successfully launched another duo of internet-providing satellites for SES.[869]

North Korea deployed spy satellite on third try

According to reports from North Korean state media, the country has asserted the successful placement of its inaugural reconnaissance satellite, Malligyong-1, into LEO on November 21st. This launch would signify North Korea's third attempt to deploy its initial spy satellite into orbit on its Chollima-1 launcher, with previous endeavours in May and August having faced failures. The United States and South Korea have criticized the launch, citing concerns that the technology employed supports North Korea's intercontinental ballistic missile program. North Korean sources have indicated plans for additional launches involving further surveillance satellites.[870]

SpaceX's launched over 270 spacecraft on four Transporter rideshare missions.

In 2023, SpaceX launched four different Transporter missions, which provide rideshare opportunities for a multitude of small satellites on their Falcon 9 rocket. Since announcing the programme in 2019, nine transporter missions have taken place until the end of this year. 2023 represents a new record with 4 missions in the same year, carrying over 270 spacecraft overall to LEO, including several firsts.

[867] Firefly launches Space Force 'Victus Nox' mission, SpaceNews, September 2023
[868] SpaceX launches final two satellites in SES C-band clearing plan, SpaceNews, March 2023
[869] SpaceX Falcon 9 rocket launches 3rd pair of O3b mPOWER satellites from Cape Canaveral, SpaceNews, November 2023
[870] North Korea claims it sent a spy satellite to orbit for 1st time: report, Space.com, November 2023

4.1.2 First launches and successes

United Launch Alliance's new Vulcan rocket launched Peregrine Lunar lander

Credit: United Launch Alliance

The Vulcan Centaur rocket, developed by United Launch Alliance (ULA), successfully embarked on its inaugural flight on January 8th.[871]

Mounted on the rocket was the Peregrine Moon lander by Astrobotic. Peregrine was transporting 20 payloads from various customers, among which are five scientific instruments for NASA, as part of the agency's first service delivery under the Commercial Lunar Payload Services (CLPS) program. Swiss-based Beyond Gravity majorly contributed to this specific mission, providing payload fairings, the interstage adapter, the heat shield, and the payload attachment fitting.[872]

The lander was planned to be the first American spacecraft to land on Earth's natural satellite since 1972, and potentially the first privately funded mission to achieve a lunar landing but it failed because of a fuel leak and was brought back to burn in Earth's atmosphere.

First successful launch of India's SSLV rocket

After the failed launch of India's new Small Satellite Launch Vehicle (SSLV) on August 7th, 2022, the second attempt on February 10th, 2023, was successful. The first payload is the small Earth observation satellite EOS 07, developed by ISRO, to test the SSLV's launching capabilities and its responsiveness. It is based on the Microsat-TD, launched by ISRO in 2018, and additionally carries a Millimetre Wave Humidity Sounder and a Spectrum Monitoring Payload.

Credit: ISRO

The other two satellites are AzaadiSAT 2, a nanosatellite developed by Space Kidz India and Janus 1, a CubeSat demonstrating the platform developed by Antaris. Compared to India's GSLV and PSLV rockets, SSLV is designed to provide more affordable and flexible access to space.[873]

China crushed national launch record twice

Credit: Ourspace/CNSA

On June 15th, 41 small satellites were successfully deployed into orbit by a Long March 2D rocket lifted off from Taiyuan, primarily expanding Changguang Satellite's Jilin-1 commercial remote sensing constellation.

This launch surpasses the previous Chinese record of 26 satellites on a single mission, which was achieved only a few days earlier, on June 7th, by CAS Space's Lijian 1 rocket.

[871] ULA's Vulcan rocket launches private US moon lander, 1st since Apollo, and human remains in debut flight, Space.com, January 2024
[872] Beyond Gravity Celebrates the Successful Launch of ULA's Vulcan Centaur Rocket, Beyond Gravity, January 2024
[873] India's SSLV rocket succeeds in second try, SpaceNews.com, February 2023

The payloads for the Lijian 1 launch mostly consisted of undisclosed technology demonstration satellites. The current record for the most satellites deployed in a single mission is 143, set by SpaceX's Transporter-1 rideshare mission in January 2021.[874]

SpaceX set two launch records

On September 3, the company successfully deployed 21 of its Starlink internet satellites into orbit atop a Falcon 9 rocket, launching from NASA's Kennedy Space Center. This marked SpaceX's 62nd orbital mission of 2023, setting a new record[875] for the most launches conducted in a single year, surpassing the previous record established also by SpaceX in 2022.

Moreover, later this month, on September 20th, SpaceX's Falcon 9 rocket achieved another significant feat by setting a reuse record. During the launch of another batch of Starlink satellites from Cape Canaveral, a particular Falcon 9's first stage completed its 17th liftoff and landing.[876] This surpasses the previous record of 16 liftoffs held by two different Falcon 9 boosters.

Ireland, the Vatican, Djibouti and Oman launched their respective first satellites

- On June 12th, the Vatican launched its first satellite, Spei Satelles as part of the Transporter 8 rideshare mission by SpaceX. The 3U CubeSat aims to be a sign of hope for all humanity.[877]
- On November 11th, Oman launched its first satellite, Aman-1 as part of the Transporter 9 rideshare mission by SpaceX. The same launch also carried Djibouti's first satellite, Djibouti 1A.[878]
- On December 1st, Ireland launched its first satellite as part of a rideshare mission on a Falcon 9 rocket. The Educational Irish Research Satellite-1 (Eirsat-1) is a CubeSat developed by students at the University College Dublin.[879]

[874] China launches national-record 41 satellites on single rocket, Space.com, June 2023
[875] SpaceX launches Starlink satellites on record-breaking 62nd mission of the year, Space.com, September 2023
[876] SpaceX rocket launches Starlink satellites on record-breaking 17th flight, Space.com, September 2023
[877] Vatican Launches First Spei Satelles, OrbitalToday.com, June 2023
[878] SpaceX Transporter 9 rideshare features new OTV from Tom Mueller's Impulse Space, NASASpaceflight.com, November 2023
[879] Eirsat-1, Ireland's 1st satellite, makes space history, Space.com, December 2023

4.1.3 Some noticeable failures in 2023

Among the 221 launches taking place in 2023, a few of them (10) failed. Some of these failures are noticeable.

SpaceX conducted two test flights of Starship

Credit: SpaceX

On April 20th, SpaceX conducted a test flight of its first integrated Starship vehicle at its Starbase test site in Boca Chica, Texas. However, shortly after liftoff, the vehicle began to tumble and the flight termination system was activated.[880]

On November 18th, Starship vehicle embarked on its second integrated test flight and successfully demonstrated its booster's performance and the introduction of a new hot staging separation technique. Additionally, the booster was intended to execute a "boostback" manoeuvre for a planned splashdown in the Gulf of Mexico.

However, the flight termination system of the booster was activated again approximately 3 minutes and 30 seconds after liftoff. Simultaneously, the Starship continued its ascent but lost communication after 8 minutes. At the time of telemetry loss, the spacecraft was at an altitude of 148 kilometres, hurtling at over 24,000 kilometres per hour, nearing orbital velocity. Despite the mission not achieving all intended outcomes, this flight showcased considerable advancements compared to the initial test flight.[881]

Starship holds critical importance for both SpaceX and NASA. SpaceX relies on Starship for launching payloads like full-sized V2 Starlink satellites. Additionally, NASA has awarded SpaceX contracts valued at $4 billion to develop a crewed lunar lander version of Starship for the Artemis 3 and 4 missions.

Virgin Orbits failed first launch from UK soil

On January 9, Virgin Orbit's inaugural launch from the United Kingdom did not achieve orbit. The launch, named "Start Me Up," involved a Boeing 747 aircraft from Virgin Orbit departing from Spaceport Cornwall. The mission aimed to place nine small satellites into a sun-synchronous orbit. The operation was undertaken for the U.S. National Reconnaissance Office, featuring as its main payload two cubesats known as Prometheus-2, developed by the UK Ministry of Defence's Defence Science & Technology Laboratory (DSTL). This event held significant prominence as it represented the first attempt at an orbital launch from British soil, aligning with the UK government's ambition to cultivate a comprehensive space industry. This setback follows a series of four successful LauncherOne missions conducted from the Mojave Air and Space Port in California, spanning from January 2021 to July 2022. Virgin Orbit faces this challenge during a critical period, as it works to increase its launch frequency and financial performance. In April, Virgin Orbit filed for bankruptcy.[882]

[880] Starship lifts off on first integrated test flight, breaks apart minutes later, SpaceNews.com, April 2023
[881] Starship/Super Heavy lifts off on second flight, SpaceNews.com, November 2023
[882] First Virgin Orbit U.K. launch fails. SpaceNews.com, January 2023

Two rocket failures on maiden flights in March 2023

On March 7th, JAXA's new H3 rocket failed during its first flight. According to investigations, the cause of the malfunction was likely an excessive electric current inside the second-stage engine. H3 carried the Advanced Land Observation Satellite (ALOS) 3, intended for cartography, regional observation, disaster monitoring, and resource surveying. The H3 rocket is set to replace JAXA's current launcher the H-2A by offering a higher capacity (28.3 metric tons compared to H-2A's 10-15 tons) at lower costs. Hence, the current setback delayed Japan's future space ambitions.[883]

Another second stage malfunction caused the (partial) failure of the maiden flight of the Terran-1 rocket and its test payload on March 23rd. While the rocket, manufactured by US company Relativity Space, managed to launch, it did not reach the designated orbit. Terran-1 is the first launcher predominantly manufactured through 3D-printing. Despite the failure, the main objectives of the mission, i.e. flying through max-q and being the first 3D-printed and first methane-fueled rocket to reach orbit, were achieved.[884]

First failure for Chinese Galactic Energy's Ceres-1 launcher

Credit: Galactic Energy

Chinese commercial space launch company Galactic Energy encountered its first launch failure during its 10th launch attempt. The Ceres-1 solid rocket that took off from Jiuquan on September 21, carried the Jilin-1 Gaofen-04B satellite for Changguang Satellite Technology (CGST), a commercial remote sensing company.[885]

This mission marked the company's first significant setback after a series of nine successful launches, which commenced in November 2021. Galactic Energy had been actively conducting a concentrated series of launches using their Ceres-1 rocket, encompassing four missions between July 22nd and September 5th. This included the historic first launch from a mobile sea platform by a Chinese commercial launch service provider on September 5th.[886]

[883] Japan's H3 rocket launch fails after second stage malfunction, SpaceNews.com, March 2023
[884] Relativity overachieves Terran 1 debut objectives, NASASpaceflight.com, March 2023
[885] China's Galactic Energy suffers first launch failure, SpaceNews.com, September 2023
[886] China's Galactic Energy Launches Rocket from the Sea, Payloadspace.com, September 2023

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Acknowledgment

The authors would like to thank the Marco Aliberti, Associate Manager and Lead on International Engagement, and Julien Potin, Research Fellow, who reviewed the Yearbook, providing invaluable feedback and comments, and Julia Drössler, Communications & Engagement Intern, for providing support on graphic design, incl. in Yearbook's Executive Summary.

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