European Space Policy Institute

ESPI Yearbook 2022

SPACE POLICIES, ISSUES AND TRENDS

Report:

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FOREWORD

Dear members of ESPI and readers in Europe and worldwide,

I am pleased to introduce to you this 2022 edition of the ESPI Yearbook. This long-established annual publication has gained a solid reputation along the years of being a reliable source of information and a useful tool for monitoring the development of the European space policy in a global context.

With this new issue of the Yearbook for 2022, we aim to meet the expectations of our readers and we invested substantial efforts to ensure a consistent overall coverage of the 2022 space activities and business. The purpose we pursue with this publication is highlighting the evolving position of Europe on the international stage and putting forward the trends at work that deserve being considered in the further development of European space policy. The Yearbook is part of our mission to promote European space policy globally.

In 2022, the the Russian war on Ukraine had far-reaching and lasting direct and indirect impacts on the global space sector and international cooperation in space. The war intensified the geopolitical polarisation in international relations. Moreover, the war unveiled dependencies and put strategic autonomy also with regards to space into the spotlight for Europe. Furthermore, the war increased the awareness of the importance of resilience and cybersecurity of space assets, of the dual use aspect of space, and of the link between space and security/defence. Moreover, the space sector was affected by the overall economic crisis with the challenge to justify space budgets and public investments in space to the society by demonstrating the benefits of space on the economy and our daily lives.

The Yearbook is structured in 4 chapters:

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

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 Perspectives, ESPI Briefs**, and **ESPI Reports.**

The monthly **ESPI Perspectives** analyse major developments in the space sector, outstanding ESPI activities that are contributing and boosting European ambitions as well as highlight how Europe is positioned in the international context, especially in comparison with major space powers, such as the U.S. and China.

Major key messages from 2022 ESPI Perspectives include:

- **The International Astronautical Congress (IAC) and the World Satellite Business Week (WSBW) in September 2022:** more than ever both events demonstrated that governmental objectives and commercial ambitions in space increasingly become intertwined. Private and governmental actors are engaging to explore new ways to increase the socio-economic impact that space can have well beyond the traditional space eco-system. New branches of government and of the economy become users and investors in space. It may be the challenge of the decade ahead of us to bring these actors together to **optimise synergies between entrepreneurial ambitions and policy goals**. Next to other measures, **public procurement schemes will need to evolve to allow industries to compete for new markets**, expected to be accompanied by a **shift of governance towards more public-private schemes**.

- **"Energy and Security Crisis: The future of Space for a Europe at Risk" – in October 2022:**
  The policy focus, that was especially on the energy and economic crisis in fall 2022, risks depriving Europe of developing its strategic autonomy and strength in a global space-enabled economy, in which space-based data and services will be all pervasive. The socio-economic benefits of **space already comprise solutions to the energy transition**, to reach NetZero, for telemedicine and education, finance, autonomous vehicles, smart cities, aviation and maritime transport, digital sovereignty, connectivity, security and more. This value of space is acknowledged by the majority of Europeans, who also recognize space as a key driver of inspiration, innovation and for mobilising young talent. **However, there remains a persistent lack of political awareness in Europe on the strategic role of space**, to perceive space not merely as a cost but as part of a **more effective response to energy and security challenges**, not as a niche market but as an investment opportunity and key enabler of the future. With its low level of public funding for space, Europe risks missing on the next opportunity for high economic multipliers at a time when continued support from smart and **directed public funding will be essential to raise the share of private investments in Europe**.

- **ESA CM22 in November 2022: "Success within political boundaries – but widening the gap":**
  The €16.9B budget entrusted to ESA by its Member States continues to represent the **largest public funding for space on European level**, about double the funding for the EU Space Programme of €14.9B over 7 years. All individual programme proposals were approved, resulting in the **most complete European space programme to date**, with a continued rise in space applications programmes, and new programmes, including Civil Security from Space (CSS), the Commercialisation Programme "ScaleUp", the Moonlight Initiative as well as ESA programme related to IRIS² - which just 5 days after the adoption of IRIS² at EU level, provides an excellent example of **EU and ESA with its Member States working hand-in-hand when it matters.** Nevertheless, the ESA CM22 result, as a success within political boundaries, translates into a **further widening of the gap between Europe and other world regions. A 2023-2025 match-plan for space is needed**, if Europe wants to be with the space powers, which will set the rules and shape the future of space for the foreseeable future.

With regard to developments in Policy and Programmes, 2022 has been quite remarkable regarding the development of space policy-related matters with:

- The **geopolitical polarisation and politisation of space**, reinforced by the **war in Ukraine** and its impacts on the European and global space sector and implications for Europe's new ambitions for strategic autonomy.
- Space defence and military space: major developments in EU, NATO and in the U.S. in terms of programmes, strategies and cooperation, including **NATO's overarching space policy**, the **EU's Strategic Compass, European Defence Fund (EDF)** funding for space, space military exercises, national space security and defence strategies and the rising awareness of the relevance of **cybersecurity and resilience of space systems** and of capability development for **responsive space**, as well as the **rising role of commercial actors also to support space for security**.
- Developments in Europe and globally in access to space, with the **European "launcher crisis"** through the loss of Soyuz, further delays of Ariane 6, and the launch failure of Vega C, contrasted by progress and multiplication in European micro-launcher efforts.
- The **ESA Council Meeting at Ministerial Level CM22** in November 2022 with a result of a €16.9 billion budget for the next 3-5 years and new programmes approved – a success within political boundaries but widening the gap between Europe and international space powers.
- The progress on the **EU Secure Connectivity Programme IRIS²**, a push to bring Europe closer to equal footing in low-latency space-based connectivity and secure communications.
- Strategic efforts for **European human spaceflight and robotic exploration by kicking off the High-Level Advisory Group (HLAG)**, tasked by ESA and supported by ESPI. Developments in space exploration and space science, including Europe's long-term space exploration roadmap and strategy **"Terra Novae 2030+"**, the **kick-off of the Artemis Programme** with Artemis I, the **reorganisation of the ExoMars mission**, approval of **European Large Logistics Lander,** the **Moonlight Initiative** and the **Comet Inceptor Mission**, as well as updates on the extension of participation in the ISS and the **completion of China's Tiangong Station**.
- Europe's efforts to foster a wider ecosystem of institutional and commercial space actors and boost commercialisation through the launch of the **Cassini Space Fund**, the creation of ESA's **European Center for Space Commerce (ECSECO)** hosted at ESPI, and the approval of the **new ESA Scale-Up programme**.
- Developments in space safety, sustainability and responsible behaviour in space on European and global level, including an **EU approach for STM**, and the approval of the **FCC's 5-year deadline for LEO satellites deorbiting**.
- New impetus for in-space security through the new **UN OEWG on norms of responsible behaviours**, the U.S.-led **ASAT test ban**, and the **announcement** of the upcoming **EU Space Strategy for Security and Defence** in the Strategic Compass.
- New developments in national **space governance**, space policies, strategies, and laws, including the re-organisation of the Italian space governance, South Korea unveiling a plan for space for the upcoming years, China releasing new priorities.
- And finally, international and bilateral cooperations, including new members and commitments for international initiatives such as the **Artemis Accords**, the **Space Climate Observatory**, the **ASAT test ban initiative**.

Regarding space industry, 2022 has also been quite dense with the advent of major initiatives that define the trend in the medium term:

- **Latest development in satellite connectivity**, highlighting the growth of communication constellations, the ambitions of satellite operators to advance broadband connectivity, 5G/6G and the Internet of Things (IoT) sectors seeing value in satellite connectivity, and the emergence of satellite-to-smartphone connectivity.
- **The emergence of space cybersecurity companies and solutions**, with significant developments driven by companies based in the U.S. as well as few developments in Europe and covering also further developments in the field of satellite-based quantum encryption.
- **Additive Manufacturing (AM) makes its way into the space industry** - with the U.S. leading the Global Additive Manufacturing market, but a remarkable ramp up of Additive Manufacturing in Europe as well as in the Asia-Pacific region.
- **Notable developments in novel energy solutions for (and from) space:** in particular, early investigations and developments in preparing for space-based nuclear reactors and space-based solar power.
- **Boosting of various in-orbit servicing value propositions and technology developments** – with relevant developments in the U.S. and a few developments in Europe, especially in active debris removal.
- **Developments in Commercial Space Situational Awareness (SSA)** – including notable developments in the U.S. and in Europe in increasing companies focusing on and progressing in space safety and security.
- **Developments in the area space as a service:** from emerging to established market, including developments in the three categories Infrastructure-as-a-service, Software-as-a-Service, and Space data as a service.
- **Rising interest in laser communications for military applications** – including SDA, DARPA, AFRL proceeding with parallel projects on laser intersatellite links for the U.S military.
- **Developments in space tourism and private space stations ongoing:** Including Blue Origin fourth, fifth and sixth commercial human suborbital flight in May, June and August 2022 and SpaceX who - in addition to providing the launch services for the Ax-1 mission - is seeking to become a tourism player in its own right through its future Starship system, as well as progresses in commercial space stations.
- **Developments of spaceports toward autonomous access to space in Europe,** with at least 15 commercial spaceports (for vertical and horizontal launches) currently proposed, planned or already under development in Europe - half of them located in the UK, and other spaceports in Norway, Iceland, and Italy.

With regard to the Global Space Economy, 2021 and 2022 are characterised by the following numbers and developments:

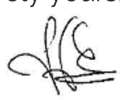
- The **Global Space Economy in 2021** is estimated being worth $386 billion (SIA) and $469 billion Space Foundation) and is comprised of **4 main indicators: 1) Government Space Budgets, (2) Commercial Satellites and Launches, (3) Ground Stations and Equipment, (4) Space Products and Services.**
- With 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 2021 is estimated to be **$107 billion by SIA/Bryce**, **$107.3 billion by the Space Foundatio**n, and **$92.4 billion by Euroconsult**.
- With regards to the **European space budget**, the dedicated section gives an overview on the **consolidated European Space Budget valued €11,925 million** in 2021 and its components, including the national space budgets, as well as the budgets of ESA, EU and EUMETSAT.
- The sections include **European Space Economy Statistics**, including the European space manufacturing industry and the European GNSS and EO sector. The **European space manufacturing industry final sales increased by 11,7% to around €8.620 million (2021)**. The European EO sector sees data revenues of €82 million (15.4% global share) and value-added service revenues of €342 million (15.3% global share), while the GNSS sector devices revenues of €12.1 billion (25.0% global share) and services revenues of €27.4 billion (18.2% global share).
- Finally, the section analyses the **Global Private Space Investment**, including global investment dynamics, the global distribution of investment, and a focus on private investment in China (based on ESPI Space Venture 2022 Report). The Global investment in space ventures in 2022 totalled €8.8 billion (28% decline from the previous year's peak of €12.2 billion), while for Europe, 2022 was another record-breaking year, with more than €1 billion invested in European space start-ups distributed across 112 deals.

Regarding launches, 2022 is characterised by the following numbers and launch highlights:

- **185 launches conducted in 2022** (+28% compared to 2021), thereof 7 launch failures (which makes 3,8% of all launches)
- **2491 satellites launched** (+35% compared to 2021), thereof 2432 satellites launched into LEO, 6 into MEO, 34 into GEO and 19 into other orbits.
- The majority of satellites launched in 2022 were telecommunication satellites (79% of all satellites launched)
- **Top 3 launch countries: 1. U.S., 2. China, 3. Russia**
- Launch highlights of 2022 include the **Artemis I launch**, China's launches to complete the **Tiangong Space Station**, the **first Vega C flight in July 2022** (followed by a launch failure of the second Vega C flight in December 2022), the **launch of the European satellites Meteosat 3rd Generation** and the **Eutelsat Konnect VHTS satellite**, first satellites of African countries launched, OneWeb satellites launched with ISRO.

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

Sincerely yours,



Hermann Ludwig Moeller
Director of the European Space Policy Institute (ESPI)

ABOUT ESPI SPACE SECTOR WATCH AND OTHER REPORTS

As part of its mission, the European Space Policy Institute (ESPI) continuously monitors international space affairs and tracks a selection of indicators in proprietary databases. The ESPI Yearbook series is part of this broader ESPI Space Sector Watch that includes complementary publications.

ESPI Yearbook

The **ESPI Yearbook** is an annual publication providing an overview of major developments and trends in space policy, industry, programmes, and overall worldwide space sector activity over the year.

The Yearbook is organised in four complementary chapters:

- **Policy & Programmes:** space policy highlights and trends, major space programme developments
- **Industry & Innovation:** industry developments including insights on manufacturers, operators, and R&D actors,
- **Economy & Business:** global and European space economy indicators (turnover, budgets, investment) on a global as well as national scale,
- **Launches & Satellites:** space activity statistics, mission highlights and insights derived from ESPI launch database

The ESPI Yearbook does not aim to be comprehensive but rather to provide useful information, data and insights on a selection of topics expected to shape the future of the global and European space sector.

ESPI Yearbook 2022 is the 4th edition of the new ESPI Yearbook series, available for free on our website. Previous editions are available in eBook and Hardcover format on the Springer website.

ESPI Insights

The **ESPI Insights** are a monthly overview of major developments in the global space sector. The publication provides a digest of relevant space news and an overview of official documents, public reports, web articles or conference outcomes.

The ESPI Insights series was designed to be complementary to the ESPI Yearbook series and since 2023 both series follow the same structure.

You can sign up to the ESPI Newsletter through the ESPI website to receive ESPI Insights directly to your mailbox every month. All previous editions are available for free on our website.

ESPI Director's Perspectives

The **ESPI Director's Perspectives** is a newly established monthly editorial established in September 2022 on a topic of particular strategic importance. The monthly edition is also integrated into the ESPI Insights.

Perspectives from 2022 covered the following topics:

- 11/2022: Success within Political Boundaries – But Widening the Gap (Link)
- 10/2022: Energy and Security Crisis: The Future of Space for a Europe at Risk (Link)
- 09/2022 IAC and WSBW 2022: Part of our best Energies and Skills (Link)

ESPI Executive Briefs

ESPI Executive Briefs are regularly published short analyses that provide views of the Institute on outstanding space policy topics.

Topics from 2022 include for example:

- Meteosat – A Successful Model of European Cooperation in Space (ESPI Brief 62, December 2022)
- IRIS2: The new (material) girl on the block (ESPI Brief 61, December 2022)
- Rising opportunities in the Satellite Connectivity market: Eutelsat and OneWeb combination (ESPI Brief 60, December 2022)
- Towards a slowdown of European New Space Investment? (ESPI Brief 59, August 2022)
- The urgent need for sustainable EU-UK relations in space (ESPI Brief 58, June 2022)
- The War in Ukraine and the European Space Sector (ESPI Brief 57, May 2022)
- ESA Accelerators: challenges and opportunities (ESPI Brief 56, April 2022)
- Global EEE supply chain disruptions and implications for the space sector (ESPI Brief 55, March 2022)

All ESPI Executive Briefs are available for free on our website.

ESPI Reports

ESPI Reports offer an in-depth perspective and analysis on one specific topic or issue. Written by our Research Fellows, they combine thorough independent analysis with vision in order to formulate policy advice and recommendations.

Recent Reports from 2022 include:

- The War in Ukraine from a Space Cybersecurity Perspective (Report 85, October 2022)
- Green applications of space-borne sensing on the rise (Report 84, October 2022 with EPO and ESA)
- Space Venture Europe 2021 (Report 83, June 2022)
- Space Environment Capacity (Report 82, April 2022)
- Space Education in Europe (Report 81, March 2022)
- Space in Support of Security Missions (Report 80, February 2022)

All ESPI Reports are available for free on our website

1 POLICY & PROGRAMMES

1.1 Highlights and key developments at EU, ESA and National levels

1.1.1 ESA, EU and National budgets and priorities for space

In 2022, ESA and EU fuelled European space ambitions with budgets for new programmes. At the ESA Ministerial Council Meeting CM22, ESA drew a record budget of €16.9B for the next 3-5 years with several new programmes.

ESA Council Meeting at Ministerial Level CM22: strong support for European space

On November 22nd and 23rd, the ESA Ministerial Council Meeting CM22 took place in Paris, chaired by Germany and hosted by France. ESA drew Member State subscriptions of €16.9B (17% increase compared to the €14.4B drawn at CM19) for the next 3-5 years, with the four main contributors (~70% of total budget) being Germany (€3.5B), France (€3.2B), Italy (€3B) and the UK (€1.8B). All programmes proposed were approved. The €16.9B budget was allocated as follows, with the figure related to Space Science indicating a 5-year period, and all other encompassing a 3-year period:[1]

Space Science (€3.2B):

- For the implementation of missions of the Cosmic Vision programme
- For preparing the new Voyage 2050 programme
- For the launch of Juice and Euclid in 2023
- For the extrasolar planet exploration missions Plato and Ariel to launch in 2026 and 2029

Human and Robotic Space Exploration (€2.7B):

- For the next phase of Terrae Novae, and as part of this, the large logistics lander "Argonaut"
- For the extension of European participation in the ISS up to 2030
- For work on the next batch of ESMs and reinforced role of ESA in Artemis (incl. flights of 3 ESA astronauts to the Lunar Gateway and for a continuation to build ESA's elements of the Gateway)
- To support the development of international lunar services with the Lunar Pathfinder satellite
- For building a European lander to take the Rosalind Franklin (€360M) rover to the surface of Mars (ExoMars mission) cooperation with NASA was envisaged, and the next steps were confirmed for ESA's cooperation with NASA on Mars Sample Return.

Earth Observation (€2.7B):

- For the continuity of the space component of Copernicus
- For the Aeolus-2 mission
- For the InCubed-2 initiative
- Development of a digital twin Earth model
- For continuing the TRUTHS mission
- For expanding the network of third-party EO missions
- For the continuation of FutureEO (Earth Explorer missions)

[1] Ministers back ESA's bold ambitions for space with record 17% rise, ESA Corporate News, November 2022

Connectivity (TIA) (€1.9B):

- For the Artes Programme
- ESA contribution for IRIS²: for the first phase €35M for preparatory activities that will lead to the development and validation of the constellation are firmly subscribed. As for the second phase, €685M are due to be confirmed in 2023.
- Funding for the Moonlight programme.
- Funding for Civil Security from Space (CSS) Programme.

Navigation (€351M):

- For the FutureNAV programme, incl. a LEO-PNT-satellites in-orbit demonstration and the single satellite mission "GENESIS".
- For continuation of the NAVISP programme.

Space safety (€731M):

- For Vigil to monitor the Sun's activity.
- For Hera probe that will perform a detailed post-impact survey of the Dimorphos asteroid.
- For the first removal of space debris from orbit scheduled for 2026.
- For core activities, including kick-starting a new market for in-orbit servicing, while developing. new technologies to help ensure a sustainable, circular economy in space.

Space transportation (€2.8B):

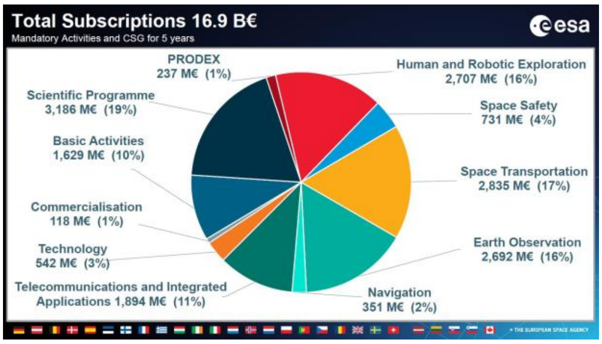
- For further strengthening Ariane 6 and Vega-C deployment & ramp-up.
- For completion of the development of the reusable Space Rider.
- For developing a green hydrogen system to fuel Ariane launchers in Kourou.
- For preparatory activities for human space transportation capabilities.
- For increasing the efforts of the ESA Boost! Programme.

Technology (542M):

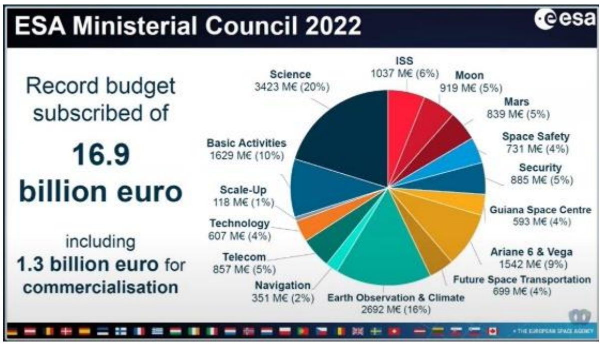
- For funding early-stage technology developments and studies via its Discovery and Preparation elements, and the Technology Development Element, developing early prototypes and laboratory versions of new technologies.
- Two new components added to GSTP: (1) EEE Space Component Sovereignty for Europe and (2) ENDURE (EuropeaN Devices Using Radioisotope Energy)
- SOLARIS to advance key technologies for Space-Based Solar Power plants

Commercialisation (118M):

- For the kick-off of the new programme "ScaleUp" to support space commercialisation.
- For the development of a European New Space ecosystem.



Credit: ESA



Credit: ESA

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New European Space Flagship Programme: EU Secure Connectivity Programme IRIS²

Credit: EUSPA

In 2022, the EU Secure Connectivity Programme IRIS² was proposed as a new EU Flagship Programme. It aims to be (1) an innovative multi-orbital space-based connectivity system, offering reliable secure and cost-effective communications services. The key objectives are to (1) ensure worldwide access to secure governmental satellite communication services for the protection of critical infrastructures, surveillance, external action and crisis management, and to (2) enable the provision of commercial services by the private sector, by allowing the availability of high-speed broadband and seamless connectivity throughout Europe, removing dead zones. The Programme is based on 3 pillars: (1) Connecting key infrastructures, (2) Crisis management and external action, and (3) Surveillance. On April 28th, the **European Parliament Committee on Budgets released a draft opinion on the Secure Connectivity Programme (2023-2027)**, welcoming the new initiative, but highlighting that this programme was not foreseen in the current EU's MFF 2021-2027. The European Parliament proposed €1.7 billion for the programme, consisting of funds drawn from unallocated funds of the MFF, complemented by funding implemented under Horizon Europe and EU Space Programme, and additional financial contributions from Member States.[2] On June 29th, the **Council adopted a negotiating mandate** on the proposal for a regulation on the Secure Connectivity Programme. The Council stated several changes to the Commission's proposal, including clarifying EUSPA and ESA's role in supporting the programme, setting out support measures expected from the Commission, setting out different phases and activities of the programme, and clarifying budgetary allocations opting not to set specific amounts to allocate towards Secure Connectivity from other programmes, but instead choosing to only give a total amount which should be allocated to Secure Connectivity.[3] On October 27th, **the trilateral negotiation between the European Parliament, the European Commission and the Council of the EU** on the EU legislation for the Secure Connectivity programme began, with a provisional agreement reached by November 17th, including the decision to name the Programme "IRIS²" ("Infrastructure for Resilience, Interconnectivity, and Security by Satellite"). The Commission will be the owner of (in)tangible assets relating to governmental infrastructure. Infrastructure will be developed through public-private partnerships, and the programme will also use commercial infrastructure to provide the services. **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.[4] In particular, through the existing MFF, the EU allocating a budget of €1600 million from 2023 to 2027. Considering that the MFF did not foresee this new programme, its budget would have to be sourced from reductions in other programmes, including €400 million from the EDF and €260 million from the EU Space Programme. An additional envelope of €800 million would serve as a contribution to the Secure Connectivity System, to be implemented under Horizon Europe (€430 million), EU Space Programme (€220 million) and the Neighbourhood, Development, and International Cooperation Instrument (€150 million). This brings the total contribution of the EU up to €2400 million until 2027. IRIS² will be developed from 2023 onwards, with initial services to begin end of 2024, and full operational capability ambitiously expected by 2027.

[2] Draft Opinion of the EP's Committee on Budgets for the Committee on Industry, Research and Energy on the proposal for a regulation of the European Parliament and of the Council establishing the Union Secure Connectivity Programme for the period 20232027 (COM (2022)0057 – C9-0045/2022 – 2022/0039(COD)), European Parliament, April 2022
[3] Proposal of the Council for a Regulation of the European parliament and of the Council establishing the Union Secure Connectivity Programme for the period 2023-2027 - Mandate for negotiations with the European Parliament, June 2022
[4] Commission welcomes political agreement to launch IRIS², the Union's Secure Connectivity Programme, Press release European Commission, November 2022

EU Space Programme received €2 billion out of the €12 billion Horizon Europe budget for 2023

On November 23rd, the European Parliament voted on the EU budget for 2023, including the allocation of the €12.4 billion budget for Horizon Europe - 1.1% more than in 2022. The **EU Space Programme got a budget of €2 billion**. Moreover, on top, "Digital, Industry and Space" gets a budget of €1.07 billion, and "Civil Security for Society" €164 million, with several projects using satellite products from the EU Space Programme. The EDF €319.3 million, "Digital Europe" €1.3 billion and Invest EU €340.7 million, which all hold minor space-related elements.[5]

14th European Space Conference: EU Commissioner Thierry Breton on EU priorities for 2022

On January 25th, EU Commissioner for the Internal Market Thierry Breton opened the 14th European Space Conference and **outlined his 4 priorities of the European Commission for 2022.**[6]

1. Consolidate existing assets and initiatives:

- Expected launch of the first Galileo 2nd generation satellite in 2024.
- Develop a modernisation strategy for Copernicus to face the competition from private actors.
- Develop a European launcher strategy and to formally launch the European Space Launcher Alliance to define a technological roadmap and a holistic European approach to launchers.

2. Prepare and project Europe into the realities of tomorrow:

- Presenting a legislative proposal on the secure connectivity infrastructure to Member States and the European Parliament.
- Launching an initiative to define a European strategy for Space Traffic Management.

3. Develop a strategy to spur innovation in space:

- Need to develop a strategy to boost innovation in space through the first ever Space Partnership, which brings together industrial, public, and academic stakeholders to define technological roadmaps, long-term plans, and coordinate investment in space innovation.
- Utilisation of public procurement to boost innovation and support private companies and to test new solutions and stimulate the launcher ecosystem.
- Launch of the flight ticket initiative to support mini- and micro-launcher development.
- The European Commission and the European Investment Bank signed a joint letter to start the €1 billion CASSINI Space Investment Fund to provide investment capacity for space start-ups.

4. Give a defence dimension to the EU space policy:

- Expanding the defence dimension in existing and upcoming infrastructures, including Copernicus, the secured connectivity initiative and STM.
- Need to develop dual-use infrastructures by design in order to better integrate the needs of the defence community.
- As part of the Strategic Compass, announcing an upcoming release of a EU Space Strategy for Security and Defence in 2023.

Priorities of the Presidencies of the EU Council 2022-2023

In 2022, priorities were set, and developments were pushed in European space policy by the Presidencies of the Council of the EU France (January-July) and the Czech Republic (July-December). Moreover, Sweden released the programme and its priorities for space of its upcoming EU Presidency from January-July 2023, in December 2022.

[5] Horizon Europe to get €12.4B budget for 2023, Science Business, November 2022
[6] Speech by Commissioner Thierry Breton at the 14th EU Space Conference, European Commission, January 2022

EU Council Presidency		Time Period	Priorities
France	FRANCE22	January 1st – June 30th 2022	• Work with its partners to define the European large constellation project proposed by the EU Commission • Develop a common vision on Space Traffic Management • Establish the European Launcher Alliance • Develop the EU Strategy for Space, Security and Defence[7]
Czech Republic	EU2022.CZ	July 1st – December 31st 2022	• Make the EU Space Programme a key priority to realise security ambitions and tackle security challenges • Strengthen EU defence capabilities and cybersecurity infrastructure using capabilities from the European Space Programme • Negotiate with EU Parliament on the regulation for establishing the EU Secure Connectivity Programme[8]
Sweden	sweden2023.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[9]

Table 1: Priorities of the EU Presidencies for Space

Major updates on national space budgets of European countries

Recent years have also seen increased budgets devoted to space at national level, beyond established national programmes and ESA PROGRAMMES. This was largely **driven by national resilience and recovery plans**, as part of the post-Covid-19 economic recovery measures. In this context, Italy, France and Spain stand out with some notable developments the year prior.

In **Italy**, the Minister of Technological and Digital Innovation announced that Italy reserved a budget of €4.5 billion, financing Italy's contribution at the ESA CM22, and the development of its national space sector over the period 2021-2026, with a national budget of €2.3 billion, used to boost SatCom (€320 million), EO (€1.07 billion for **IRIDE**), Space Transportation and In-Orbit Servicing.[10] At the end of 2022 the **first tranche of contracts for its IRIDE constellations** of EO satellites was approved.

France continued conducting its space policy focused on three strategic objectives: (1) to strengthen European sovereignty, in particular in the field of launchers; (2) to help the domestic industry position itself in new markets like the constellations market, particularly by significantly increasing telecommunications and EO budgets, and (3) to improve space's contribution to the fight against climate change and applications benefiting the public. France announced it will allocate €9 billion over the next 3 years to its space policy (including a €3.2 billion ESA contribution, and funding

[7] Programme of France EU Presidency – UE France22, December 2021
[8] Programme of the Czech Presidency of the Council of the EU – EU2022.CZ, July 2022
[9] The Swedish Presidency Programme – Sweden2023.EU, December 2022
[10] Italy's Strategy and Position at the next ESA's CM-22, Spacewatch global. October 2022

for CNES increased by €285 million over the next three years).[11] Under the **France 2030** programme, two initial batches of **15 and 5 projects respectively were selected in December 2022**, with projects ranging from SSA, in-orbit services, and launcher development. The overall budget devoted to space under France 2030 is set at €1.5 billion.

Spain prepared the development of the national space agency and pushed forward space-related projects, the **Constelación Atlántica**, which will deploy 16 small platforms in space, the Spainsat NG comprised of two large secure communications satellites, and the Arrakihs scientific probe.[12] The Constelación Atlántica, announced in 2022, is part of the Spanish **Strategic Projects for Economic Recovery and Transformation (PERTE)** devoted to aerospace, and is done in cooperation with Portugal who is deploying its own recovery funds to the cause. The project was highlighted at the 33rd Spanish-Portuguese summit held on 4 November 2022.

1.1.2 Revived European interest in robotic and human space exploration

In 2022, Europe re-focused on its future in robotic and human space exploration, in particular human spaceflight, including European autonomous and independent access to space. This revived interest was expressed at the European (joint ESA and EU) Space Summit in February 2022, where an initial call by the French President Emmanuel Macron was made to set up a High-Level Advisory Group (HLAG) for Human Spaceflight and Exploration. from summer 2022 on and further manifested in the ESA CM22 with milestone approvals of future European robotic exploration missions.

European Space Summit pushed for action on ESA Inspirators

Credit: ESA

On February 16th, the **European Space Summit took place in Toulouse** under the French Presidency of the EU[13], comprised of two parts.

The first part of the Summit was an **informal EU Competitive Council Meeting on Space**, attended by ministers and their representatives from EU Member States as well as the European Commission. The Member States agreed to work on proposals in order to increase Europe's operational STM capabilities and establish common rules at EU level for STM and welcomed the EC's proposal for a regulation on the EU Secure Connectivity Programme (for 2023-2027).

The second part of the Summit was **an ESA Council Meeting,** attended by government ministers and their representatives from ESA Member States. The Member States outlined the need to define the future European space exploration policy and reaffirmed their support for the three "Accelerators" (1) Space for a green future; (2) Rapid and resilient crisis response; (3) Protection of space assets, and the two "Inspirators" initiatives, (1) the icy moon sample return mission; and (2) Human space exploration, defined by ESA in the Matosinhos Manifesto. As an action for the Human Space Exploration Inspirator, the Member States welcomed the proposal of the creation of a high-level advisory group (HLAG) on space exploration and human spaceflight.[14]

[11] Council of Ministers – France's space policy – Statement, France in the UK, November 2022
[12] Spain makes its way into ESA with Constelación Atlántica, Arrakihs and Spainsat NG, Atalayar, November 2022
[13] Decisions from the 2022 Space Summit, ESA News, February 2022
[14] European Space Agency Council Information document Council Resolution on "Accelerating the Use of Space in Europe" (Matosinhos Manifesto), November 2021

ESA creates High Level Advisory Group (HLAG) for Human Spaceflight and Exploration

Based on the proposal welcomed at the Space Summit and following the decision taken by the ESA Council in March 2022, ESA Director General Josef Aschbacher received the mandate to establish a High-Level Advisory Group (HLAG) on Human and Robotic Space Exploration for Europe.[15] The HLAG's overarching mandate was to provide ESA Member States with an independent and objective high-level assessment regarding the **(geo)political, economic and societal relevance of human and robotic space exploration for Europe** and recommended options for a way forward. The group met in September and in November 2022, and in early 2023, with a final report published in March 2023.[16]

ESA presents new generation of astronauts

Following ESA's CM22, **ESA presented the new ESA astronaut class, comprised of 17 astronauts**. Thereof, 5 career astronauts, namely Sophie Adenot (France), Pablo Álvarez Fernández, (Spain) Rosemary Coogan (UK), Raphaël Liégeois (Belgium) and Marco Sieber (Switzerland) were selected, who will start training full-time at the EAC in Germany in April and will join ESA's 7 current career astronauts after one year of basic training. For the first time, ESA selected a "parastronaut", John McFall, a British doctor and Paralympian. The remaining 11 candidates of the astronaut class will serve in reserve.[17]

Europe's access to the Moon: Argonaut Lander, Moonlight and further contributions to Artemis

Moreover, Europe enters the Moon race, as a partner in the Artemis Programme as well as by kick-starting its own European initiatives, namely the large logistics lander "Argonaut" and the "Moonlight" initiative. At ESA CM22, ESA Member States agreed on the **development of the large logistics lander "Argonaut"** for Europe's autonomous cargo capabilities to the Moon und on the Moonlight Programme.[18] Argonaut's design is suitable for a series of missions and is able to carry various payloads, such as a rover, a cargo and infrastructure delivery, or a power station, and is planned to be able to land at any region on the Moon. Argonaut consists of three main components: the lunar descent element to fly to the Moon and land on target, the cargo platform element which serves as the interface between lander and payload. The Argonaut lander will use navigation and telecommunication capabilities around the Moon provided by **ESA's Moonlight communication network**, for fast communication and data exchange with the Gateway and Earth and for location finding for Argonaut's automated landing. In the Moonlight initiative, which was also approved at ESA CM22, ESA through a partnership with commercial European companies aims to put a constellation of telecommunications and PNT satellites around the Moon. Moreover, with regard to **European participation in Artemis**, at ESA CM22, ESA Member States agreed on the work for the next batch of ESMs and ESA's reinforced role of in Artemis, including flights of 3 ESA astronauts to the Lunar Gateway and for a continuation to build ESA's elements of the Gateway.[19]

Reorganisation of the ExoMars Mission

With regard to the **restructuring of the ExoMars mission without Russia's participation**, ESA agreed on measures to replace contributions initially planned to be delivered by Russia, including building a European lander to take the Rosalind Franklin rover to the surface of Mars, in the range of €360M, and further cooperating with NASA, especially for the mission launch.[20]

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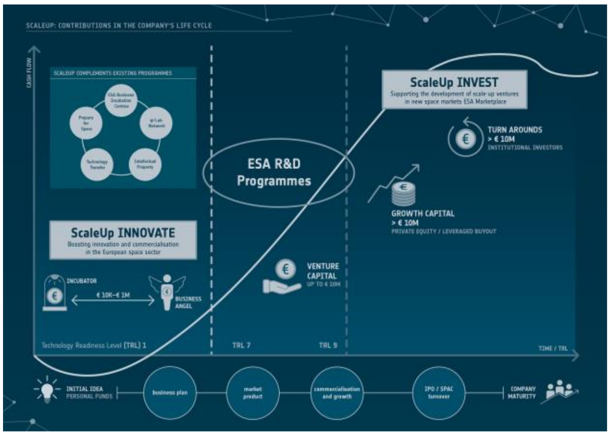
[15] ESA to embolden Europe's space exploration, ESA News, July 2022
[16] Revolution Space - Report of the HLAG on Human and Robotic Space Exploration for Europe, March 2023
[17] ESA presents new generation of ESA astronauts, ESA News, November 2022
[18] Ministers back ESA's bold ambitions for space with record 17% rise, ESA News, November 2022
[19] Ministers back ESA's bold ambitions for space with record 17% rise, ESA News, November 2022
[20] Ministers back ESA's bold ambitions for space with record 17% rise, ESA News, November 2022

1.1.3 Europe boosts commercialisation and use of space

In 2022, Europe's ambitions towards commercialisation received a boost through new financing initiatives and platforms launched by ESA and the EU. Namely ESA's ScaleUp Programme, the EU's Cassini Initiative, and the European Centre for Space Economy and Commerce (ECSECO).

ESA launched a full-fledged commercialisation programme "ScaleUp"

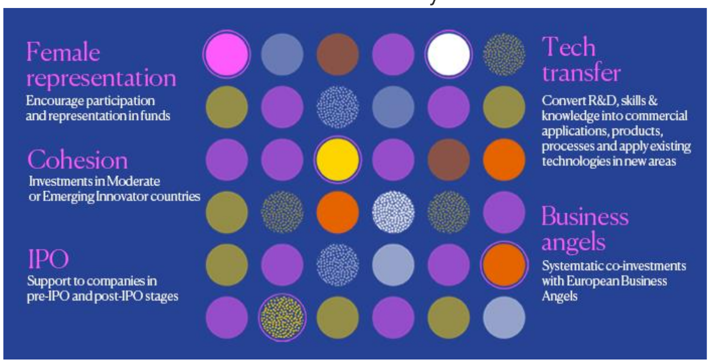


Credit: ESA

At the ESA Ministerial Council Meeting in November 2022, **Ministers pledged €117.6M to ESA's ScaleUp programme**.[21] Member States oversubscribed by 17%. ScaleUp is a new programme under the helm of the ESA Directorate of Commercialisation, Industry and Procurement. Divided into two pillars, (1) "Innovate" and (2) "Invest", ScaleUp aims to boost entrepreneurship and commercialisation across all ESA programmes by supporting companies throughout their life cycles. The **pillar "Innovate"** aims to boost innovation and commercialisation by supporting the innovation process to develop space products/services upstream in the space market or downstream for other industrial use. "Innovate" is comprised of three elements, the ESA Business Incubation Centres (BIC) Network, Φ-Labs Network and the ESA Technology Brokers. The **pillar "Invest"** aims to support the scale-up of companies and will is comprised of two elements, the Accelerator Pool and the ESA Market Place. ESA will act as an external support to business development as an enabler or a customer.

The European Investment Fund launched the CASSINI Space Investment Facility

In January, at the 14th European Space Conference, officials from the European Commission, the European Investment Bank and the European Investment Fund confirmed and **committed to the CASSINI Space Investment Programme**. In line with this, ESA, EUSPA, the EIB and the European Commission signed a MoU[22] on principles of cooperation to support SMEs in the space sector, fostering information exchange and engaging in joint space entrepreneurship's cross functional actions. In April, the **European Investment Fund (EIF) officially launched the CASSINI Space Investment Facility**[23], enabling risk capital investments in space-related companies at the level of €1 billion or more for the next six years. The EIF also launched a call for expression of interest to select eligible financial intermediaries under the framework InvestEU for providing equity investments in support of innovation, growth, and social impact. The call mostly targets private equity, venture capital funds, fund-of-funds, cross-over funds, co-investment schemes, special purpose vehicles that carry out long term risk capital investments.



Credit: European Investment Fund

[21] Commercialisation of space boosted at ESA Ministerial Council, ESA News, November 2022
[22] EU Space: Further cooperation to support space entrepreneurship in Europe, European Commission News, January 2022
[23] Launch of the CASSINI space investment facility, European Commission News, April 2022

ESA and ESPI launched the European Centre for Space Economy and Commerce (ECSECO)

In April, ESA announced the **creation of a European Centre for Space Economy and Commerce (ECSECO)**[24] hosted at the European Space Policy Institute in Vienna. ECSECO's purpose is "to serve as a European forum for interdisciplinary discussions and research on space economy and commerce" and to provide a platform in which professionals with diverse backgrounds and working in the space economy and commerce field can discuss, network, collaborate, and carry out activities. The launch event of ECSECO took place on July 4th and the first ECSECO General Assembly meeting in November 2023.

Further Progress on the Accelerators

The three Accelerators were further developed and defined by in 2022. The Accelerators aim to provide new ways of cooperation and action for a more accessible, open, and user-driven space sector. Accelerating the use of space to address the various societal challenges requires a new user-driven approach.


Space for a green future


Rapid and resilient crisis response


Protection of space assets

The Accelerators respond to European policy priorities and direct efforts in space solutions and services towards the attainment of these objectives, for the benefit of European policymakers and citizens alike. The Accelerators address three action areas, (1) the identification of new use cases, (2) the development and demonstration of new (space) solutions, and (3) the scaling of these solutions to new sectors and regions.[25]

ESA sets up New Space Advisory Board

To further reinforce ESA's role and actions in the European New Space ecosystem, Josef Aschbacher appointed in April 2022 the New Space Advisory Board (NAB) - a senior body of high-level representatives from companies that are following a New Space approach in their business execution. The NAB's objective is to share lessons learned and provide recommendations for ESA's commercialisation policy and ESA's transformation process to adapt to the New Space needs.

The NAB members are Benoit Deper (AerospaceLab), Luc Piguet (ClearSpace), Cassi Welling (constellr), Luca Rossettini (D-Orbit), David Henri (Exotrail), Philippe Gautier (Hemeria), Rafal Modrzewski (Iceye), Daniel Metzler (Isar Aerospace), Aleix Mégias (Open Cosmos), Juan Tomas Hernani (Satlantis), Theresa Condor (Spire), Peter Taubenreuther (STT-SystemTechnik).[26]

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[24] Creation of the European Centre for Space Economy and Commerce, ESA News, March 2022
[25] Accelerators: a vision and call for action, ESA Vision 2023.
[26] ESA Director General appoints the New Space Advisory Board (NAB), ESA News, April 2022

1.1.4 Finding a balance in EU-UK relations following Brexit

Credit: ESA

EU-UK relations after Brexit remain difficult and the impacts on the wider European space ecosystem were increasingly clear throughout 2022. While on route to resolution, the participation of the UK in the EU's Horizon Europe programme and its participation the EU Space programme was a recurring subject of discussions in 2022. In June, ESPI published the Executive Brief 58 "The urgent need for sustainable EU-UK relations in space" on this difficult relation and impacts on European cooperation in space.[27]

UK participation in the EU Space Programme and Horizon Europe

EU-UK relations are regulated by the Trade and Cooperation Agreement (TCA), originally signed on December 31st 2020, and then updated on April 30th 2021, in order to better define their reciprocal obligations. Space is one among many areas referred to in the TCA. The agreement addresses the topic of UK participation in the EU Space Programme[28], by setting up **a two-pillar mechanism**:

- Establishment of a Specialised Committee on Participation in Union Programmes to discuss and adopt two Protocols containing norms on UK participation in specific EU programmes.
- Provision of a UK contribution to each programme in which it aims to participate.
- This mechanism was created because some EU programmes were still unsettled at the date of the stipulation of the TCA, so the discussion on UK participation had to be postponed.[29]

The UK has been excluded from the Public Regulated Service of Galileo and EUSPA under Art. 127 of the Withdrawal Agreement (WA) and the UK now only access to the open signal as a third country. Moreover, the UK has left the EU SST Consortium pursuant to Art. 127 of the WA and lost access to SST services from January 2022 because of the pending adoption of Protocol II to the TCA.[30] Also, the UK no longer participates in EGNOS. The UK's participation in Copernicus, regulated by Protocol I to the TCA, has been in question, with both the EU and UK unable to come to an agreement for UK participation in EU programmes. This has led to a funding shortfall in 2022, for the Copernicus programme. The UK remains a member of ESA and continues to participate in the Copernicus Space Component (CSC-4) of the Copernicus programme through ESA.[31] The UK association with Horizon Europe has been similarly uncertain due to the pending adoption of Protocol I to the TCA. While initially granting UK entities access to the calls, the Commission has suspended the right of signing the grant agreements until association with the programme is formalised, consequently reallocating the leading positions to non-UK members of the consortia. The exclusion from Horizon Europe would also mean the UK would not be able to take part in the European Quantum Communication Infrastructure (EuroQCI) initiative, despite the leading role of its companies, such as ArQit, in quantum key distribution.[32] On December 19th, the British government announced the extension of the funding to the eligible UK applicants to the Horizon Europe, which will guarantee financial support to all UK researchers for the calls that close on or before March 31st 2023 and represents a temporary solution to the UK exclusion from Horizon Europe since 2021. The UK government confirmed its intention to continue pushing for its association to the programme, while at the same time working on transitional measures to be implemented in case the association is not possible.[33] The UK membership of EUMETSAT and the European Centre for Medium-Range Weather Forecasts (ECMWF) has been remaining unaffected.

[27] The urgent need for sustainable EU-UK relations in space, ESPI Executive Brief 58, June 2022
[28] UK involvement in the EU Space Programme, Government of UK, August 2022
[29] The urgent need for sustainable EU-UK relations in space, ESPI Executive Brief No 58, June 2022
[30] The urgent need for sustainable EU-UK relations in space, ESPI, Executive Brief No. 58, June 2022
[31] ESA offers the UK alternatives to Copernicus project, Spacewatch Global, June 2022
[32] Quantum and Space: The ultimate solution to secured communications?, ESPI, Executive Brief No. 51, June 2021
[33] UK extends funding support for its Horizon Europe research applicants, Reuters, December 2022

UK launched own national funds and initiatives for the UK space sector

In 2022, the **UK launched several new national funds to boost the UK space sector** and support UK space missions and projects. These include:

In September, the **UK Space Agency launched a new Enabling Technology Programme (ETP) with approx. £15 million** to support innovative and emerging space research and technologies in the UK space sector. Moreover, the UK Space Agency awarded ClearSpace and Astroscale £4 million to design space debris removal missions towards the UK's first national space debris removal mission launch in 2026.[34]

Moreover, the UK Defence Science and Technology Laboratory (Dstl), the UK Space Agency and the Defence and Security Accelerator (DASA) awarded a £1 million overall funding in contracts to five innovative organisations through the Space to Innovate Campaign "Bravo Drop", to boost development of technologies to enhance the UK's space capabilities. The Space to Innovate Campaign Bravo Drop is a joint initiative between the UK Dstl, UKSA and UK DASA.[35]

UK fostering space cooperation with established international partners

Beyond, the **UK notably intensified relations with its other established international partners**, such as the U.S., Australia and with other nations of the Five Eyes Alliance, as well as with India. Agreements include:

In April, the U.S. and UK Space Commands signed an MoU for Enhanced Space Cooperation, based on the U.S.-UK Statement of Intent between the U.S. DoD and the UK MoD from 2021. The agreement aims to optimise resources, increase assurance and resilience of missions and includes information exchange, reconciling military space requirements, and the identification of potential collaborations.[36]

Moreover, in May, the UK MoD awarded the UK-based SSA specialists Northern Space and Security Limited (NORSS) and the Australian company Nominal Systems a $1 million contract of 1,5-year duration to develop ARTSIM, a spacecraft and missions simulator solution, to support the UK MoD's future satellite operational plans to provide a modular, data representative satellite simulation architecture.[37] Also in May, the **UK and the U.S. Ministries of Transport signed a partnership agreement to enhance spaceflight opportunities and to mutually benefit from operating from each other's spaceports** – working together on future commercial spaceflight missions, in particular on commercial space launch licensing.[38]

In July, the UK and U.S. discussed how to further strengthen cooperation based on the MoU from April. The UK Royal Airforce mapped out priorities for the next 3 years to increase cooperation with the U.S. Moreover, the UK Royal Airforce and the Republic of Korea Air Force (ROKAF) signed a Terms of Reference, which outlines future space cooperation between the UK Space Command and the ROKAF. The agreement opens bilateral talks on the integration of space capabilities and to boost defence space cooperation.[39]

[34] £4m projects to clear space debris, eenews Europe, September 2022
[35] £1 million in contracts awarded to enhance the UK's space capabilities, Gov.UK, July 2022
[36] USSPACECOM and UKSpaceCom sign space cooperation agreement, Spacewatch global, April 2022
[37] UK Defence contracts UK-Australian collaboration to enhance capabilities, Spacewatch global, May 2022
[38] Landmark partnership between the U.S. and UK to launch new era of spaceflight, Gov.UK, May 2022
[39] South Korea & UK Outline Future Space Cooperation, Orbital Today, July 2022

1.2 Developments in National Space Governance, Policy and Law

1.2.1 New space policies, laws, and strategies

In 2022, several countries went through major updates with regard to national policies, organisational frameworks or laws related to space activities, with observable sharpened priorities (sustainability, security) & expanding horizons (cislunar, in-orbit services) in national policies. 2022 saw a large number of **domain-specific space strategies launched, for instance space security (and defence) strategies or strategies related to exploration or sustainability**. All security and defence related space strategies or space policy documents are included the following section 1.3 Space Defence and Military Space in the subsection 1.3.2 Increased public policy awareness of defence & military dimensions of space. The strategies related to **exploration** are included in the sections 1.1.2 Revived European interest in robotic and human space exploration and in 1.7.1 Planetary Exploration and Space Science.

Developments in Europe

Wales unveiled its National Space Strategy "Wales: A Sustainable Space Nation"

In February, the Welsh Government released its National Space Strategy "Wales: A Sustainable Space Nation", which highlights the country's vision of becoming "the world's first sustainable space nation leading the way to a greener space" by 2040, including the development of greener fuels and reusable technology. The strategy sets out areas in which Wales aims to grow, including spaceflight, in-space manufacturing and recovery of space vehicles, test and evaluation ecosystem, advanced manufacturing capability and emerging clusters, EO, research and teaching facilities.[40]

Luxembourg released National Space Strategy and Defence Space Strategy

In December, Luxembourg released its National Space Strategy 2023-2027 titled "Focus on Sustainability", prioritising sustainable development as its key agenda item. This new space strategy aims to develop existing and new skills for economic and environmental sustainability, with a responsible approach to activities in space. The 4 priorities are: (i) Economic sustainability; (ii) Sustainability on Earth; (iii) Sustainability in Space; (iv) Sustainable use of space resources through the support to the Spaceresources.lu initiative, and positioning ESRIC as a hub for sustainable space resource utilisation while continuing international engagement. Also, earlier in February, Luxembourg released the Defence Space Strategy[41], which is described in more detail in section 1.3.2 Increased public policy awareness of defence & military dimensions of space.[42]

Lithuania released Space Sector Development Concept

In July 2022, the Lithuanian Space Sector Development Concept was introduced. According to the Strategy, vision for Lithuania is to become a provider of competitive space downstream services, a provider of upstream products and technologies created by leveraging world class research in advanced technologies. Additionally, Lithuania aims to become an integral part of ESA, EU and other international space cooperation frameworks.[43]

[40] Wales: a sustainable space nation, Space Wales Leadership Group and Space Wales network, February 2022
[41] Defence Space Strategy 2022, the Government of the Grand Duchy of Luxembourg, Ministry of Foreign and European Affairs, February 2022
[42] 2023-2027 National Space Strategy "Focus on Sustainability", Luxembourg Space Agency, December 2022
[43] Lithuania is ready to strengthen its role in the space technology revolution, Ministry of the Economy and Innovation of the Republic of Lithuania, July 2022

The Netherlands released Letter on Space Policy (2023-2025) and Defence Space Agenda

Moreover, in October, the Dutch Ministry of Economic Affairs and Climate Policy published a letter to Parliament on Space Policy[44], including the NSO advice on space policy in the period 2023-2025. In November, the Dutch Ministry of Defence released its Defence Space Agenda. The plan aims to increase strategic autonomy by developing and operating a satellite constellation of small/micro satellites that provide military relevant ISR information, while reducing reliance on external communication, navigation, and EO capabilities. The strategy is described in more detail in section 1.3.2 Increased public policy awareness of defence & military dimensions of space.[45]

UK released Plan for Space Sustainability, Defence Space Strategy and Space Power Doctrine

The UK introduced a plan with new measures to drive space sustainability, including a "Space Sustainability Standard", reviewing the regulatory framework for orbital activities to incentivise Active Debris Removal and In-Orbit Servicing. Moreover, in 2022, the UK released its Defence Space Strategy[46] and the first edition of the Joint Doctrine Publication (JDP) 0-40 "UK Space Power", which provides a UK military perspective on space and highlights the relevance of space as an operational domain. Both documents are described in detail in 1.3.2 Increased public policy awareness of defence & military dimensions of space.[47]

German BDI published NewSpace Germany report with recommendations for action

Mid of July, the German industry association Bundesverband der Deutschen Industrie (BDI) published the Report "New Space Made in Germany – Handlungsempfehlungen für eine ambitionierte Agenda". The report presents and recalls the BDI's NewSpace Initiative, traces 10 strategic-operational recommendations for action and outlines 7 areas of action: (1) Sustainability, Climate Protection and Agriculture, (2) State as Customer, (3) Security and Defence, (4) Industry 4.0, Cybersecurity and Connectivity, (5) Mobility and Automotive, (6) Law Framework, (7) Sustainability in Space.[48]

Credit: BDI

Slovenia passed space activities legislation

In March, Slovenia's Parliament passed the space activities legislation, an act regulating space activities, including the creation of a space object registry and a permit system. The act aligns with international rules and sets up national authorization procedures for launch.[49]

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[44] Letter to Parliament on the action plan on policy coherence for development, Government of the Netherlands, November 2022
[45] Netherlands MoD publishes Defence Space Agenda, Janes.com, November 2022
[46] Defence Space Strategy: Operationalising the Space Domain, Gov UK, Ministry of Defence, February 2022
[47] Joint Doctrine Publication 0-40, UK Space Power, Gv UK, Ministry of Defence, September 2022
[48] Report "New Space Made in Germany – Handlungsempfehlungen für eine ambitionierte Agenda, Bundesverband der Deutschen Industrie (BDI), July 2022
[49] Parliament confirms space activities legislation, Slovenia Times, March 2022

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., China, South Korea and Canada.

South Korea unveils new plan for space activities

In November, South Korea's President Yoon Suk-yeol announced a new plan for space activities, including doubling the space budget in 5 years, to invest 100T won ($74.7B) by 2045, to land on the Moon in 2032 and on Mars by 2045, as well as to establish a national space agency the "Korean Aerospace Administration (KASA)" (separate from KARI) at the end of 2023, to establish aerospace policies and lead R&D&T acquisition.[50]

Credit: Yonhap/Koreaherald

Yoon revealed 6 policy directions:

- Explore Moon and Mars
- Leap forward as a space technology powerhouse
- Foster space industry
- Nurture space talent
- Realise space security
- Lead international cooperation

China releases a 5-year White Paper on priorities in the space domain

On January 28th, China's State Council Information Office released "China's Space Program: A 2021 Perspective", a 5-year white paper document. The document highlights the importance of space for China's overall national strategy and addresses the country's major space-related plans for the next 5 years in 6 different areas:

- Space technologies and systems
- Space applications
- Space science
- Space governance
- International cooperation

In line with China's 2014 policy shift towards a space sector more open to private capital, this year's white paper placed great emphasis on commercial activities and applications. On the other hand, the white paper does not address topics such as the national large constellation project, space resources or space-related military capabilities.[51]

The White House released the National Cislunar Science and Technology Strategy

The White House released a new strategy, the National Cislunar Science and Technology Strategy, developed by the NSTC. The strategy outlines 4 objectives:

- Support R&D to enable long-term growth in cislunar space
- Expand international S&T cooperation in cislunar space
- Extend U.S. SSA capabilities into cislunar space
- Implement cislunar communications and PNT capabilities with scalable and interoperable approaches.[52]

[50] Moon landing in 2032, Mars by 2045: Yoon sets space goals, The Korea Herald, November 2022
[51] China's Space Program: A 2021 Perspective, White Paper, The State Council Information Office of the People's Republic of China, January 2022
[52] National Cislunar Science and Technology Strategy, National Science & Technology Council, November 2022

The White House released Strategy for In-Space Servicing, Assembly, and Manufacturing

On April 4th, the White House's Office of Science and Technology Policy (OSTP) released the National Strategy for In-Space Servicing, Assembly, and Manufacturing (ISAM). The new federal strategy outlines how the United States will coordinate its agencies and collaborate with the private sector for ISAM capability development. Accordingly, the strategy establishes six strategic goals:

- to advance ISAM R&D
- to prioritise expanding scalable ISAM infrastructure
- to accelerate the emerging ISAM commercial industry
- to promote international cooperation
- to prioritise environmental sustainability
- to inspire future space workforce.

The strategy seeks to drive the involvement of multiple U.S. government agencies and entities, from NASA to the U.S. Space Force.[53]

Canada proposes updates its criminal code to address crimes committed on the Moon

Canada proposed an amendment to its criminal code, allowing for crime prosecution committed by a Canadian astronaut when traveling to and back from the Moon and during presence on the Moon. The proposed code Bill C-19 outlines:[54] "A Canadian crew member who, during a space flight, commits an act or omission outside Canada that if committed in Canada would constitute an indictable offense is deemed to have committed that act or omission in Canada".[55]

1.2.2 Organisational and governance changes and new appointments

Developments in Europe

Slovakia became an ESA Associate Member State

In June, ESA and Slovakia signed the Association Agreement on Slovakia becoming ESA an Associate Member State. Following signature of the Association Agreement between ESA and Slovakia, **Slovakia's Associate membership came into effect on October 13th**. The membership will last for an initial duration of 7 years. This Association Agreement replaces the European Cooperating State Agreement of 2016. The new agreement includes exchange of experts and information and the provision of a fair industrial return to Slovakia.[56]

Reorganisation of Italy's space governance

In May, the Italian space governance underwent a broad reorganisation. The Decree-Law April 30th 2022, n. 36[57], which entered into force May 1st and modifies the Legislative Decree of June 4th, 2003, n. 128, assigns to the Presidency of the Council of Ministries (Prime Minister) the responsibilities of direction, coordination, planning and supervision of the Italian Space Agency (ASI), while the Ministry of the University and Research (MUR) will only maintain the strategic direction limited to scientific research and activities. The Legislative Decree of June 4th, 2003, n. 128 defines the aims, activities, bodies, principles, and criteria of the organisation and functioning of the ASI.[58]

[53] National Strategy for In-Space Servicing, Assembly, and Manufacturing, National Science & Technology Council, April 2022
[54] Bill C-9 An Act to implement certain provisions of the budget tabled in Parliament on April 7, 2022 and other measures, Parliament of Canada, House of Commons Canada, April 2022
[55] Canada Proposes Space Law to Punish Crimes Committed on Moon, CNET.com, May 2022
[56] Slovakia becomes ESA Associate Member state, ESA News, October 2022
[57] Decree-Law April 30th 2022, n. 36, Gazzetta Ufficiale, May 2022
[58] Riordino dello Spazio, il coordinamento alla Presidenza Consiglio, Gazzetta Ufficiale, Ansa.it, May 2022

This long-overdue reform aims at guaranteeing the simplification, greater efficiency, and speed of action of the governance system, especially in consideration of the digital transition objectives set by the National Recovery and Resilience Plan (PNRR). Over €4 billion of the PNRR have been allocated for the development of space activities. In particular, the Department for Digital Transition (DTD) has recently invested €880 million in ASI and €1.3 billion in ESA. The Decree-Law also transformed the mechanism of evaluation of ASI's research programmes. If the process was previously based on criteria set by MUR, henceforth the parameters defined by the Italian National Agency for the Evaluation of Universities and Research Institutes (ANVUR) will serve as the reference for the evaluation.

Moreover, the President of ASI will now be appointed by the Prime Minister, in agreement with the MUR. The Decree-Law provides ASI with the establishment of a financing fund of €499 million, which started from 2022, intended to cover operating and management costs, including collaboration programmes with ESA. Finally, the shares of the Italian Aerospace Research Center (CIRA) owned by ASI are transferred to the National Research Council.[59]

Moreover, in September, the **Office for Space and Aerospace Policies within the Italian Presidency of the Council of Ministers was established**. The new office formalises the institution of a body appointed to support the Prime Minister's Office in its functions of "senior management, general political responsibility and coordination of the policies of the Ministries relating to space and aerospace programmes". Elena Grifoni Winter has been appointed as Head of Office.[60]

In November, the **Italian Ministry of Defence and ASI signed a framework agreement for cooperation in space activities** through the implementation of programmes and studies of joint interest. The MoD-ASI cooperation is an important element in the implementation of the national Defence Space Policy, incl. the defence of space infrastructure.[61]

UK Space Agency and UK BEIS released Framework Document to formalise relations

On September 6th, the UK Space Agency and the Departments for Business, Energy and Industrial Strategy (BEIS) published an agreed Framework Document that "sets out the broad governance framework within which the UK Space Agency and BEIS operate". The document does not set out specific legal powers or responsibilities, but it describes the overall governance and the financial and accountability framework in which the UKSA operates, specifies the partnership principles and defines the governance and structure of the UKSA, establishing the rules concerning the appointment and responsibilities of the Chief Executive and of the Board.[62]

CNES and supervisory authorities signed Contrat d'Objectifs et de Performance

In 2022, CNES and its supervisory authorities signed a new Contrat d'Objectifs et de Performance (COP) (2022-2025) which sets the course for the French space agency for 2022-2025, with 4 pillars: contributing to economic growth, maintaining strategic autonomy, scientific excellence, and sustainable development.[63]

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[59] Riforma dello spazio. A Palazzo Chigi i poteri di indirizzo dell'Asi, Formiche, la Rivista Air Press, May 2022
[60] Aerospazio, Grifoni Winters alla guida del nuovo ufficio di Palazzo Chigi, SpaceEconomy 360, September 2022
[61] Ministero della difesa e agenzia spaziale italiana firmano un accord Quadro nel settore spaziale, ASI, November 2022
[62] UK Space Agency Framework Document, Corporate Report, UK Space Agency, Gov UK, September 2022
[63] Contrat d'objectifs et de performance Etat-CNES | 2022 – 2025, CNES, October 2022

Changes in Leadership: New appointments at key positions in agencies and institutions

Europe		In December, ESA Council appointed Carole G. Mundell as the Director of Science and Dietmar Pilz as the Director for Technology, Engineering and Quality. Both are expected to take-up of duty in 2023.[64]
Europe		In May, EUSPA elected Philippe Bertrand as new Chair of the EUSPA Security Accreditation Board, succeeding Bruno Vermeire.[65]
Egypt		In August, Sherif Mohamed Sedky was appointed as CEO of the Egyptian Space Agency.[66]
France		In June, Nicolas Hengy was named Financial Director and Executive Committee Member of CNES, succeeding Antoine Seillan.[67]
Germany		In January, Anna Christmann was appointed as new Coordinator for Aerospace of the German government, succeeding Thomas Jarzombek.[68]
Germany		In November, Eva-Maria Aicher, from Governmental Business Development Space, was elected to be Member and Deputy Chair of the Senate of the DLR.[69]
Luxembourg		In January, Kathryn Hadler was appointed the new Director of the European Space Resources Innovation Centre (ESRIC) and took up office on April 1st.[70]
UK		In April, the UK Business Secretary Kwasi Kwarteng appointed Lord David Willetts as Chair of the UK Space Agency's Board.[71]
USA		In January, Laurie Leshin was appointed as new Director of NASA's Jet Propulsion Laboratory (JPL) and took office on May 16th, succeeding Mike Watkins.[72] Also in January, Katherine Calvin was appointed NASA's new chief scientist and senior climate advisor, succeeding Jim Green who retired on January 1st and Gavin Schmidt who has been senior climate advisor since February 2021.[73]

[64] ESA appoints two new Directors, ESA News, December 2022
[65] New chair-elect for the Security Accreditation Board (SAB) of EUSPA, EUSPA News, May 2022
[66] Sherif Mohamed Sedky appointed as CEO of Egyptian Space Agency, Spacewatch Global, August 2022
[67] Nicolas Hengy est nomme directeur financier du CNES, CNES News, June 2022
[68] Dr. Anna Christmann is the Federal Government Coordinator of German Aerospace Policy, BMWK, January 2022
[69] Eva-Maria Aicher elected as Deputy Chair of the DLR Senate, Hensoldt, December 2022
[70] Dr Kathryn Hadler, FNR PEARL Chair, nominated as Director of ESRIC as of 1st April 2022, ESRIC, January 2022
[71] Lord David Willetts appointed as Chair of UK Space Agency Board, Gov.UK, April 2022
[72] Leshin to be next director of JPL, SpaceNews, January 2022
[73] Katherine Calvin, Chief Scientist and Senior Climate Advisor, NASA News, January 2022

U.S.		In April, Richard DalBello was appointed to become the Director of the U.S. Office for Space Commerce.[74]
U.S.		In January, U.S. Navy Vice Adm. Frank Whitworth was nominated to become new Director of the National Geospatial Intelligence Agency, succeeding Vice Adm. Robert Sharp National.[75]
U.S.		In November, Gen. B. Chance Saltzman took command as new chief of the U.S. Space Force.[76]
USA		In April, Frank Calvelli's nomination to assistant secretary of the Air Force for space acquisition and integration was approved by the U.S. Senate. He is the first person to hold the newly created position.[77]
UNOOSA	UNITED NATIONS Office for Outer Space Affairs	Since March, Niklas Hedman is designated Acting Director of UNOOSA, succeeding Simonetta Di Pippo. He is Chief of the Policy and Legal Affairs Section and serves as Secretary to COPUOS and its Scientific & Technical and Legal Subcommittees.[78]
UNCOPUOS	COPUOS	In June, the UAE-representative Omran Sharaf was appointed as Chair of UN COPUOS. Sharaf will serve as Chair of the Committee in 2022 and 2023.[79]
COSPAR		In July, Pascale Ehrenfreund was elected new President of COSPAR. Additionally, Pietro Ubertini and Catherine Cesarky were appointed as Vice-Presidents.[80]

Table 2: New appointments at key positions in agencies and institutions (Source: ESPI database)

[74] DalBello to lead Office of Space Commerce, SpaceNews, April 2022
[75] Biden nominates Navy admiral to run National Geospatial Intelligence Agency, SpaceNews, January 2022
[76] Saltzman takes command as new chief of the U.S. Space Force, SpaceNews, November 2022
[77] Calvelli to assume duties as U.S. Air Force's space acquisition executive, SpaceNews, May 2022
[78] UNOOSA Acting Director, Niklas Hedman, UNOOSA, March 2023
[79] Omran Sharaf from UAE to chair UN's COPUOS, Spacewatch Global, June 2022
[80] Pascale Ehrenfreund elected new President of COSPAR, Spacewatch Global, August 2022

1.3 Space Defence and Military Space

1.3.1 The impacts of the War in Ukraine

Over decades European space efforts have put a keen focus on international collaboration, including with Russia, and creating ties to help benefit and progress all space activities, perhaps epitomised by Soyuz launches from Europe's Spaceport in French Guiana, with the first launch taking place in 2011. Russia's invasion of Ukraine resulted in a series of sanctions which has completely upended the close working relationship between Europe and Russia's space sectors, as well as other indirect and spill-over effects on the global and European space industry. Originally, European collaboration with Russia in space was thought to be a mutually beneficial relationship, but the war has revealed that the relationship in space did not take geopolitical developments over the past decade into account and the underlying risks these developments represented for Europe's space capabilities. While Europe shifted reliance in the short-term almost exclusively to the U.S., in the long term, Europe will look to patch up the vulnerabilities exposed by the war, in terms of striving for more strategic autonomy and independence from other space powers.

Several immediate impacts of the war in Ukraine could be observed in the short term, such as the cancellation of Soyuz launches from the Guiana Space Centre, the cancelation of the cooperation with Russia in the ExoMars mission to deliver the Rosalind Franklin rover to Mars, and the effects on Europe's Vega launcher, which uses Ukrainian built engines.[81] ESA studied options to ensure a continued supply of upper stage engines for the Vega-C launcher. Among the options are keeping the Ukrainian supplier Yuzmash - but if the company loses the ability to deliver its engines, ESA could accelerate the development of Avio's M10 engine, or procure two other engines, in case the supply of Ukrainian engines stops. Nevertheless, ESA assured that in the medium-term there is no risk of launches being paused, as Avio has a stockpile of AVUM engines.[82]

With regard to launches, **payloads initially planned to be deployed with Soyuz were partly shifted to be launched with SpaceX's Falcon 9, or Vega C**, while the ride for some is still to be determined. Moreover, the ESA-JAXA EarthCARE (Earth Cloud Aerosol and Radiation Explorer) mission, originally planned to be launched onboard Soyuz, was planned in November (also due to the delays of Ariane 6) to launch with Vega-C.in 2024. ESA and the EU are still looking to resume launches of Galileo satellites, which were impacted and put on hold due to the loss of Soyuz and Ariane 6 delays, yet the 2023 and 2024 deadlines seem ambitious.[83]

The cooperation with Russia on the ISS remains the last notable area of cooperation in space. Nevertheless, alongside the threatening twitter posts, also on the ISS the situation was affected by the political situation. In particular, in July, Russian cosmonauts Sergey Korsakov, Oleg Artemyev and Denis Matveev displayed a flag of the disputed Luhansk People's Republic, a region of Ukraine occupied by Russian forces.[84]

ESA and NASA criticised Russia for using the ISS to promote the war in Ukraine, followed by ESA DG Josef Aschbacher announcing a few days later that the ESA Council formally decided to finally terminate the cooperation with Russia on the ExoMars mission, which had been on hold since March in response to Russia's invasion in Ukraine. ESA started looking for alternative partners, such as NASA, to replace Russia in the ExoMars mission.[85]

[81] The War in Ukraine and the European Space Sector, ESPI Executive Brief No. 57, May 2022
[82] ESA weighs options for replacing Soyuz launches, SpaceNews, March 2022
[83] ESA moves two missions to Falcon 9, SpaceNews, October 2022
[84] Russian cosmonauts spread anti-Ukraine propaganda from space station, Space.com, July 2022
[85] ESA suspends work with Russia on ExoMars mission, SpaceNews, July 2022

A few days later, Russia's President Vladimir Putin dismissed Roscosmos DG Dmitry Rogozin from his duties and appointed Yuri Borisov, former Deputy Prime Minister and Deputy Minister of Defence, as the new Head of Roscosmos. In parallel, **Roscosmos and NASA finalised and signed a seat barter agreement, which allows Russian cosmonauts to fly on commercial crew spacecraft and U.S. American astronauts to fly on Soyuz** spacecraft.[86]

Moreover, the **war in Ukraine highlighted the benefit of space applications**, incl. Earth observation / remote sensing, Positioning, Navigation and Timing (PNT) as well as space-based communication and connectivity for surveillance and defence - representing a unique challenge for European space ambitions.[87] Moreover, Russia's cyberattack on Viasat's KA-SAT satellite right before the start of Russia's invasion, which impacted connectivity and communication in Ukraine (and produced spillover effects in other European countries) highlights the vulnerability and the need of cybersecurity for and resilience of space systems and puts cyberattacks as a tool of hybrid warfare into the spotlight.[88] A big driver for recognising the value of space in security beyond specialised audiences, were **commercial companies who publicly supported the Ukrainian government and the armed forces with crucial data for surveillance and communications infrastructure.**[89] Examples include, SpaceX's provision of connectivity and space-based communication through its Starlink constellation, the delivery of high-resolution imagery from U.S. companies such as Maxar[90] as well as insights derived from products made available by European companies, such as the Finland-based SAR company Iceye.[91]

Credit: Maxar Technologies

Further to private initiatives, the **EU pushed the use of space applications to support Ukraine**: end of June 2022, the #EUSpace4Ukraine Hackathon, organised by EUSPA took place, addressing humanitarian support related to the war in Ukraine by using data from the EU Space Programme. The purpose of the hackathon was to develop solutions and applications for humanitarian aid organisations, targeting innovators across Europe to leverage data and services from the EU Space Programme for humanitarian aid. Areas the hackathon include the provision of roadmaps for supplies, satellite temporary connection to replace broken landlines, identification of the level of destruction, creation of platforms for helping people integrate in new countries, as well as coordination of private and public helper organisations.[92]

Credit: EUSPA

On the other hand, the war in Ukraine, and in particular Russia's cyberattack via Viasat's KA-SAT communications satellite, **demonstrated the lack of resilience of space systems as critical infrastructure, raising awareness on the strategic use of cyberattacks on space assets as a tool of hybrid warfare**.

[86] Rogozin removed as head of Roscosmos as seat barter agreement signed, SpaceNews, July 2022
[87] The War in Ukraine and the European Space Sector, ESPI Executive Brief No. 57, May 2022
[88] The War in Ukraine from a Space Cybersecurity Perspective, ESPI Short Report, October 2022
[89] War in Ukraine highlights the growing strategic importance of private satellite companies — especially in times of conflict, space.com, August 2022
[90] Satellite imagery shows intense fighting on Ukraine frontline amid new Russian offensive, Independent, February 2022
[91] ICEYE signs contract to provide Government of Ukraine with access to its SAR satellite constellation, August 2022
[92] EUSpace4Ukraine, EUSPA, June 2022

In a nutshell: Impacts of the War in Ukraine on space in 4 dimensions:

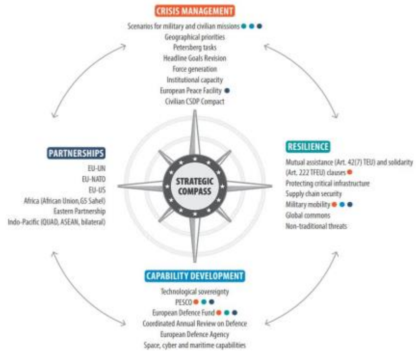
- Impacts on international and bilateral cooperation in space with Russia: space exploration missions, launch agreements, industrial cooperation/supply chains, reinforced polarisation of international relations and politization of the space domain.
- Increased awareness of the strategic value and use of (commercial) space application and services for security on Earth and support of governments and armed forces.
- Increased awareness of the vulnerability of space systems, the need to protect space assets and increase their resilience and cybersecurity, and of cyberattacks on space systems as a major threat and tool of hybrid warfare.
- "Wake-up call" and push for Europe to strive for strategic autonomy in security, defence, and space, strive for autonomous and independent access to space, increase Europe's efforts to strengthen security, defence and space capabilities and bring these areas together with an EU Space Strategy for Security and Defence.

1.3.2 Increased policy awareness of defence & military dimensions of space

2022 saw several developments in security, defence and military dimensions of outer space – notably also pushed by the War in Ukraine. Trends include the use of commercial space services for armed forces, cybersecurity of space assets, responsive space, debates on responsible behaviours in space, as well as increased connection of space and security & defence in strategies.

European cooperation in space from the Strategic Compass

The Council of the EU formally approved the Strategic Compass



Credit: EPRS

On March 21st, the Council of the EU formally approved the Strategic Compass. The document outlines a plan of action to strengthen the security and defence policy of the EU by 2030 and sets out concrete priority actions in four work strands: (1) Act, (2) Secure, (3) Invest and (4) Partner. The Strategic Compass recognises the European Defence Fund (EDF) and PESCO as the main instruments to develop joint European capabilities.[93] Additionally, it states that the EU will strengthen international cooperation in space, including NATO and the UN. The Strategic Compass acknowledges space as a congested and contested operational domain and highlights how Europe should be able to act promptly in space to respond to threats and the importance of the EU Space Programme for the security of the EU.

It sets out space-related priority actions across 4 work strands:

- **ACT:** (1) Reinforce civilian and military CSDP missions; (2) Develop an EU Rapid Deployment Capacity; (3) Strengthen command and control structures; (4) Conduct capability and increase readiness and cooperation through enhancing military mobility and regular live exercises, in particular for the Rapid Deployment Capacity. Regarding space, the Strategic Compass outlines that Europe must be able to act promptly in space to respond to threats.
- **SECURE:** (1) Boost our intelligence capacities, such as the EU Single Intelligence and Analysis Capacity framework; (2) Create an EU Hybrid Toolbox for hybrid threats; (3) Further develop the EU Cyber Defence Policy. Regarding space, the EU will draft an EU Space Strategy for Security and Defence, and will strengthen its intelligence-based situational awareness and relevant EU capacities, notably in the framework of the EU Single Intelligence Analysis Capacity, and the EU Satellite Centre. It also recognises that enhancing cybersecurity will improve the effectiveness and security of the EU's efforts in space. The EU will work on the proposal for an EU space-based global secure communication system, in order to better prepare for a more competitive and contested environment. The EU will continue to invest in SSA to understand and reduce threats in space. The EU will strengthen dual-use innovation and invest in capability development to benefit from an autonomous access to space. The EU will protect space supply chains and invest in critical space technologies in coordination with EDA and ESA. It will conduct exercises to test the resilience of space assets and expend the Galileo threat response to other components of the EU Space Programme.

[93] Strategic Compass: European Defence Fund and EU Space Programmes as Key Pillars for European Security, European Commission, March 2022

- **INVEST:** (1) Spending more in defence and improving development of capability and necessary strategic enablers for EU operations in all domains; (2) Make full use of PESCO and the EDF to invest in technological innovation for defence and create a new Defence Innovation Hub within the EDA. Regarding space, the EU will adapt the EU's defence capability planning and development in order, among other things, to secure access to strategic domains such as space. It will also invest in space surveillance systems as part of PESCO and the EDF.
- **PARTNER:** (1) Reinforce strategic partnerships with NATO and the UN and cooperation with regional partners, incl. OSCE, AU, ASEAN; (2) Boost cooperation with bilateral partners; (3) Develop EU Security and Defence Partnership Forum. Regarding space, the EU will expand international cooperation in space, including with NATO. The EU will increase cooperation with the UN and provide satellite imagery through the EU SatCen.[94]

European Commission adopted the Contribution to European Defence and the Roadmap on Critical Technologies

In February, the European Commission adopted EU initiatives in defence and security, comprising (1) a Contribution to European Defence, covering the full range of challenges, from the conventional defence industry and equipment on land, sea and air, cyber, hybrid and space threats, military mobility and climate change; and (2) a Roadmap on Critical Technologies for Security and Defence.

The Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the **Contribution to European Defence**[95] includes a paragraph on "Strengthening the defence dimension of space at EU level", highlighting the relevance of the envisaged EU space strategy for security and defence and to consider the following actions:

- EU space assets should be further protected to enhance resilience of the EU in and from space.
- The Commission and the High Representative will enhance the security and defence dimension in existing and upcoming EU space infrastructures.
- The Commission will work to reduce related strategic dependencies on critical technologies.
- The Commission and the High Representative will implement the enlargement of the current Galileo threat response mechanism to the systems and services under the other components of the EU Space Programme.

The **Roadmap on Critical Technologies for Security and Defence**[96] mentions space in the context of critical technologies and strategic dependencies for security and defence: "The space and cyber are strategic 'enablers' for the security and defence sectors. The space sector shares many of their specific features, with its small market volumes and limited leverage on the private market for components. The resilience of the space programmes and of the space value chains are critical for the EU security and defence objectives." Moreover, the space sector is mentioned in the context of the "Observatory of critical technologies" set up by the Commission, "to identify, monitor and assess critical technologies for the space, defence and related civil sectors and their potential application and supply chains, and to identify, monitor and analyse existing and predictable technology gaps and root causes of strategic dependencies and vulnerabilities."

[94] A Strategic Compass for Security and Defence, Council of the EU, March 2022

[95] Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Commission contribution to European defence, February 2022.

[96] Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Roadmap on critical technologies for security and defence, February 2022.

European Commission put forward a proposal for the Regulation for a European Defence Industry Reinforcement through a common Procurement Act

In July, the European Commission put forward a proposal for a regulation establishing the European defence industry reinforcement through common procurement act (EDIRPA) for 2022-2024 to reinforce European defence industrial capacities through common procurement by EU Member States with the objective to facilitate access for all Member States to urgently needed defence products and to encourage them to jointly procure. The European Commission proposes committing €500 million of EU budget from 2022 to 2024. In December, the Council of the EU adopted its general approach.[97]

European Defence Fund includes space-related projects

In May, the European Commission published the 2022 EDF work programme with a total budget of €925 million. The programme is organised around 8 calls covering 33 topics that are divided into 16 categories, including space. Space projects will be awarded €150 million in the following way:

- Responsive Space Systems (Research): €20 million
- Innovative Space ISR capabilities (Development): €40 million
- Space-based Missile Warning (Development): €90 million

In addition, the 2022 EDF work programme provides support for SMEs and supports the stimulation of Defence Innovation through targeted measures. The EDF is implemented through annual work programmes. The 2022 work programme follows the EDF's kick-off and its first calls in July 2021.[98]

Credit: EDF/EU

In July, the European Commission selected several projects that use space technologies in the framework of the €1.2 billion call for proposals under the EDF. Among the list of 61 funded projects, the selected space-based initiatives and projects aim at:

- Strengthening the Galileo PRS resilience (Navguard)
- Starting the development of a secure waveform for future satellite communications (EPW)
- Developing an integrated solution for automated response to threats to military space systems (SPRING)
- GEO orbit surveillance (NAUCRATES)
- Protecting SatCom services (RFSHIELD)[99]

[97] European defence industry reinforcement through common procurement act (EDIRPA), Briefing, European Parliament Think Tank, July 2022
[98] EDF Calls for Proposals 2022 Factsheet, EDF Work programme 2022, EDF, EU, May 2022
[99] Defence Industry: EU takes steps to invest almost €1.2 billion to support 61 defence industrial cooperation projects, European Commission, July 2022

Transatlantic space cooperation for security and defence

NATO released the public version of its Space Policy

NATO released its first public space policy document in January, which states that space is increasingly important for NATO and its allies' security.

Credit: NATO

The policy outlines 4 roles and functions of NATO in the space domain:

- Integration of space into NATO's core tasks
- NATO's role as a forum for political-military consultations and information-sharing on deterrence and defence-related developments in space
- Effective provision of space support and effects to NATO operations and missions
- Simplifying the development of interoperability as well as compatibility between NATO member's national space assets, services and capabilities

NATO outlined several activities across 9 "lines of effort", including space support; the creation of space domain awareness; deterrence, defence, and resilience; development of capabilities and interoperability; and joint training on space issues.

Additionally, NATO reported that it requires space systems in the following functional areas:

- Space Situational Awareness (SSA)
- Intelligence, Surveillance and Reconnaissance
- Satellite Communications
- Positioning, Navigation and Timing (PNT)
- Shared early warning
- Space-based monitoring of the atmospheric, oceanic and space environments.[100]

Seven countries release the Combined Space Operations (CSpO) Vision 2031 statement

The United States., Australia, Canada, France, Germany, New Zealand, and the UK co-drafted and released the Combined Space Operations (CSpO) Vision 2031 statement. The document defines the 7 nations' 10-year vision of cooperation in national security space operations and commitment to lead as responsible actors.[101]

Credit: CSpO

The statement outlines 4 shared objectives:

- Prevent conflicts
- Unity of effort
- Space mission assurance
- Defence and protection of space interests

[100] NATO's overarching Space Policy, NATO, January 2022
[101] Combined Space Operations Vision 2031, February 2022

National Security and Defence Strategies and organisational changes

United Kingdom released a new Defence Space Strategy and a 'UK space power' doctrine

On February 1st, the U.K. Ministry of Defence and the Defence Science and Technology Laboratory released the first ever Defence Space Strategy (DSS), pledging to **invest £1.4 billion over the next 10 years to protect UK space-related interests**. The objective of the strategy is to generate, integrate and operate space capabilities to protect and defend the UK's interests in support of global operations.

Credit: UK DSS

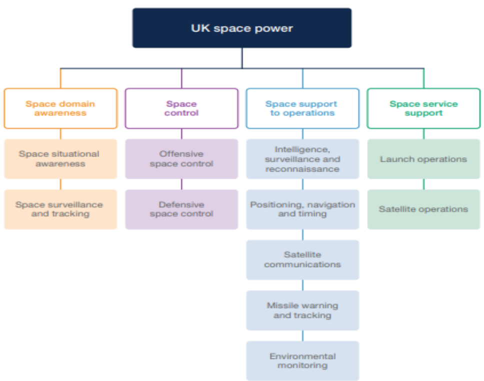
The strategy sets out 4 cross-cutting principles:

- Broadening and deepening multinational cooperation
- Improving cross-government cooperation
- Driving innovation and making use of technological opportunities
- Own, collaborate or access

The Strategy recognises space as a warfighting domain similar to land, sea, air, and cyberspace. As a result, the Strategy defines objectives and principles for space military operations based on 3 strategic themes:

- **Protect and Defend:** the UK aims to develop space capabilities to deliver effective operational outcomes, identify and attribute threats to space systems, and respond to hostile activities in a proportionate and coordinated manner. The strategy recognises that attacks to, from or within space represent as a challenge to the security of the Transatlantic Alliance and could lead to the invocation of NATO's Article 5.
- **Enhance Military Operations on Earth:** the UK aims to integrate space into all relevant aspects of Defence Business, deliver resilient space services crucial to military operations, and enhance multi-domain integration and architectures. The UK will develop defence-led resilient global navigation and alternative means to navigate and synchronise timing, in particular through cooperation with the Five Eyes. It will also develop its own small satellite capabilities.
- **Upskill and Cohere:** the UK aims to produce coherent space policies and plans, develop a skilled and sustainable space workforce, and recruit, train and retain talented individuals.[102]

Moreover, in September, the UK Government published the Joint Doctrine Publication (JDP) 0-40 "UK Space Power", which provides an overview of space from a UK military context and highlights the relevance of space as an operational domain. The doctrine which aims to support the defence sector, government departments, and UK allies, outlines 4 key space power roles: (1) Space Domain Awareness, (2) Space Control, (3) Space Operations Support, and (4) Space Service Support. The UK government considers space infrastructure and assets to be linked to critical national infrastructure.[103]



Credit: UK Ministry of Defence

[102] Defence Space Strategy: Operationalising the Space Domain, UK Ministry of Defence, February 2022
[103] Joint Doctrine Publication 0-40 UK Space Power, September 2022

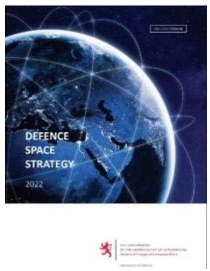
Australia released its Defence Space Strategy

In March, the Australian government released a Defence Space Strategy outlining a vision is to "assure Australian civil and military access to space, integrated across Government, and in concert with allies, international partners and industry". The Defence Space Strategy sets the trajectory for Defence space efforts to 2040, building on the 2020 Defence Strategic Update, Force Structure Plan and Defence Transformation Strategy. The strategy analyses the strategic context in the space environment, points out the vision and mission for the space domain. The outlined mission is "to prepare space power to ensure Australia's interest in peace and war" and the strategy's vision is to "assure Australian civil and military access to space, integrated across Government, and in concert with our allies, international partners and industry". The strategy highlights 5 Lines of Effort (LOEs):

- Enhance Defence's space capability to assure Joint Force access in a congested and contested space environment.
- Deliver military effects integrated across Whole of Government and with allies and partners in support of Australia's national security.
- Increase the national understanding of the criticality of space.
- Advance Australia's sovereign space capability to support the development of a sustainable national space enterprise.
- Evolve the Defence Space Enterprise to ensure a coherent, efficient and effective use of the space domain.[104]

Luxembourg unveiled its first Defence Space Strategy

In February, Luxembourg presented its first Defence Space Strategy. The Strategy aims to "consolidate Luxembourg`s role as a reliable reference partner in the field of space by 2030", "guarantee access and preserve a peaceful and sustainable use of space, in full compliance with international law, while relying on the expertise of the Luxembourg space sector". To achieve this long-term goal, the Defence Space Strategy defines 4 main strategic objectives:



Credit: Luxembourg MoD

- Consolidate current space capacities, increase their resilience and develop new systems
- Supporting freedom of action in and from space
- Foster national and international cooperation
- Attract and secure a skilled and motivated workforce.[105]

The Netherlands released its Defence Space Agenda

In November, the Dutch Ministry of Defence released its Defence Space Agenda. The plan aims to increase strategic autonomy by developing and operating a satellite constellation of small- and micro-satellites that provide military relevant ISR information, while reducing reliance on external communication, navigation, and EO capabilities. From 2023 until 2027, €25 million - €100 million will be allocated to address and realise these ambitions. Key priorities are the development of a sovereign-controlled constellation of small/micro satellites for military-relevant ISR information and the development of a national SSA capability, which will be achieved by adding the capability to two Thales SMART-L Multi Mission radars to detect satellites and other debris in space.[106]

[104] Australian Space Defence Strategy, Australian Government, Department of Defence, March 2022
[105] Defence Space Strategy 2022, the Government of the Grand Duchy of Luxembourg, Ministry of European and Foreign Affairs, February 2022
[106] Netherlands MoD publishes Defence Space Agenda, Janes.com, November 2022

The role of space in new security and defence strategies

U.S. National Security Strategy (NSS)

In October, the White House released the National Security Strategy (NSS) in October - initially planned to be released in spring 2022 - but it was delayed due to reconsiderations in response to Russia's invasion in Ukraine. The strategy highlights the tripolar race and competition with China and Russia, while emphasizing the need of enhanced collaboration with allies to address transnational and global challenges, such as climate change, terrorism, food insecurity and energy shortages. Related to space, the NSS highlights the value of space tech for climate monitoring and surveillance, the U.S. role to ensure sustainability, safety, stability, and security of and in space, including space governance, STM/SSA, space norms and arms control.[107]

U.S. National Defence Strategy (NDS)

The U.S. DoD released the unclassified National Defense Strategy (NDS), which is related to the broader National Security Strategy, and includes the Nuclear Posture Review (NPR) and the Missile Defense Review (MDR). The National Defense Strategy defines 4 key priorities for the U.S, defense:

- Defending the homeland, paced to growing multi-domain threat posed by China;
- Deterring strategic attacks against the U.S., allies and partners;
- Deterring aggression, while being prepared to prevail conflict when needed, prioritising the PRC challenge in the Indo-Pacific region and Russia in Europe;
- Building a resilient Joint Force and defense ecosystem.

Credit: U.S. Department of Defense

To address these priorities, 3 approaches were identified: (1) Integrated deterrence; (2) Campaigning; (3) Building enduring advantage. Related to space, the NDS calls for diverse, resilient and redundant space networks and satellite constellations. The strategy outlines that since the domains cyber and space empower the armed force, resilience in these areas needs to be prioritised, and validates the plan to develop a multilayer missile defence and missile-tracking satellites network as well as to add commercial systems to complement military space networks – thus increasing collaboration with the commercial space industry.[108]

U.S. National Strategy for the Arctic Region

The White House released an updated "National Strategy for the Arctic Region", laying out a 10-year roadmap plan. Related to space the strategy document recommends investments in infrastructure to monitor the region and to improve connectivity through space-based communications and Earth monitoring, recommending investments in modernization / improvement of:

- Domain awareness for detection/tracking of potential airborne and maritime threats
- Sensing and observational capabilities for sea ice, ship traffic, weather;
- Communications and PNT capabilities by developing communications and data networks capable of operating in the northern latitudes;
- Arctic observing and weather, water, and sea ice forecasting;
- Satellite coverage for efficient commerce as well as maritime and air safety.[109]

[107] National Security Strategy October 2022, the White House, October 2022
[108] 2022 National Defence Strategy of the United States of America, U.S. Department of Defense, October 2022
[109] National Strategy for the Arctic Region October 2022, the White House, October 2022

Japan's National Security Strategy and National Defence Strategy

In December, Japan released a new National Security Strategy (NSS) along with two other defence-related strategic documents. Space is one of the domains outlined in the strategy document in the context of (1) Japan's multi-layered cross-domain response to threats as a capability multiplier for the Japan Self Defense Forces (SDF) and (2) deepening security cooperation with the U.S.[110]

The strategy **includes a dedicated section on space, "Reinforcing Comprehensive Efforts for Space Security" stating that "Japan will strengthen its response capabilities in the field of space security"**. This will Include measures such as strengthening mechanisms for understanding the space domain, fostering cooperation between JAXA and the SDF, enhancing cooperation with the U.S.

Moreover, also in December, Japan released a National Defence Strategy. With regard to the space domain, the strategy states: "securing its stable use for information gathering, communication, positioning, etc., is vital for ensuring the lives of our nationals and our defence, and MOD/SDF will reinforce cooperation and collaboration including research and development with relevant agencies including JAXA and private companies. In doing so, MOD/SDF will further apply civilian technologies into the defence field, facilitate investment in technology development in the private sector and improve space capabilities for Japan as a whole".[111]

Military space-related governance

Australia launched new Defence Space Command

Credit: Australian Department of Defence

In March, Australia's new Defence Space Command, established in January, became officially operational.[112] The new Command aims to ensure Australia's access to space to protect the country and its national interests, and to promote global security and stability.[113] The tasks of the Command are to:

- Develop and advocate for space specific priorities across Whole of Government, industry, allies and our international partners.
- Allow us to establish an organisation to create, train and sustain our people and assign trained space specialists to the Chief of Joint Operations when needed.
- Conduct strategic space planning, assist in the development of refinement of space policy, guide scientific and technological space priorities and define a resilient and effective space architecture in close collaboration with our allies.
- Ensure the design, construction, maintenance and operation of Defence space capabilities are in accordance with Defence standards and limitations.

Canadian Armed Forces establish a new Space Division

In July, the Royal Canadian Air Force's (RCAF) established a new Space Division the "3 Canadian Space Division (3 CSD)". This new division will focus on the growing importance of space to military operations for Canada's security. The new space division is responsible to the Royal Canadian Air Force (RCAF) commander for space capability generation for missions. The RCAF is in charge of the protection and defence of military space capabilities as well as for the development of space-based capabilities to be provided for the Canadian Forces.[114]

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[110] National Security Strategy of Japan (provisional translation), December 2022
[111] National Defense Strategy (provisional translation), December 2022
[112] Defence Space Command, Australian Airforce, March 2022
[113] Defence soars into space, Australian Government Defense, March 2022
[114] Establishment of 3 Canadian Space Division, Government of Canada, July 2022

Space Force establishes a unit within Indo-Pacom

In November, the Space Force formally established a permanent presence (unit) within the Hawaii-based U.S. Indo-Pacific Command (Indo-Pacom). The Space Force unit, which will be led by Brig. Gen. Anthony Mastalir, a former Commander of the space launch wing.[115]

Space Command creates a new task force: the "Combined Joint Task Force-Space Operations"

Credit: U.S. Space Command

In November, the U.S. Space Command announced the creation of a new task force, the "Combined Joint Task Force-Space Operations" (CJTF-SO) to support operations coordination and to accelerate the provision of satellite-based services and capabilities to military forces. In particular, the CJTF-SO will serve as a bridge between the Space Command's HQ at Peterson Space Force Base and the Combined Force Space Component Command (CFSCC) at Vandenberg Air Force Base and the Joint Task Force Space Defense (JTF-SD) at Schriever Air Force Base. CJTF-SO will also include an operations centre to track objects and activities in space. CJTF-SO will temporarily be led by Maj. Gen. T. James, until a permanent three-star commander is appointed.[116]

Space Military Exercises in Europe

On May 10-13th, the **EU carried out the fourth edition of Space Threat Response Architecture (STRA-22) exercise** at the European External Action Service HQ in Brussels, building on the scenario of the French Space Command's exercise AsterX conducted in March. The exercise aimed at testing the EU's capacity to respond to an attack on space systems, affecting essential and/or critical services. As part of the exercise, the EU response mechanisms were activated and involved many actors including the Galileo Security Monitoring Centre as well as the High Representative for Foreign Affairs and Security Policy and the Council. The exercise also aimed at providing input for drafting of the EU Space Strategy for Security and Defence.[117]

The French **"AsterX 2022" French military space exercise took place** from February 24th to March 4th in France. The objective of the exercise was to train the Space Command units to respond to threats in space in a simulated environment and to experiment the structure of the future Command and Control of military space operations and improve the expertise of the Space Force in SDA and geospatial intelligence. The exercise consisted of a scenario with 16 space-related events.[118]

[115] Space Force establishes permanent presence in Indo-Pacific region, SpaceNews, November 2022
[116] U.S. Space Command creates new task force to coordinate space operations, SpaceNews, November 2022
[117] Space: EU carries out Space Threat Response Architecture Exercise 2022 (STRA-22), EEAS Press, May 2022
[118] Seconde Èdition D'ASTERX, Exercise Spatial Militaire Francais, L'Armee de l'air et de L'espace, air.defense.gouv.fr, February 2022

1.3.3 Cybersecurity of space assets increasingly in EU spotlight

Cybersecurity and resilience of space systems received increased attention in 2022. Russia's cyberattack on Viasat' KA-Sat satellite was a "black swan event" and led to debates on the topic. ESPI published the Report "The War in Ukraine from a Space Cybersecurity Perspective", a case study of the KA-SAT cyberattack, enabling to draw lessons to learn for the cybersecurity of the European space infrastructure.[119]

Credit: Shutterstock/Blue Planet Studio

The report is focusing on (1) links and interdependences between space and cyberspace, (2) technical description of the KA-SAT cyberattack, (3) general analysis on similar cyber threats on the space supply chain and the user segment, (4) lessons to learn from the KA-SAT cyberattack, and (5) an analysis on the next steps for cybersecurity of European space infrastructure.

Developments in Europe

EU efforts for cybersecurity of space infrastructure

The **EU secure connectivity satellite constellation IRIS² aims to enhance cybersecurity** through a secure-by-design approach for the infrastructure and through relying on quantum cryptography through the European Quantum Communication Infrastructure (EuroQCI).[120] With the development of EuroQCI, IRIS² users will be able to rely on encryption capabilities, notably relevant for government and institutional users, data processors, and the banking & finance industry.[121] IRIS² is described in more detail in section 1.1.1 ESA and EU budgets and priorities for space.

Furthermore, the European Parliament and the Council of the EU released a **Joint Communication on EU Policy on Cyber Defence** in response to address the increasing cyberattacks targeting military and civilian critical infrastructure in the EU. Space is explicitly addressed, highlighting the strategic role of space for security and the need to enhance space assets' resilience and cybersecurity.[122] Moreover, the Council adopted new legislation for a high common level of cybersecurity.[123] The new directive "NIS2" will replace the current directive on the security of network and information systems (NIS).

On October 18th, the European Commission unveiled a **proposal to strengthen the resilience of EU critical infrastructure** for a Council Recommendation. The draft Recommendation aims to accelerate the efforts to protect critical infrastructure in the three priority areas (1) preparedness, (2) response and (3) international cooperation. Among others, such as energy, digital infrastructure and transport, space is one of the prioritised key sectors.[124] In December, the Council adopted a directive to strengthen the resilience of critical entities – the Critical Entities Resilience Directive (CER).[125]

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[119] The War in Ukraine from a Space Cybersecurity Perspective, ESPI, ESPI Short Report, October 2022
[120] IRIS²: the new EU Secure Satellite Constellation, European Commission, November 2022
[121] IRIS² Factsheet, EU, November 2022
[122] Joint Communication to the European Parliament and the Council: EU Policy on Cyber Defence, EEAS, November 2022
[123] EU decides to strengthen cybersecurity and resilience across the Union: Council adopts new legislation, Council of the EU, November 2022
[124] Critical Infrastructure: Commission accelerates work to build up European resilience, European Commission Press Release, October 2022.
[125] EU resilience: Council adopts a directive to strengthen the resilience of critical entities, Council of the EU Press Release, December 2022

Eagle-1 – European space-based quantum key distribution system

Credit: ESA

In September, ESA DG Josef Aschbacher and SES CEO Steve Collar **signed the contract for Eagle-1, which will be the first European space-based quantum key distribution (QKD) system.**[126]

The mission is led and co-funded by ESA (ARTES), co-financed by the European Commission (Horizon Europe) with costs valued €130 million, and the mission implemented by SES, leading a consortium of 20 European companies. Entities from 8 ESA member states Austria, Belgium, Czech Republic, Germany, Italy, Luxembourg, the Netherlands and Switzerland are contributing to the project.

Eagle-1 is planned to be launched in 2024 with a European launcher and will complete a 3-year in-orbit validation supported by the Commission. Eagle-1 is connected to the EuroQCI Initiative. Moreover, technologies demonstrated on Eagle-1 could be incorporated into IRIS^2. SES selected Arianespace to launch its EAGLE-1 satellite on a Vega C rocket as early as Q4/2024.[127]

Germany unveiled guidelines for cybersecurity of space infrastructure

Germany advanced in the field cybersecurity for space assets. Germany's Federal Office for Information Security (BSI) published **guidelines and standards for cybersecurity of space infrastructure and systems "Cybersicherheit für Weltrauminfrastrukturen".** The BSI worked jointly with OHB Digital Connect, Airbus D&S and the German Space Agency at DLR on the document, which lists measures to protect satellites during different phases and lays out minimum cyber measures to help satellite companies ensure their supply chains address specific vulnerabilities.[128]

Developments beyond Europe

Cybersecurity was also pushed especially in the U.S.

In particular, the U.S. Air Force Research Laboratory (AFRL) plans to develop a cyber training range for the Space Force and subordinated organisations (such as the SSC and SDA), to conduct realistic exercises in a replicated real-world satellite operations centre - simulating cyberattacks against satellites and ground system, by using 4 experimental cubesats planned to launch to LEO in 2024. AFRL is working with the company Stephenson Stellar Corp. According to AFRL additional funding of approx. $18M is needed for the satellites' launch and for the development of the cloud-based ground stations.[129]

[126] Quantum encryption to boost European autonomy, ESA News, September 2022
[127] SES-led group to deploy quantum security satellite for Europe in 2024, SpaceNews, September 2022
[128] Germany Offers Model for Space-Industry Cybersecurity Standards, The Wall Street Journal, August 2022
[129] AFRL developing 'cyber range' for space operators, SpaceNews, October 2022

1.3.4 Responsive Space

The U.S. and China progressed with their responsive space capabilities in 2022 – another dimension of their military space race. In November, the U.S. Space Command stated to support use of responsive launch to deter China and Russia - given the two states' recent advances in anti-satellite weapons. Responsive launch would be strategically important and needed during a conflict to replace damaged or destroyed satellites.[130]

Developments in Europe

Moreover, Europe pushed the ambition to develop responsive space (launch) capabilities in 2022. In particular, the European Defence Fund (2022 EDF Work Programme) funded Responsive Space Systems Research Projects with €20 million, as one of 3 space-related funded topics.[131]

Credit: DLR

The **European Commission opened a call for proposals for Responsive Space**. ESPI contributed to a proposal that a European Consortium led by the German Aerospace Center (DLR)'s Responsive Space Cluster Competence Center was preparing and submitting in 2022. The general objective of the call is "to pave the way towards a future European responsive space system able to place small satellites in various types of orbits within a short notice, in order to address specific operational needs, including tactical ones, and capability gaps stemming from shortage, failures and damages of existing space assets. This is particularly relevant in the field of intelligence, surveillance and reconnaissance (ISR) and satellite communication (SATCOM) where space assets have to be continuously operational and available to monitor and react to risks and events" The overall strategic objective is to enhance European resilience and autonomy in access to space and space capabilities for defence applications.[132]

On October 17th, the **Luxembourg Directorate of Defence and Virgin Orbit signed an agreement** (Letter of Intent) for collaboration on developing responsive space capabilities, including a mobile launch infrastructure that would be based in Luxembourg, available and of benefit for NATO partners and other European Allies.[133]

Developments in the United States

In particular, with regard to the U.S., the compromise version from December of the FY2023 National Defense Authorization Act called for the U.S. Space Force to fund a tactically responsive space program.[134] In May, the SSC issued a solicitation for the Tactically Responsive Space (TacRS-3) launch service and the U.S. Space Forces contracted companies for the Tactically Responsive Space TacRS-3 mission "Victus Nox". The U.S. Space Force's first tactically responsive launch mission was launched in June 2021.[135]

[130] U.S. Space Command supports use of 'responsive launch' to deter China and Russia, SpaceNews, November 2022
[131] EDF work programme 2022, European Commission, May 2022
[132] Responsive space system TOPIC ID: EDF-2022-RA-SPACE-RSS, European Commission, Funding & tender opportunities, June 2022
[133] Virgin Orbit and Luxembourg Minister of Defence sign agreement to advance allied responsive space capabilities across Europe, Virgin Orbit, October 2022
[134] Defense bill underlines need for tactically responsive space program, c4isrnet.com, December 2022
[135] 24 hours from 'go': Next Space Force 'responsive launch' experiment aims to loft satellite in a hurry, Breaking Defense, September 2022.

The Space Force announced in May to select a small rocket for its Tactically Responsive Space (TacRS-3) mission. In particular, it was announced that the Space Systems Command plans to award a contract in August for the TacRS-3 mission. The mission aims to demonstrate the capability of "tactically responsive space" which was requested by Congress to be acquired for Space Force in order to quickly replace satellites that are shot down.[136]

Credit: Tactically Responsive Space

Furthermore, Gen. J. Dickinson, Head of U.S. Space Command, endorsed the idea to partner with commercial launch companies that can demonstrate tactically responsive space and highlighted that the U.S. Space Command needs to prepare for "dynamic space operations", which will include rapid software updates, responsive launch, and manoeuvre capabilities.

In July, the U.S. company Rocket Lab launched a Responsive Space Program designed to on-ramp commercial and government satellite operators to the company's 24/7 rapid call-up launch capability. Rocket Lab launched NROL-162 and NROL-199 missions for the U.S. National Reconnaissance Office under the Rapid Acquisition of a Small Rocket (RASR) contract.[137]

In October, the U.S. Space Force awarded a contract to Firefly Aerospace and Millenium Space, aiming to launch the TacRS-3 mission "Victus Nox" in November 2023, with a Millennium smallsatellite bus carrying an SDA sensor as payload, which will be delivered in late April.[138]

In November, General James Dickinson, head of U.S. Space Command, explained that the U.S. military should partner with commercial launch companies, that can demonstrate tactically response space launch operations, in order to benefit from "more flexible, commercially available launch options and vehicles that can operate from multiple locations".[139]

Developments in China

In June, China launched 4 satellites with 2 rockets within 2 days. The first launch on June 21st (at 10:08 pm EDT), was conducted by the commercial launch service provider Expace launching a Kuaizhou-1A rocket with the Tianxing 1 satellite from Jiuquan Satellite Launch Center. The second launch was conducted approx. 24 hours later by China's main space operators and contractor for Long march rockets the China Aerospace Science and Technology Corporation (CASC), launching a Long March 2D rocket from Xichang Satellite Launch Center, carrying 3 Yaogan 35 satellites.[140]

On September 5th, **China performed two launches (its 36th and 37th launches of 2022) within two hours** from the Jiuquan spaceport and the Xichang spaceport. First, from Jiuquan a Kuaizhou-1A rocket lifted off at 10:24 UTC), carrying the CentiSpace 1-S3 and 1-S4 satellites. 1:55h later, from Xichang a Long March 2D was launched with a fifth batch of 3 Yaogan-35 satellites.[141]

Moreover, in November, China launched two rockets with six satellites from Jiuquan in under 30 hours: the first launch on November 15th (01:38 UTC) with the Chang Zheng 4C (CZ-4C) rocket with the Yaogan 34-03 (Yaogan-34C) government remote sensing satellite from Jiuquan Satellite Launch Center (JSLC) and the second launch on November 16th (06:20 UTC) with Ceres-1 launcher and 5 Jilin-1 Gaefen-03D remote sensing satellites onboard from JSLC.[142]

[136] Space Force to select small rocket for 'responsive space' mission, SpaceNews, May 2022
[137] RocketLab launches Responsive Space Program, Precious Payload, July 2022.
[138] U.S. Space Force Selects Firefly Aerospace for 'Rapid Space' VICTUS NOX Mission, Business Wore, October 2022
[139] U.S. Space Command supports use of 'responsive launch' to deter China and Russia, SpaceNews, November 2022
[140] China launches 4 satellites with 2 rockets in 2 days, space.com, June 2022
[141] China performs two launches inside two hours, SpaceNews, September 2022
[142] China launches two missions from Jiuquan in under 30 hours, NASA Spaceflight, November 2022

1.3.5 Commercial satellites increasingly used for security and defence

Developments in Europe

Several European companies received contracts to support security and defence operations

The Finnish start-up ICEYE agreed to support the Ukrainian armed forces by delivering SAR satellite data and imagery. ICEYE signed a contract (undisclosed value) with the Kiev-based Ukrainian Serhiy Prytula Charity Foundation, which supports the Ukrainian armed forces. As part of the agreement, ICEYE will transfer full capabilities of one of its SAR satellites in orbit, operated by ICEYE for the Ukrainian Government. Beyond this, ICEYE will provide access to its SAR satellites constellation which will allow the Ukrainian Armed Forces to receive radar satellite imagery.[143]

The German Bundeswehr awarded the German aerospace start-up Polaris a contract for building and flight-testing a scaled demonstrator of its Aurora space launch and hypersonic system. The company ambitions to develop a horizontal launch vehicle Aurora able to conduct suborbital and hypersonic flights, as well as launch activities.[144]

Developments beyond Europe

U.S. push the use of commercial space systems for military use

U.S. Undersecretary of Defense for Research and Engineering, Heidi Shyu, established a Defense Science Board task force, comprised of civilian experts, on **'commercial space system access and integrity' to examine the growing demand of the military for commercial space technology and related implications and to formulate recommendations for the DoD**. The task force will conduct research on (1) how the DoD should acquire commercial space services, in order to include it in the broader U.S. defence architecture, (2) how to ensure the availability of space services to military users and agencies that have demand but usually not access, and (3) on security threats to U.S. commercial or institutional space systems.[145]

In December, the U.S. Space Force has been considering a change of the approach for the selection of national security launch services providers and the procurement process – i.e. the National Security Space Launch (NSSL) Phase 3 procurement. The strategy for the Phase 3 procurement is the finalisation process and a draft solicitation is envisaged to be released in the second quarter of 2023. The contracts for Phase 3 are expected to be awarded in 2024. In 2020, ULA and SpaceX won the Phase 2 competition, and the current contracts will be re-competed in 2024.[146]

Credit: U.S. Space Command

In April, the U.S. Space Command unveiled an unclassified outline of a new Commercial Integration Strategy to improve the cooperation with the private industry, including procurement of commercial capabilities in defined priority areas, which encompass satellite communication, space domain awareness command and control, AI and big data management, modelling and simulation and space control systems.[147]

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[143] ICEYE Signs Contract to Provide Government of Ukraine with Access to Its SAR Satellite Constellation, ICEYE, Press Release, August 2022
[144] Polaris receives Bundeswehr contract for spaceplane demonstrator, Spacewatch Global, March 2022
[145] Advisory panel to examine DoD's demand for commercial space systems, SpaceNews, December 2022
[146] Space Force weighing new approach for selecting national security launch providers, SpaceNews, December 2022
[147] Commercial Integration Strategy Overview, US Space Command, April 2022

Other European space and security related developments

- In October 2022, the flight test and qualification phase of the Italian 2nd Generation Cosmo-SkyMED satellite CSG2 has been successfully completed, and data have been made available to users by ASI and the Italian Ministry of Defence. The Second-Generation satellites ensure full operational continuity of the entire COSMO-SkyMED mission put in orbit 15 years ago. In addition, their innovative features allow to characterise the nature of the observed territory and to represent it with false-colour images. Thales Alenia Space was responsible for the construction of the space segment and the End-to-End system, Telespazio for the Ground Segment, logistics and operations, and Leonardo for the supply of trackers and other sensors for satellite orientation, the photovoltaic panels, and electronic units for electrical power management. Finally, e-GEOS is the exclusive concessionaire of ASI for the marketing of COSMO-SkyMed and COSMO-SkyMed 2nd Gen. products and services worldwide.[148]
- Australia Defence signed a $40 million deal with Airbus Defence and Space for the Australian Defence Force (ADF)'s research programme Resilient Multi-mission Space (RMS) STaR Shot, which aims to develop future space capabilities for the ADF. Airbus will team-up with Australia Defence and with the three Australian industry companies Inovor Technologies, Shoal Group and Deloitte, to ensure the resilient and assured access of the Australian war to satellite services. Australian Defence has already purchased two Airbus Arrow 150 satellite buses and two experimental satellite missions are in the planning phase.[149]
- In August, Airbus D&S completed the performance enhancements of the SATCOMBw military satellite communications network for the German Armed Forces, which are required for the NATO commitment VJTF23. SATCOMBw Level 2 will ensure the autonomy, security and reliability of the satellite-based telecommunications of the Bundeswehr. Airbus D&S is the prime contractor and responsible for designing, integrating, and delivering of the operational system. Specifically, the BSg-A ground station located in Weilheim in Germany which became operationally ready end of the July and is operated by Airbus, was now fully integrated into the SATCOMBw network. To meet the requirements of VJTF2023, Airbus modernised the infrastructure by increasing transmission bandwidth, replacing ISDN technology with IP-based services, and modernising the cross-sectional management module.[150]
- In late June, the German Bundeswehr's military radar EO satellite SARah-1 built by Airbus was launched aboard SpaceX's Falcon 9 from the U.S. Space Force base in Vandenberg, following a launch contract that the German government awarded to SpaceX in 2013. SARah-1 is the first of in total three satellites of the SARah mission. The Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw) contracted OHB System for the development and integration of the satellite in March 2018, while Airbus was appointed as the main subcontractor. The new SARah system will replace the SAR-Lupe reconnaissance satellites and includes a space segment with three radar satellites (two by OHB, one by Airbus) and a ground segment connected to two German-built ground stations.[151]

[148] The second Cosmo-SkyMed Second Generation (CSG) satellite becomes operational, ASI, Press Release, October 2022
[149] Airbus selected as STaR Shot strategic partner, Australian Defence Magazine (ADM), July 2022
[150] Airbus delivers modernized Infrastructure to Bundeswehr in support of NATO commitment VJTF, Airbus, Press Release, August 2022
[151] Falcon 9 launches Germany's SARah-1 from Vandenberg, NSF, June 2022

1.3.6 Multilateral cooperation for security and responsible behaviour in space

UN OEWG on norms of responsible behaviours held first meetings

In November 2021, the General Assembly's First Committee on Disarmament and International Security, adopted five resolutions related to outer space, including the resolution titled "Reducing space threats through norms, rules and principles of responsible behaviours (L.52)". Specifically, the resolution supported a shift in approach to consider and value behaviours – instead of technological hardware and capabilities – as the basis for international norm-setting.[152]

The resolution states "the need for all states to work together to reduce threats to space systems through the further development and implementation of norms, rules and principles of responsible behaviours […] which might […] contribute to further consideration of legally binding instruments".

Credit: United Nations

As a concrete measure, the resolution decided to **convene an UN Open-Ended Working Group (OEWG), meeting twice in 2022** and 2023 and working on the basis of consensus, to take stock of existing international legal and normative frameworks concerning threats arising from states' behaviours that could be considered irresponsible, and to make recommendations on possible norms of responsible behaviours.

U.S. DoD adopts 5 tenets of responsible behaviour

The U.S. DoD released an updated space policy document (DoD Directive 3100.10, "Space Policy") signed by Deputy Secretary of Defence Kathleen Hicks, which replaces a previous document issued in 2012 and updated in 2016. The new document recognises space "as a priority domain of national military power" and formally adopts the 5 "tenets of responsible behavior in space" which Defense Secretary Lloyd Austin introduced in a memo last year.[153]

U.S. launches self-imposed ASAT test ban

In April, the U.S. committed not to conduct direct-ascent anti-satellite tests and launched a self-imposed ASAT test ban. This U.S.-led initiative received **further support with 9 nations joining in 2022: Canada, Australia, New Zealand, Japan, Germany, South Korea, Switzerland, UK, and France**. The initiative was promoted in the meetings UN OEWG on reducing space threats through norms rules and principles of responsible behaviours.

Moreover, in December, the UN General Assembly approved an ASAT test ban resolution among other resolutions on arms control and related topics. The resolution called for the development of "further practical steps and contribute to legally binding instruments on the prevention of an arms race in outer space." According to a UN press release, within the vote session, 155 voted in favor, 9 countries (including Russia and China) voted against the adoption, and 9 countries (including India) abstained.

[152] UN resolution on norms of responsible behaviours in space: a step forward to preserve stability in space?, ESPI, November 2021
[153] DoD updates space policy, formally adopts 'tenets of responsible behavior', Space News, September 2022

1.4 Growing policy awareness of safety & sustainability, but limited funding in sight

Throughout the past decade, the long-term sustainability of space activities has clearly emerged as a top international space policy domain, with a major impact on multilateral space diplomacy as well as policymaking at national level. Space sustainability issues remained high in policy agendas also in 2022, with notable developments in space safety, and Space Traffic Management (STM). Despite growing public policy awareness of safety & sustainability issues, there is limited funding to address the issue in a cooperative and comprehensive manner in sight.

1.4.1 Developments in Europe

The EC - EEAS Joint Communication on STM

On February 15th, the European Commission released a Joint Communication titled "EU approach to Space Traffic Management". The Communication outlined several challenges for a safe, secure, and sustainable use of space, calling for a compelling need to act urgently and collectively. Four key actions are highlighted:

- Assessing the STM requirements and impacts for the EU
- Enhancing EU operational capabilities to support STM
- Fostering STM regulatory aspects
- Promoting the EU STM approach globally.[154]

Following the release of the Joint Communication on April 26th, DG DEFIS launched the EU Industry and Start-ups Forum on STM (EISF) in close collaboration with the European Space Surveillance and Tracking (EU SST) Consortium. The forum aims to **support the innovation and competitiveness of the European commercial SSA sector** with the goal to achieve a higher level of strategic autonomy in Europe. EISF aims at turning the EC Communication into implementation, more specifically supporting the implementation of actions 2, 3 and 4 of the Joint Communication on STM, in coordination with the EU SST Consortium, namely:

- **Action 2:** improve the performance of existing services, develop new services and foster technology.
- **Action 3:** initiate specific actions in the framework of CASSINI to reap the full innovation potential of start-ups.
- **Action 4:** make accessible to industry by 2023 parts of the data sharing platform; and by 2025 parts of the future EU SST catalogue.[155]

On June 10th, the Council of the EU adopted conclusions on an EU approach to space traffic management.[156] The conclusions highlight the importance of increasing EU SST capabilities and of a legislation and standardisation framework. The conclusions addressed the following aspects:

- Reinforcing our capabilities
- Encouraging coordination on legislation and standardisation
- Reinforcing the EU's voice on the international scene.[157]

[154] Joint Communication of the European Parliament and the Council, An EU Approach for Space Traffic Management - An EU contribution addressing a global challenge, European Commission, February 2022
[155] Inaugural Event of the European Union Industry and Start-up Forum on STM, European Commission, April 2022
[156] Towards safe and sustainable use of space and a vision for Copernicus: the Council adopts conclusions, European Council, Press Release, June 2022
[157] Outcome of Proceedings EU approach to space traffic management – council conclusions, Council of the EU, June 2022

EUSPA takes on the Space Surveillance and Tracking front desk from 2023

Following the European Commission's decision in June 2022, the EUSPA Galileo Security Monitoring Centre (GSMC) in Madrid was assigned to over the responsibility for the SST Front Desk operations service as of 2023.[158] The Front Desk is the main interface for the delivery of SST information and services, including activities related to user coordination, service performance, engagement and promotion.

The SST is part of the Space Situational Awareness (SSA) component of the EU Space Programme. As such, transferring the system's Front Desk to EUSPA aligns with the Agency's mission of linking space to user needs and further strengthens the resiliency of the EU Space Programme.

Previously, the European Satellite Center (SatCen) was responsible for the service. In addition, EUSPA is preparing the system's security monitoring together with the European Commission and the EUSST Consortium and will operate the security monitoring of the network.

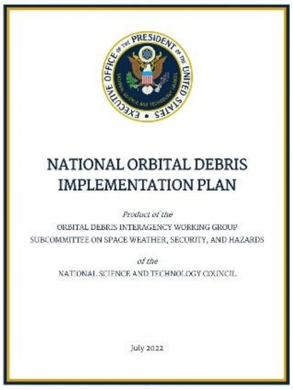
Other European developments in space sustainability

- In June, the UK Government made several announcements regarding space sustainability at the **SWF-UKSA Summit for Space Sustainability**. UK Minister for Science, Research, Innovation, George Freeman, introduced a plan with new measures to drive space sustainability. The Government will establish a new "Space Sustainability Standard" to incentivise companies to implement best practices to limit space debris. The British regulatory framework for all orbital activities will also be reviewed to incentivise Active Debris Removal and In-Orbit Servicing.[159]
- ESA DG Josef Aschbacher inaugurated a new Space Safety Center at the ESOC Mission Control Center which aims to monitor space weather, to support the provision of space weather warnings and to exploit data acquired by ESA's space safety missions Vigil, Hera and ClearSpace-1.[160]
- Space Scotland published the Space Sustainability Roadmap for Scotland which traces the direction and to work towards a more sustainable Scottish space sector through a series of 11 detailed work packages in the areas of leadership, in-orbit, environment and Net Zero, including recommendations for the sustainable development of the sector.[161]
- In May, ESA awards Astroscale UK €14.8 million funding from the Sunrise Partnership Programme between ESA, OneWeb and the UKSA for the 2024 ELSA-M debris removal mission. The launch of ELSA-M is planned by the end of 2024.[162]

[158] EUSPA takes on the Space Surveillance and Tracking helpdesk as of 2023, EUSPA, June 2022
[159] U.K. government announces new space sustainability measures, Space News, June 2022
[160] ESA Director General opens ESOC's new Space Safety Centre, ESA, Press Release, April 2022
[161] Scotland Releases Space Sustainability Roadmap, Payload, 2022
[162] OneWeb, Astroscale, and the UK and European Space Agencies Partner to Launch Space Junk Servicer ELSA-M with €14.8 million Investment, Astroscale, Press Release, May 2022

1.4.2 Developments beyond Europe

U.S. releases the National Orbital Debris Implementation Plan


NATIONAL ORBITAL DEBRIS IMPLEMENTATION PLAN

Product of the

ORBITAL DEBRIS INTERAGENCY WORKING GROUP
SUBCOMMITTEE ON SPACE WEATHER, SECURITY, AND HAZARDS

of the

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

July 2022

Credit: National Science and Technology Council

In July, the U.S. released the National Debris Implementation Plan. The document, released by the National Science and Technology Council as a product of the Orbital Debris Interagency Working Group, aims at guiding the U.S. Government in addressing the orbital debris issue. Building on the 2021 National Orbital Debris Research and Development Plan, the document of 2022 identifies 44 tangible actions for agencies, distributed across 3 main pillars:

- Debris mitigation
- Tracking and characterization of the debris population
- Active remediation

The Plan is consistent with the interagency work on implementing the Space Policy Directive-3, the U.S. National Space Traffic Management Policy.[163]

U.S. FCC's proposal for 5-year deadline for LEO satellites deorbiting approved

The Federal Communication Commission (FCC) issued a draft order setting a five-year deadline rule for post-mission disposal of LEO satellites, designed to limit the creation of orbital debris.[164] The draft order requires LEO satellite operators to deorbit their satellites at the end of their missions by disposing their spacecrafts through re-entry into the Earth's atmosphere within a five-year deadline - a much shorter timeframe than the currently required 25-year timeframe. On September 29th, the FCC took up the order at its open meeting where the proposal for the rule was approved, passing unanimously. **This new rule will apply to satellites launched two years after adoption of the order and would concern satellites licensed by the U.S. as well as satellites serving U.S. markets**. Earlier in September, the DoC and the DoD signed a MoU defining their cooperation on civil/commercial STM, in line with the U.S. National STM Policy (SPD-3), which directed the DoC to take over the provision of SSA data and services relevant to STM and that are currently provided by the U.S. military.[165]

U.S. Office of Space Commerce began unveiling a new STM architecture

Credit: U.S. Office of Space Commerce

The U.S. Office of Space Commerce started to unveil a new architecture for space traffic management (STM). The Department of Commerce's STM initiative was on hold for several years due to a lack of appropriate funding - but the budget increase for 2023 (the Biden administration requested $87.8M for the Office of Space Commerce for 2023) provides the office with an 800% increase over the previous budget.

In February, the Department of Commerce unveiled a first space catalogue and a traffic software platform prototype providing basic SSA and STM services.[166]

[163] National Orbital Debris Implementation Plan, U.S. National Science and Technology Council, July 2022
[164] FCC to set five-year deadline for deorbiting LEO satellites, Space News, September 2022
[165] Commerce and Defense Departments sign agreement on space traffic management cooperation, Space News, September 2022
[166] Office of Space Commerce rolls out prototype space catalog for traffic management, Space News, February 2022

Other International developments in space sustainability

- In September, the International Astronautical Federation (IAF), the International Academy of Astronautics and the International Institute of Space Law (IISL) concluded a joint report on Space Traffic Management. The initiative, launched in 2018, aimed to develop approaches and proposals for STM (technical and legal aspects) to assist policy- and decision-makers on national and international levels. Over 130 members from the three organisations contributed to the report.[167]
- On November 4th the remnants of a Long March 5B re-entered earth's atmosphere and splashed down in the Pacific Ocean in two separate pieces. The booster had originally been used to launch the Mengtian module of the Tiangong space station on October 31st. The Long March 5B booster engines are only able to fire once. Therefore, after the rocket has placed its desired payload into orbit it cannot relight its engines to perform a controlled de-orbit burn. The November 4th splashdown was one such uncontrolled re-entry of the Long March 5B. It sparked strong rebukes from officials such as NASA administrator Bill Nelson and ESA Director General Josef Aschbacher.[168]

[167] IISL, IAA and IAF conclude major report on STM, IISL, September 2022
[168] Long March 5B rocket reenters over Pacific Ocean after forcing airspace closures in Europe, Space News, November 2022

1.5 Access to space

1.5.1 Incumbents overcoming a crisis, new entrants with increased support

While in July Vega C's inaugural flight was celebrated as a success for the European launchers' fleet, 2022 ended with a less bright outlook on Europe's autonomous access to space. As a matter of fact, European launch capabilities have been severely impacted by the loss of the Russian Soyuz launch vehicle due to the war in Ukraine, the delay of Ariane 6, whose maiden flight was announced not to take place before Q4 2023 (and the last Ariane 5 launch in summer 2023), and the launch failure of Vega C's second flight in December.[169]

At the ESA CM22 in November, ESA Members States decided to allocate €2.8 billion for space transportation to further strengthening Ariane 6 and Vega C launchers, for the completion of the development of the reusable Space Rider, and of a green hydrogen system to fuel Ariane launchers in Kourou. In addition, this will include efforts in preparatory activities for human space transportation capabilities as well as to increase the efforts of the ESA Boost! Programme, including revisioning ESA's launcher procurement policy.[170]

Joint Statement by Germany, France and Italy on the future of launcher exploitation in Europe

Credit: ESA

Moreover, at the sidelines of the ESA CM22, Germany, France and Italy, represented by Bruno Le Maire (France), Robert Habeck (Germany) and Adolfo Urso (Italy), signed a **Joint Statement on the future of launcher exploitation in Europe.**[171]

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.

ESA Director General Josef Aschbacher highlighted that the Joint Statement gives impetus to stabilise the situation between the key countries engaged in European launch vehicle development and provides guidance on the way ahead. With regards to Art. 12 on space transportation and launcher exploitation proposed in the draft Council Resolution on "ESA Accelerating the use of space in Europe", in the statement it says: "**The public funding necessary to equilibrate the Ariane 6 and Vega-C institutional and commercial exploitation will be reviewed** in order to take into account the evolution of market prices, institutional prices, economic conditions and status of negotiation between the launcher primes and the industrialists, while maintaining the main principle which is to allow the commercial exploitation of the two launchers with a duly defined public support while at the same time maintaining an independent and autonomous access to space following the principle of European preference for institutional missions."[172]

Once funding committed at CM22 is reviewed, it will be allocated in contracts awarded by ESA to the launch service providers and the launcher system primes, based on the principles:

[169] The War in Ukraine and the European Space Sector, ESPI, May 2022
[170] Ministers back ESA's bold ambitions for space with record 17% rise, ESA, November 2022
[171] Ministers from France, Germany and Italy signed a Statement on the future of launcher exploitation in Europe, ESA, November 2022

- A mechanism to incentivise cost reduction will be applied.
- For the launch service provider: the allocation of funding will be commensurate to the commercial risks taken, which will be assessed in joint efforts with ESA.
- For the launcher system primes and key industry: the funding will be allocated subject to them meeting their respective target prices as agreed between ESA, the respective launcher system prime and the concerned main industrialist, using ESA audits.

The 3 nations called on ESA Director General Josef Aschbacher to **propose revised exploitation parameters for public funding**, based on these principles and the ESA Council Resolution adopted in 2021 by mid-2023 and for approval by the concerned participating states (who are concerned on the conditions for the industrial and geographical distribution of work in exploitation). A first step towards the evolution of the launch service procurement policy for ESA missions could be the proposed acknowledgement of operational European NewSpace micro/mini launch systems for ESA satellite launch service procurements.

The new framework is planned to become effective from June 2024, with the following milestones:

- December 2022: Sharing of the joint statement at the occasion of the ESA Council
- May 2023: Progress meeting at Ministerial Level from France, Germany, and Italy
- June 2023: Status report to ESA Council
- November 2023: Consultation meeting at Ministerial Level from France, Germany, and Italy on a proposed way forward
- December 2023: Decisions of ESA Member States on a proposed way forward
- June 2024: New and final architecture (incl. the legal framework) to become effective.

Developments in the European launcher sector – new entrants getting increased public support

The French government supports the development of Maia and other French small launchers

Credit: MaiaSpace

On February 2nd, CNES President Philippe Baptiste testified before the French Senate Economic Affairs Commission. He presented CNES's objectives and priorities for 2022. Among other elements, Baptiste outlined that the French government will support the development of ArianeGroup's Maia reusable launchers in order to face the fierce competition on mini launchers in Europe and sustain France's leadership in this domain. He also highlighted that it is essential for France to master reusability regardless of future features of Ariane 6 and its successors. The French government aims to financially support mini and micro launchers developed by French start-ups.[173]

ArianeGroup unveils SUSIE


Credit: ArianeGroup

During the International Astronautical Congress (IAC) in Paris, ArianeGroup unveiled the Smart Upper Stage for Innovative Exploration (SUSIE) spacecraft concept.[174] The spacecraft, which aims to provide Europe with independent crew and cargo access to LEO, would be launched aboard an Ariane 64. To that end, it will be able to carry up to 7.000kg of cargo or a crew of five people to LEO and will have a total weight of 25.000 kg. Beyond capabilities for LEO, there is also the possibility of adding a Space Transfer Module to SUSIE, which is a system to provide the necessary propulsion, energy, and air supply to reach lunar orbit.

[173] France's CNES: There's a mini-launcher competition in Europe, Space Intel Report, February 2022
[174] ArianeGroup unveils SUSIE at IAC, ArianeGroup, September 2022

European Commission procured 5 Vega-C launches from Arianespace

On November 29th, the European Commission (DG DEFIS) awarded a contract to Arianespace to launch the five Copernicus satellites Sentinel-1D, Sentinel-2D, Sentinel-3D, *Sentinel* CO2M-A and CO2M-B on Vega C vehicles in 5 launches between 2024 and 2026.[175]

Sentinel-1D was scheduled in the first half of 2023 on board Vega C. It will provide all-weather ocean and land high resolution multi-purpose observations. Sentinel-2C is planned to be launched in mid-2024. It will provide observations for land services (variability in land surface conditions and Earth's surface changes). Sentinel- 3C is planned to be launched between 2024-2025. It will host radar altimeters, radiometers, and spectrometers, to measure the height of the ocean surface, sea and land surface temperature, and vegetation cover. Sentinel CO2M-A and CO2M-B launches are scheduled for 2025-2026. Both will be equipped with a near-infrared and shortwave-infrared spectrometer to measure atmospheric carbon dioxide.

European progress for reusable launchers and GHG emission reduction

ESA, CNES and MT Aerospace cooperate in Hyguane project to reduce launch GHG-emissions

ESA, CNES and OHB SE' subsidiary MT Aerospace joined forces to lead a consortium of European industrial and academic partners for the **Hyguane (HYdrogène GUyanais A Neutralité Environnementale)** project. The initiative aims to reduce CO2 emissions of orbital launches by creating an infrastructure (a pilot plant) for a hydrogen ecosystem supporting Europe's Spaceport in French Guiana. The pilot plant is planned to be capable to produce 130 tons per year of renewable green hydrogen. An innovative co-financing concept envisages to pool funds from ESA, industrial partners, and France's national economic stimulus programme.[176]

ESA selected ArianeGroup to boost development of Europe's reusable launchers

The European Commission selected ArianeGroup to lead the SALTO and ENLIGHTEN projects under the Horizon Europe programme, with the aim to accelerate the development of reusable and eco-friendly European launchers, to continue the development of the Themis reusable booster demonstrator, and Prometheus reusable rocket engine projects.[177]

ArianeGroup leads two consortia with European partners for the two projects:

- **The 2-year €39 million SALTO ("reuSable strAtegic space Launcher Technologies & Operations") project** aims to test the vertical landing of a reusable launcher. The full-scale demonstrator will carry out several low-altitude flights from Sweden. The test preparations are made in cooperation with ESA's Themis reusable stage program and the Callisto project of CNES, DLR, and JAXA. The consortium is comprised of 26 partners from 12 countries.
- **The €17.4 million ENLIGHTEN ("European iNitiative for Low cost, Innovative & Green High Thrust Engine") project** aims to advance additive manufacturing and AI which are necessary for monitoring and maintaining applications for reusable engines. As part of the project, production and deployment technologies for reusable rocket engines will be developed and tested, and a series of reusable propulsion systems powered with bio-methane or green hydrogen will be created. The consortium comprises 18 partners from 8 countries.

[175] Arianespace supporting the European Union's Copernicus programme with Vega C, November 2022
[176] MT Aerospace, ESA and CNES intend to reduce Ariane Launch greenhouse gas emissions, OHB, July 2022
[177] ArianeGroup selected for two European Commission calls for projects to speed up the development of Europe's first reusable and eco-friendly launchers, ArianeGroup, July 2022

1.5.2 Scarce launch availability due to tight timelines and scale

Developments in European launch facilities and spaceports

In 2022, the UK saw developments for the Spaceport Cornwall and the SaxaVord Spaceport:

On November 16th, the UK Spaceport Cornwall received the UK's first-ever spaceport licence, issued by the UK Civil Aviation Authority (CAA). The spaceport, based at Cornwall Airport Newquay, proved that it met the safety, security and environmental requirements to operate a UK spaceport and that it has the infrastructure, equipment and services for horizontal space launches. This marks the UK's first ever spaceport licence.[178]

The Scottish government approved two pending applications, so that the construction of SaxaVord Spaceport, which is to be located on the Lamba Ness peninsula on Unst, can enter now into the final phase.[179] In January 2021, Farningham Planning submitted applications for the spaceport to the Shetlands Islands Council for 30 launches per year. Rocket companies to launch from SaxaVord Spaceport are the U.S. company ABL Space Systems' RS1, the **U.S. company Lockheed Martin's UK Pathfinder satellite launch system**, which was supported by grants of £23.5 million from the UK Space Agency, and the German company Hylmpulse Technologies for the development of its launch vehicle for orbital launches targeted to take place in 2023.

Italian Grottaglie Spaceport to gain new legal personality

In July, a MoU was signed between the Puglia Region, the Italian National Civil Aviation Authority (ENAC) and Airports of Puglia to establish a new legal entity called "Criptaliae Spaceport" (from the ancient name of Grottaglie). With an envelope of €50 million for the construction of the infrastructure linked to the Spaceport, and €30 million for research, the move has been enacted to allow the three parties and other relevant authorities to better intercept the demand for innovative services in the aerospace sector, of both public and private nature.[180]

Developments beyond Europe

China progresses with launchers

According to Chinese officials, China is in progress with the development of "Long March 9", a new generation of super-heavy carrier launchers designed to conduct landing on the Moon by 2030, as well as launch elements for the planned International Lunar Research Station (ILRS) jointly planned by China and Russia. Though not stated, the new engine configuration would also be expected to be more amenable to first stage reusability, as demonstrated by launches of "Long March 2F".[181]

Moreover, State-owned and commercial companies in China are developing capabilities to launch liquid fuelled rockets, including from sea-based platforms. Private company Orienspace was founded in late 2020 and is developing the Gravity-2 liquid propelled launcher which it aims to launch from a sea-platform. State-owned China Academy of Launch Vehicle Technology (CALT) Is also looking to adapt the Long March 8 for launches from sea platforms.[182]

Additionally, China continued its development of a reusable space transportation system when it launched a spaceplane on a sub-orbital flight from Jiuquan Satellite Launch Center in August. The

[178] Spaceport Cornwall receives first-ever UK spaceport licence, Civil Aviation Authority, November 2022
[179] Spaceport construction set to begin on UK's northernmost island, Space.com, April 2022
[180] "CRIPTALIAE SPACEPORT", MoU signed, ENAC, July 2022
[181] China claims progress on rockets for crewed lunar landings and moon base, Space News, August 2022
[182] China looks to launch liquid propellant rockets from the seas, Space News, June 2022

spaceplane, which landed horizontally at an airport In Inner Mongolia, is being developed by CALT and Is potentially part of a 2 stage fully reusable space transportation system.[183]

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, but the first rocket launch is envisaged early next year. The project is led by the National Aerospace Services Company.[184]

Russia launched Angara 1.2 for the first time

In April, Russia launched a new version of the Angara rocket for the first time, the Angara 1.2. The launch took place from Plesetsk Cosmodrome. The launch was confirmed to be a success by Russian state media, after it placed a small satellite into a near-polar orbit. Angara 1.2 can reportedly launch a payload of 3.8 tons to LEO, compared to 24.5 tons of the Angara A5 rocket. Angara 1.2 launched a second time in October carrying the military satellite EMKA-3.[185]

United States: Spaceport Camden struck down by voters, while Rocket Lab received final approval from FAA to launch Electron rocket from Spaceport on Wallop's Island

A proposed spaceport in the state of Georgia, called Spaceport Camden, has been struck down by voters in Camden County. A special referendum was held in the county in which voters voted 72% in favour of terminating an agreement between the county and Union Carbide to purchase property the county intended to use for the spaceport. Camden Spaceport had already been granted a license to operate by the Federal Aviation Administration (FAA).[186]

In December, Rocket Lab received final approval from the Federal Aviation Administration (FAA) to launch their Electron rocket from the Mid-Atlantic Regional Spaceport located on Wallop's Island, Virginia. The certification process saw the FAA request a risk assessment report from NASA before giving final approval. Once NASA completed the risk assessment and showcased confidence In Rocket Lab's operations, the company was cleared to conduct flights from the spaceport. The first launch to occur in early 2023, signalling the first time Rocket Lab will conduct launch operations from the United States, in parallel to continued flights conducted in New Zealand.[187]

Japan delayed launch of its new H3 rocket and launch failure of Epsilon-6 launch

Japan delayed the launch of its new H3 rocket after its development continued to encounter difficulties, most notably issues relating to the LE-9 main engine.[188] Engineers continued to grapple with the difficulties, when qualification testing in 2020 showed cracked turbine blades in the LE-9's turbopump assembly, and a hole burned into the engine's combustion chamber wall. The H3 is built to be the successor to Japan's H-2A medium-lift launch vehicle and is intended to be Japan's new workhorse rocket. JAXA announced the delay of the rocket but did not give an updated schedule for when it might debut.

Moreover, in October, JAXA attempted to launch the Epsilon-6 launch vehicle from Uchinoura Space Center on Kyushu Island carrying eight satellites. During ascent the rocket began deviating from its planned trajectory, after which JAXA ordered the rocket to self-destruct some seven minutes after lift-off. JAXA opened an investigation into the cause of the failure with the hope of identifying the failure, fixing the issue, and returning the Epsilon-6 to flight. No new return flight date has been announced.[189]

[183] China makes progress in reusability with secretive second flight of suborbital spaceplane, Space News, August 2022
[184] Oman to build the Middle East's first spaceport, Spacewatch.global, January 2023
[185] Angara-1.2 flies its first mission, Russian Space Web, April 2022
[186] Voters reject spaceport plan long pursued by Georgia county, npr, March 2022
[187] FAA clears Rocket Lab for first launch from U.S. spaceport, Spaceflight Now, December 2022
[188] Japan's H3 rocket further delayed by engine woes, Space News, January 2022
[189] Japan destructs its Epsilon-6 rocket following failed launch, SpaceWatch.Global, October 2022

India's first privately developed rocket Vilkram-S launched, while ISRO's SSLV inaugural flight failed to deploy satellites into desired orbit

In August, ISRO attempted to conduct the maiden flight of its new Small Satellite Launch Vehicle (SSLV). Despite the initial success at liftoff, and a deployment of the satellites into orbit, it was deemed the Velocity Trimming Module (VTM) failed to insert the satellites into their desired orbit, rendering them unusable. The rocket placed the satellites into 56 km x 76 km elliptical orbit instead of 356 km circular orbit. ISRO set up a committee to review the failure.[190]

Credit: ISRO

The Indian startup Skyroot Aerospace launched the country's first privately developed (suborbital) rocket, called Vikram-S, in November.[191] Vikram-S, which is a single stage, solid fuelled sub-orbital rocket took off from the Satish Dhawan Space Centre in Sriharikota. The launch was aimed at testing and validating technologies the company plans to use for its first orbital-class rocket, Vikram 1, which is slated for a 2023 debut. The Vikram 1 is a three-stage rocket capable of launching 500 kilograms to LEO. The third stage of Vikram 1 has already undergone a successful full-duration test, with tests of the first and second stages expected soon.[192]

Canada's new spaceport "Spaceport Novia Scotia" received approval for construction

On August 29th, the provincial government of Nova Scotia announced the approval of the construction of a new spaceport, named Spaceport Novia Scotia, in the Atlantic coastal town of Canso. The new facility will be managed by Maritime Launch Services. The Department of Environment and Climate Change gave the green light after the project met all the necessary environmental assessment terms and conditions. CEO of Maritime Launch Services, Stephen Matier, said construction of the spaceport will begin in 2023, with the goal of launching the first commercial payload by the end of 2024. The spaceport expects to support its first launches from Quebec startup Reaction Dynamics, who will conduct sub-orbital flights from the spaceport.[193]

South Korea's first fully domestic developed rocket Nuri successfully launched

In June, the first ever rocket fully originating from South Korea placed satellites into orbit for the first time. The Nuri rocket, which was making its second orbital launch attempt after an initial failed launch in October 2021, took off from Naro Space Center and successfully reached orbit and deployed the six satellites on board. It is not the first time South Korea has launched a satellite, previously successfully launching the Naro rocket in 2013. But the Naro rocket was a joint collaboration with Russia, whereas Nuri is fully developed by South Korea.[194]

Iran successfully completes a suborbital flight, testing Ghaem-100's first stage

In November, Iran announced it had successfully completed a test flight of a rocket that is capable of delivering satellites to orbit. The rocket, named Ghaem-100, was reported by state affiliated media to have successfully completed a sub-orbital launch.[195]

The test flight tested the first stage of the rocket only. The entire rocket, which will be three stages, will be capable of delivering satellites weighing 80 kilograms into an orbit with an apogee of 500 kilometres.

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[190] The first flight of India's small satellite vehicle results in loss, Tech Crunch, August 2022
[191] India's PSLV rocket launches nine satellites in final mission of 2022, Space News, November 2022
[192] India's Skyroot Aerospace raises $51 million ahead of inaugural launch, Space News, September 2022
[193] Maritime Launch to Begin Construction of Spaceport Nova Scotia, Business Wire, August 2022
[194] South Korea Nuri rocket launches satellites to orbit for 1st time, Space.com, June 2022
[195] Iran's Revolutionary Guard launches successful rocket test, Space.com, November 2022

1.6 Applications and downstream

1.6.1 Earth Observation

UN COP27 highlights the role of space for climate action

Credit: Groundstation.Space

From November 6th to 18th, the UN Climate Conference 2022 (COP27) took place in Egypt (in Sharm el-Sheikh).[196] The use of space for climate action was addressed under the auspices of the event, with several notable developments:

- UNOOSA and UKSA published a report on space-related climate action efforts. The report aims to enhance the understanding of the potential of the use of space for climate action, to support strategic decision-making and to outline opportunities for cooperation.[197]
- The UN Environment Programme (UNEP) signed the Space Climate Observatory (SCO) International Charter. The signature consolidates the collaboration of the SCO with the UN World Environment Situation Room (WESR), which gathers environmental studies and data that the SCO will regularly provide.[198]
- UN Secretary-General Guterres announced a 3.1B plan to invest in the Early Warnings for All initiative.[199] A text approved by the UN Subsidiary Body for Scientific and Technological Advice (SBSTA) highlights the need to address climate change through robust EO data.[200]
- The Copernicus Climate Change Service (C3S) and the Copernicus Atmosphere Monitoring Service (CAMS) highlighted during COP27 how the Copernicus programme contributes to climate mitigation and adaptation and supports policy-making with EO data and science.[201]

Developments in Europe

Europe enters new era of satellite meteorology with the launch of first satellite of Meteosat Third Generation series

Credit: ESA

The antepenultimate flight of Ariane 5 on December 13th 2022 carried on-board MTG-I1, the first in the series of third-generation Meteosat (MTG) satellites, operated by EUMETSAT.[202] To be fully deployed over the upcoming decade, the third generation of the Meteosat programme will consist of 6 geostationary satellites (4 MTG-Imagers and 2 MTG-Sounders), with considerably improved instruments alongside completely novel ones for both European (Lightning Imager) and global (Infrared Sounder) observations. Leveraging these capabilities, the new system will:

- contribute to **increasing societal and infrastructure resilience, by providing civil protection actors with near real-time information on fast-developing meteorological phenomena with potentially disastrous consequences, such as violent thunderstorms, heavy rains.**
- guarantee the continuity of data for weather forecasting from geostationary orbit for national meteorological and hydrological services **into the 2040s,**
- ensure Europe's **continuous contribution to globally coordinated satellite meteorology activities under the World Meteorology Organisation (WMO) framework.**

[196] Sharm El-Sheikh Climate Change Conference – November 2022, United Nations Climate Change, November 2022
[197] UNOOSA and United Kingdom release report on global space-related climate action efforts, UNOOSA, November 2022
[198] Back to COP27: SCO overview, SCO, November 2022
[199] COP27: $3.1 billion plan to achieve early warning systems for all by 2027, United Nations, November 2022
[200] Implementation of the global climate observing system, UNFCCC, November 2022
[201] Copernicus at COP27, Ground Station, November 2022
[202] Meteosat – A Successful Model of European Cooperation in Space, ESPI, December 2022

ESA selects Harmony as the tenth Earth Explorer mission in the FutureEO programme

The mission includes twin EO satellites that will accompany the already orbiting Sentinel-1. On-board they both feature SAR and Multiview thermal-infrared instruments, that will carry out motion observation and provide information about oceans, ice, earthquakes and volcanoes, making significant contributions to climate research and risk monitoring.[203]

The European Commission launched its Destination Earth (DestinE) initiative

On March 30th, the European Commission officially launched the Destination Earth (DestinE) Initiative which strives to develop a digital twin of Earth by 2030. **DestinE** aims to become a tool in tackling the climate crisis by providing help to monitor, model and predict natural and human activity, as well as by developing and testing future scenarios related to the evolution of Earth-climate systems. The initiative is supported by €150 million funding from the Commission's Digital Europe Programme and funds from, ESA, ECMWF, and EUMETSAT, who will jointly develop the digital model and implement the programme.[204]

Credit: ESA

The Council of the EU adopted conclusion on Copernicus by 2035

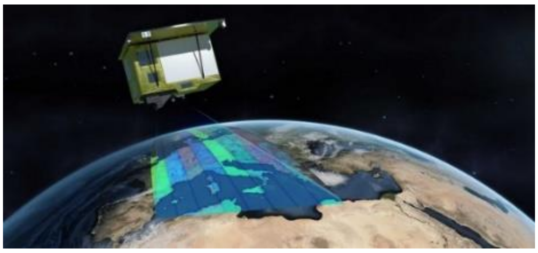
On June 10th, the ministers responsible for space in the Council of the EU adopted conclusions on the future of Copernicus by 2035, which set out a vision and political guidance for 2035 based on three key pillars aiming at contributing to a more resilient Europe: (1) the Green Deal, (2) the digital transition and (3) security. The conclusions consider user needs, new environmental challenges, the state of the art of research and maximise the inclusion of new digital technologies.[205]

Substantial contract award for a new Copernicus satellite data access service

In December, 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 to improve the exploitation of satellite data and will be fully operational in July 2023. The data will be made immediately available through industry-led standard interfaces.[206]

German environmental satellite EnMAP was launched and became operational

On April 1st, the German environmental satellite EnMAP (Environmental Mapping and Analysis Program) was launched from Cape Canaveral on SpaceX's Falcon 9, as part of the Transporter-4 rideshare mission. The satellite was developed and built in Germany (by OHB), is operated by the German Aerospace Center (DLR) and funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK). EnMAP is a research mission for environmental and climate protection, to support sustainable land use, help understand climate change and enable the detection and counteracting environmental degradation. After a 6-month test campaign, EnMAP became operational.[207]


Credit: DLR

[203] ESA selects Harmony as tenth Earth Explorer mission, ESA, September 2022
[204] ESA - Journey to Destination Earth begins, ESA, March 2022
[205] Conclusion on the future of Copernicus by 2035, European Council, June 2022
[206] European Space Agency selects T-Systems as prime contractor, Defence Industry Europe, January 2023
[207] German satellite EnMAP launches successfully, DLR, April 2022

DLR and ASI sign an implementation agreement for EO hyperspectral mission

In September, during the IAC in Paris, the Italian Space Agency ASI and German Space Agency at DLR signed an 8-year agreement, in the context of the previous framework agreement between the parties, dated back to 2007. In the new agreement, ASI and DLR committed to share information, strategies, and results of their hyperspectral missions PRISMA and EnMAP. In addition, the agencies will organise workshops and events to promote public awareness of the two missions.[208]

IRIDE constellation: Awarding first contracts

The Italian future EO satellites constellation will be built in Italy under the management of ESA and ASI. The constellation will be financed under Italy's National Recovery and resilience Plan (PNRR) and will support Civil Protection units to counter natural and human induced disasters, as well as provide analytical data for the development of commercial applications by start-ups and SMEs. The constellation's capabilities will range from microwave imaging using SAR (Synthetic Aperture Radar), to optical imaging at various spatial resolutions and in different frequency ranges. First contracts for the development of two components were signed on December 3rd for a total value of €68 million for 22 satellites, including 10 built by the Turin-based Argotec and 12 built by the Milan-based OHB Italia by November 2024. The Argotec-led industrial team includes Officina Stellare and Rhea System, while OHB Italia will team up with OPTEC, Telespazio and Aresys.[209]

ESA and ICEYE signed agreement to support Copernicus Emergency with flood data

On May 23rd, the Finnish company ICEYE and ESA announced the start of a pilot activity to support the Copernicus Emergency Management Services (CEMS) team. ICEYE will provide flood impact information, with the objective of demonstrating the extent and depth of flooding at the structural level throughout 2022. The pilot will enable CEMS to evaluate ICEYE's flood data and explore potential applications. ICEYE will provide SAR data and images following flood events and will provide ESA and CEMS access to historical time series through ICEYE's analytic archive.[210]

ESA hosts new international office to coordinate global climate modelling efforts

The new office will coordinate the Climate Model Intercomparison Project (CMIP) of the World Climate Research program (WCRP), coordinating efforts in global climate modelling for a minimum of five years, and will support the new WCRP strategy. The Netherlands-based firm HE Space Operations, contracted by ESA, appointed Eleanor O'Rourke as the office's incoming director.[211]

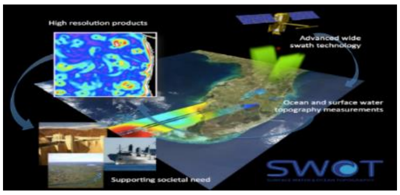
ESA decommissioned the Copernicus Sentinel 1B satellite

On August 3rd, ESA and the European Commission declared end of mission for the Sentinel-1B Copernicus satellite. In December 2021, Sentinel-1B, launched in 2016, became unable to deliver radar data, due to an anomaly related to the instrument electronics power supply provided by the satellite platform - since then spacecraft operators and engineers have been trying to solve the problem, without success. In consequence, ESA's Anomaly Review Board concluded and decided that the recovery of the 28V regulated bus of the satellite's C-band SAR antenna power supply unit which is crucial for the power provision to the radar electronics, was not possible. ESA's and the EC's plans are in force to launch Sentinel-1C as soon as possible.[212]

[208] Orbital twinning between the Italian satellite Prisma and the German EnMAP satellite, ASI, September 2022
[209] Space, name of future Italian satellite constellation announced, MIUR, June 2022
[210] ICEYE starts pilot with ESA to support Copernicus Emergency Services, Spacewatch.global, May 2022
[211] ESA hosts new office to coordinate global climate modelling push, ESA, February 2022
[212] Mission ends for Copernicus Sentinel-1B satellite, ESA, August 2022

Developments beyond Europe

Surface Water and Ocean Topography (SWOT) satellite successfully launched



Credit: NASA/CNES

On December 16th, the Surface Water and Ocean Topography (SWOT) satellite was launched by a SpaceX Falcon 9 from the Vandenberg Space Force Base. The mission, a joint effort by CNES and NASA, with contributions from the Canadian Space Agency and the UKSA, aims at measuring surface water levels in lakes and flow rates in rivers, as well as providing an accurate determination of ocean topography. SWOT will carry onboard the Ka-band Radar Interferometer (KaRIn), designed by NASA JPL, and complemented by the radio-frequency system constructed by CNES and Thales Alenia Space, for the wide-swath interferometry. In addition, the Nadir payload, which comprises the same instruments as the Jason satellites, will be carried. Thales Alenia Space manufactured the instruments. Finally, the SWOT satellite is equipped with technology to conduct a controlled atmospheric re-entry at its end of life in orbit, in full compliance with the French Space Operations Act.[213]

Canada contributes to NASA's Atmosphere Observing System programme

The Canadian government agreed to spend more than $200 million on the High-altitude Aerosols, Water vapor and Clouds (HAWC) mission, that will contribute to NASA's Atmosphere Observing System. The mission will provide measurements to understand aerosol and cloud processes driving extreme weather and climate change. As part of HAWC, Canada will contribute a satellite with two instruments and a third instrument (on NASA satellite) for the AOS mission - both will be launched in 2031.[214]

Australia to build a fleet of 4 Earth Observation satellites

The Australian government entered the first phase of its first national space mission, aiming to build a fleet of 4 dual use Earth Observation satellites, with a 2022-23 budget of $1.16 billion until 2038-39 and then with $38.5 million per year ongoing. The mission is led by the Australian Space Agency in partnership with Geoscience Australia, CSIRO, the Bureau of Meteorology and Defence.[215]

BRICS group will create a "virtual" EO satellite constellation

On the backdrop of a newly established space cooperation group among the BRICS countries, it was revealed that a new "virtual" remote sensing constellation is to be established. The constellation will be made up of six existing satellites contributed by the space agencies of four BRICS countries — Brazil, Russia, India, and China.[216]

Russia launched Iran's EO Satellite

In August, the Russian Soyuz-2.1b rocket booster blasted off with the Iranian satellite Khayyam onboard from the launchpad at the Baikonur Cosmodrome in Kazakhstan. The EO satellite Khayyam was suspected by some analysts to be used by Russia to enhance its surveillance of military targets in Ukraine. According to the Iranian Space Agency, the satellite is under exclusive control of Iran, with its purpose to monitor the country's borders, support enhancing agricultural productivity and monitor water resources as well as natural disasters.[217]

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[213] SpaceX launches NASA satellite to study world's water surface, Space.com, December 2022
[214] Canada to contribute satellite and instruments to NASA-led Earth science program, Space News, October 2022
[215] Australia to build fleet of dual use Earth Observation satellites, Copernical, April 2022
[216] BRICS to Build Virtual Constellation of EO Satellites, Space in Africa, June 2022
[217] Russia Launches Iranian Satellite Amid Ukraine War Concerns, Voa News, August 2022

1.6.2 Positioning, Navigation and Timing

Europe: Strong support for future PNT services at the ESA Ministerial

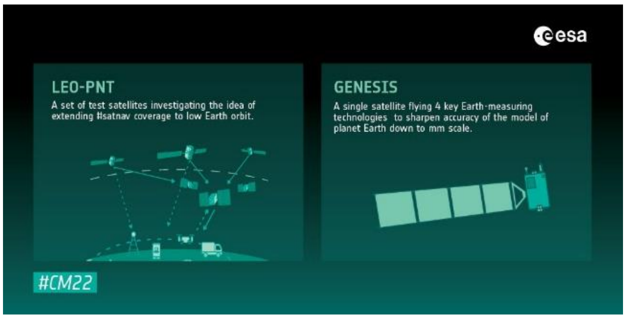
At the 2022 ESA Council Meeting at Ministerial Level, ESA had proposed a €100 million package on positioning, navigation and timing (PNT). The programme was oversubscribed due to substantial subscriptions from Germany, France, Italy, and Spain. Due to the extra finances, ESA Navigation Director Javier Benedicto said ESA can now "engage in an additional phase to develop the transition between the program and the future LEO PNT component of the EU Institutional Infrastructure".[218]

1. NAVISP (Navigation Innovation Support Programme)

ESA's Navigation Innovation and Support Program (NAVISP) aims to generate innovative concepts, techniques, technologies and systems linked to the PNT sector in the competitive and evolving global market for PNT technologies and to support the generation of innovative propositions beyond the exclusive use of satellite navigation signals and data The NAVISP programme is comprised of 3 elements: (1) Innovation; (2) Competitiveness; and (3) Support to Member States.

2. FutureNAV

The new ESA navigation programme FutureNAV, which was approved at ESA CM22, includes 2 elements: (1) the LEO PNT initiative (initially proposed at €100 million but subscribed €151.38 million) and (2) GENESIS (proposed at €80 million and subscribed €64.52 million).



Credit: ESA

Other European developments in PNT

EUSPA releases GNSS Market Report

In 2022 EUSPA released Its biennial EO & GNSS Market Report. The report found GNSS- and EO-enabled revenues crossed €200 billion In 2021, with projections forecasting that number to rise to €500 billion over the next decades. It was also projected that annual shipments of GNSS receivers between 2021 and 2031 are forecasted to grow from 1.8 to 2.5 billion units, and the global Installed base of GNSS devices in use is expected to reach over 10 billion by 2031. The global downstream market revenues covering both device sale and service-related revenues Is expected to grow at a CAGR of 9.2% up to 2031.[219]

EUSPA inaugurates new Galileo Security Monitoring Facilities in Spain

On September 30th, EUSPA and the Spanish Ministry of Defence inaugurated new facilities for the Galileo Security Monitoring Centre (GSMC) in Saint Martin de la Vega, Spain. The new facilities are located in the La Marañosa Campus, part of the National Institute of Aerospace Technology (INTA). The centre serves as a backup site to the GSMC located in Saint-Germain-en-Laye, France. The GSMC executes a specific function within EUSPA in ensuring that the Galileo infrastructure is adequately protected, providing around-the-clock monitoring of the Galileo system's security.[220]

[218] Navigation at Ministerial Council 2022, ESA, November 2022
[219] EUSPA EO and GNSS Market Report, EUSPA, January 2022
[220] EUSPA inaugurates new Galileo Security Monitoring Facilities, EUSPA, September 2022

Galileo satellites GSAT0224 enters into service

The Galileo satellite GSAT0224 "Shriya" entered into service, having passed in-orbit testing at the beginning of the year and an in-orbit validation for EUSPA and ESA's finalised testing campaign.[221]

Galileo High Accuracy Service Signal in Space Interface Control Document officially published

Following the first publication of the Galileo High Accuracy Service Signal in Space Interface Control Document by EUSPA, European Commission and ESA, Galileo further progressed towards the start of initial services for its High Accuracy Service (HAS), which will offer users improved positioning performance with an accuracy of less than two decimetres.[222]

Credit: Maritime Cyprus

Spaceopal will be service operator under Galileo

EUSPA confirmed Spaceopal, a joint venture owned in equal parts by Telespazio and DLR-GfR (owned by the German Space Agency, DLR), as Galileo Service Operator (GSOp) for the next 5 years. Spaceopal already operates and maintains the Galileo System (including ground and space segments) and ensures compliance with the Galileo Services performance requirements under the supervision and leadership of EUSPA.[223]

GMV wins EDF NAVGUARD contract for Galileo PRS

Under the EDF, the European Commission awarded GMV the NAVGUARD project (Advanced Galileo PRS Resilience for EU Defence), which will develop ground and space systems to detect illegal activities on GNSS frequencies and create an information-management subsystem together with a user interface in order to provide situational awareness.

The Galileo Public Regulated Service (PRS) is an encrypted navigation service for governmental authorised users and sensitive applications that require high continuity - in cases of interference, PRS increases the likelihood of the continuous availability of the signal-in-space.[224]

Developments beyond Europe

U.S Space Force orders 3 GPS satellites for $744 million from Lockheed Martin

In November, the U.S. Space Force ordered 3 GPS 3F satellites (18, 19 and 20) from Lockheed Martin for $744 million, as a fourth contract option awarded to Lockheed Martin under an agreement from 2017 valued $7.2 billion for up to 22 satellites. GPS 3F represents the most updated version of U.S. PNT satellites.[225]

China launched 2 navigation enhancement satellites from sea platform

In October, China launched 2 navigation enhancement satellites CentiSpace-1 S5 and S6 from a mobile sea platform with Long March 11, to enhance the accuracy of signals from China's Beidou navigation and positioning satellite system and to conduct inter-satellite laser link experiments.[226]

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[221] EUSPA welcomes Shriya satellite to the Galileo family, EUSPA, August 2022
[222] Galileo High Accuracy Service Signal in Space Interface Control Document officially published, EUSPA
[223] Galileo: Spaceopal confirmed as Service Operator under the European satellite navigation programme, February 2022
[224] GMV wins European NAVGUARD contract for Galileo PRS, GPS World, July 2022
[225] Space Force orders three GPS satellites for $744 million, SpaceNews, November 2022
[226] China launches pair of navigation enhancement satellites from sea platform, Space.com, October 2022

Russia launched fifth GLONASS-K navigation satellite

In October, launched the fifth GLONASS-K satellite with Soyuz from Plesetsk Cosmodrome. The GLONASS-K series is the most up-to-date version of the GLONASS navigation satellites and designed to replace the discontinued GLONASS-M series.[227]

Credit: GLONASS

Russia and China signed agreement to host ground stations

In late September, Russia and China signed an agreement which will see them host ground stations for their respective GNSS constellations. The contract will see China place three ground monitoring stations throughout Russia to help monitor Its BeiDou constellation, while Russia will get to place three ground monitoring stations for Its GLONASS system. Both sides also said the China Satellite Navigation Office's Testing and Evaluation Research Center and Roscosmos' Information and Analysis Center for Positioning, Navigation and Timing signed a statement on "the joint provision of Information and support services" to BeiDou and GLONASS customers.[228]

[227] Soyuz rocket launches Russian GLONASS-K navigation satellite, Space.com, October 2022
[228] Russia, China sign contracts on mutual deployment of navigation stations, TASS, September 2022

1.6.3 Satellite Communications

Developments in Europe

At ESA CM22, ESA Member States subscribed with a €1.9 billion budget for connectivity (TIA) for the continuation of the Artes Programme, as well as new programmes: Secure Connectivity, Moonlight and Civil Security from Space (CSS).

New satellite communication programmes approved at ESA CM22: IRIS², Moonlight and CSS

The IRIS² multi-orbital satellite constellation will be developed from 2023 onwards, with initial services to begin in 2024, and full operational capability expected by 2027.[229] ESA subscriptions towards **Secure Connectivity** will be geared towards the development of IRIS²: for the first phase €35M for preparatory activities that will lead to the development and validation of the constellation assets are firmly subscribed. As for the second phase, €685M are due to be confirmed in 2023. IRIS² is described in more detail in section 1.1.1.

Civil Security from Space will bring together capacities such as telecommunications, EO, ground and space sensor networks and cloud data sources to ensure rapid dissemination of information through a new platform targeted to specific crises and users and is also connected to one of the three ESA Accelerator "Rapid and Resilient Crisis Response". Before ESA CM22, on November 8th, the CSS Industry Day, supported by ESPI, took place - following the interest expressed in the ESA CSS Requests for Information published in July by the ESA TIA Directorate and the Directorate of Earth Observation.

With the **Moonlight initiative**, ESA aims to achieve a permanent and sustainable presence on the Moon through reliable and autonomous lunar communications and navigation services. The Moonlight programme aims to put a constellation of telecommunications and navigation satellites around the Moon (optimised to give coverage to the lunar south pole), in cooperation with industrial partners. The Moonlight constellation will provide data to support communication and PNT for planned and future missions.

ENTRUSTED Consortium discussed next GOVSATCOM phase

On November 4th, the ENTRUSTED consortium discussed the next GOVSATCOM phase at EUSPA in Prague. ENTRUSTED is a H2020-funded research project in the area of secure satellite communications for EU governmental actors, established in late 2020, which aims to provide a concrete set of governmental user requirements for the upcoming GOVSATCOM services, to assess the currently available state-of-the-art for SatCom technologies, and to analyse and identify future trends and key technological gaps and opportunities. The consortium is coordinated by EUSPA and is comprised of over 25 participating entities including EU Member States and agencies. So far, the results of ENTRUSTED are currently used by the European Commission (DG DEFIS) and EUSPA to shape the mission and the services offered by GOVSATCOM. For the first quarter of 2023, a live demonstration is planned to take place on ASI's premises.[230]

Credit: ENTRUSTED

[229] IRISS - Defence Industry and Space - European Union, European Commission, November 2022
[230] ENTRUSTED consortium representatives discuss the next GOVSATCOM phase, EUSPA, November 2022

ESA selected Viasat to conduct a multi-orbit satellite communication study

In July, ESA selected the U.S.-based satellite broadband operator Viasat (UK subsidiary) to condut a study to evaluate technical requirements and potential markets for hybrid networks that combine multiple frequency bands and network architectures, including systems in GEO, MEO and LEO as well as High Altitude Platform Systems (HAPS) such as balloons and airships.[231]

ESA and EBU signed agreement to create solutions for emerging satellite-enables 5G market

In June, ESA and the EBU signed an agreement with ESA to cooperate on the development of solutions that leverage 5G systems and edgecasting in the project 5G-EMERGE. The aim of the project is to develop an integrated satellite and terrestrial system based on open standards to enable high-quality content distribution services, using telecommunications satellites to deliver high-demand content as close as possible to the end user, where a smart satellite gateway will be able to connect to smartphones, tablets or TV.[232]

Developments beyond Europe

Developments in the United States

NASA moved ahead with agency's Communications Services Project (CSP) funded agreements to 6 companies (Inmarsat, SES, Kuiper, Telesat, SpaceX and Viasat) targeting greater usage of employing commercial SATCOM networks for near-Earth operations.[233] The combined amount to $278.5 million and **NASA expects each company to match or exceed agency contributions during the five-year development and demonstration period**, totalling more than $1.5 billion of cost-share investment.

Moreover, U.S. DoD plans to spend nearly $13 billion over the next five years on MILSATCOM architecture. SpaceNews reported that the 2023-2027 spending plan includes funding for the Pentagon's first-ever LEO broadband constellation and smaller numbers of bespoke communications satellites to augment or replace existing systems.[234] It is anticipated that future U.S. military spending will put greater emphasis on integration of commercial systems and services.

U.S. SDA awarded contracts for experimental satellites for T1DES and NExT programmes to:

- York Space Systems a $200 million contract of the Tranche 1 Demonstration and Experimentation System (T1DES) program for building and operating 12 satellites with experimental military Ultra-High Frequency (UHF) and S-band communications payloads for the T1DES system – which are currently providing mobile wireless services from geostationary satellites. The goal of the SDA's experiment is to explore whether these payloads can perform the same service from LEO.[235]
- Ball Aerospace a $176 million contract to build and operate 10 experimental satellites of SDA's NExT program, scheduled to launch in 2024 and 2025. The National Defense Space Architecture Experimental Testbed (NExT) aims to demonstrate low-latency data transport and beyond line-of-sight command and control. Specifically, the contract includes Ball Aerospace's manufacture of the satellites, the integration of the payloads, the procurement of rideshare launches, provision of the ground control system as well as the operation of the satellites.[236]

[231] ESA selects Viasat for multi-orbit satellite communications study, SpaceNews, July 2022
[232] ESA AND EBU TO BUILD SOLUTIONS FOR EMERGING SATELLITE-ENABLED 5G MEDIA MARKET, EBU, June 2022
[233] NASA, Industry to Collaborate on Space Communications by 2025, NASA, April 2022
[234] DoD Satcom: Big money for military satellites, slow shift to commercial services, Space News, June 2022
[235] Pentagon awards $200 million spacecraft contract to private venture York, CNBC, October 2022
[236] Ball Aerospace wins $176 million contract to build and operate 10 satellites for Space Development Agency, Space News, October 2022

Moreover, the SDA awarded in total $1.8 billion to York Space Systems, Lockheed Martin and Northrop Grumman, each to develop 42 satellites to build out SDA's Transport Layer, which will be composed of a mesh network of LEO communication satellites connected by optical links, enabling to transfer data from space sensors to the ground. The satellite network will be part of SDA's layered National Defense Space Architecture and strongly contributes to the U.S. Department of Defense's Joint All-Domain Command and Control effort.[237]

Furthermore, SpaceLink cooperates with Parsons for DARPA's new inter-satellite communications project Space BACN (space-based adaptive communications node), using Parsons' satellite scheduling and tasking software Optimyz. The project aims to develop protocols for how commercial communications constellations will connect with defence and military systems.[238]

Australia requests industry to bid for development of military communication satellites

The Australian government released a tender requesting industry to bid for the development of at least two, and as many as four, military communication satellites for the Australian military.[239] This would be Australia's first independent MILSATCOM capability, the country has also access to the U.S. WGS programme. The contract is expected to be worth $4 billion AUS ($2.86 billion), encompassing also ground stations, launch and life cycle costs.

Developments in Russia

In October, Russia launched the first prototype satellite, Skif-1D of the upcoming Skif Constellation for LEO connectivity onboard a Soyuz-2.1b launch vehicle. The spacecraft has a mass of 160kg and is four-times lighter than the planned operational satellites. The purpose of this test satellite is to test communication protocols for broadband internet connectivity and ensure spectrum rights. Russian officials anticipate that the deployment phase of the Skif system begins in 2025.[240]

In March, a Soyuz rocket launched the Russian military communications satellite Meridian-M from Plesetsk Cosmodrome. The Meridian satellite aims to provide communication between sea vessels and ice reconnaissance aircraft in the Northern Sea Route area with coastal and ground stations and expands the capabilities of satcom stations in the North of Siberia and the Far East.[241]

Developments in China

At an October event organised jointly by China and the African Union Commission, the Chinese ambassador in Namibia Yang Jun informed that China will construct a satellite digital-receiving ground station in Namibia on the outskirts of Windhoek.[242] Also in October, a new report by U.S. think-tank CSIS noted the expansion China's space communications network in South America, assessing it as part of a broader Chinese effort to establish itself as a leading space power.[243]

In July, China launched a Jinan 1 satellite developed by the Chinese Academy of Sciences. The provided information about the launch noted that the satellite would conduct quantum key distribution experiments in LEO. The statement also argued this "makes China the first country in the world to achieve real-time, satellite-to-ground quantum key distribution with micro-nano satellite and miniaturised ground stations".[244]

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[237] Space Development Agency awards $1.8 billion to build out satellite communications layer, c4isrnet.com, February 2022
[238] SpaceLink partners with Parsons for DARPA's inter-satellite communications project, SpaceNews, August 2022
[239] JP 9102: Australia opens bidding on its biggest space contract ever, Breaking Defense, February 2022
[240] Soyuz-2.1b launches Gonets trio and Skif demo satellite, NASASpaceFlight.com, October 2022
[241] Russia launches military communications satellite: reports, Spcae.Com, March 2022
[242] China Set to Build a Satellite Digital-Receiving Ground Station in Namibia, Space in Africa, October 2022
[243] Report highlights U.S. concerns over China's space infrastructure in South America, SpaceNews, October 2022
[244] China launches new satellite in 'important step' towards global quantum communications network, SatNews, July 2022

Egypt launched communication satellite Nilesat 301

In June, Egypt launched its multi-purpose communications satellite Nilesat 301 on board a SpaceX Falcon 9 rocket from the Cape Canaveral Space Force Station in Florida U.S in GEO. Nilesat 301 was manufactured by Thales Alenia Space for the Egyptian operator Nilesat and has a projected lifespan of at least 15 years, replacing Nilesat 201, which will expire in 2028. Nilesat 301 will provide expanded broadband internet services covering Egypt - including remote areas, new infrastructure projects, and new urban communities, and gas and oil fields.[245]

Developments in India

The Indian government approved new guidelines for the provision of satellite communications services in the country. The objective of the new policy reform, released in October 2022 by the Department of Telecommunications (DoT), is to streamline the licensing and clearance procedures to improve the accessibility of satellite communication services across the country.[246]

The Indian MoD approved the GSAT-7B communication satellite, which is planned to be used by the Indian Army. So far, GSAT-7 (Rukmini) and GSAT-7A are the only military satellites used by the Navy and the Indian Air Force. GSAT-7A is the heaviest satellite being launched by GSLV and provides services to the users in Ku-band across India. The Acceptance of Necessity by the Indian Defence Acquisition Council includes the procurement not only of the GSAT 7B Satellite but also of night sight (image intensifier), 4-wheeled light vehicles, air defence fire control radar.[247]

Moreover, in June, Ariane 5 launched the Indian GSAT-24, built by ISRO on behalf of NSIL, into GEO from Kourou. Moreover, the MEASAT-3d for the Malaysian operator MEASAT was launched in this Ariane 5 launch.[248]

[245] Egypt's Nilesat 301 communications satellite successfully launched into orbit, Ahram Online, June 2022
[246] Changing landscape of satellite communication laws in India, International Bar Association, October 2022
[247] Military communication satellite for Indian Army approved, DH Deccan Herald
[248] First Ariane 5 launch of 2022 is a success, supporting two loyal clients of Arianespace: MEASAT (Malaysia) and NSIL (India), Arianespace, June 2022

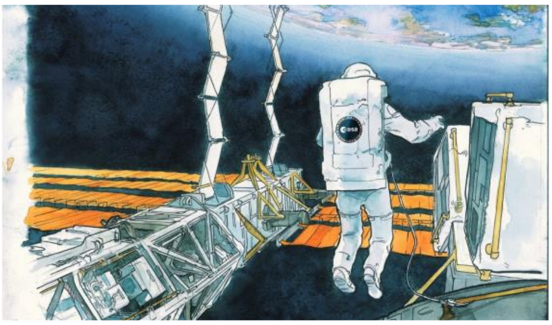
1.7 Space Science and Exploration

1.7.1 Planetary Exploration and Space Science

European developments

A new long-term Space Exploration Roadmap "Terrae Novae 2030+"

ESA publicly released its new Space Exploration Strategy Roadmap "Terrae Novae 2030+"following its presentation to the ESA Council.[249] The roadmap document lays the groundwork for Europe to maintain and ensure its leading role in space exploration and aims to guide decision-makers making the choices on Europe's future in deep-space exploration.[250]



Credit: ESA

The roadmap's objectives are threefold:

- to create new opportunities in LEO for a sustained European presence after the ISS.
- to enable the first European to explore the Moon's surface by 2030 as a step towards sustainable lunar exploration in this decade.
- to prepare the horizon goal of Europe being part of the first human mission to Mars.[251]

Green light for the European Large Logistics Lander and the Moonlight Initiative

November's ESA Council Meeting at Ministerial Level approved:

- The European Large Logistics Lander will offer a multitude of capabilities for landing on the Moon, such as delivery of cargo, science rovers, production equipment and power generation equipment, as well as offering sample return capabilities.[252] It has proposed dimensions of a 4.5-meter diameter and 6-meter height, with delivery capabilities of 1500kg to the lunar surface.[253]
- ESA's Moonlight Initiative is a programme proposing to place a number of satellites into orbit around the Moon.[254] Its intention is to provide communication and navigation services to aid the growing lunar market, strongly relying on a prominent role of the private sector.

Formal approval of the Comet Interceptor mission

ESA Council formally approved the space science mission "Comet Interceptor" which aims to 3D-map a comet, marking a milestone and the transition from the design phase to implementation phase.[255]

The Comet Interceptor project is a joint effort between ESA and JAXA. The spaceflight is planned for 2029 – the spacecraft with the two robotic probes (the other one built by JAXA) will then wait for a comet and will approach and study it.

[249] Earth orbit, Moon, Mars: ESA's ambitious roadmap, ESA, July 2022
[250] Terrae Novae 2030+ Strategy Roadmap, ESA, June 2022
[251] ESA to embolden Europe's space exploration, ESA, July 2022
[252] Ministers back ESA's bold ambitions for space, with record 17% rise, ESA, November 2022
[253] Argonaut, ESA
[254] What is ESA's Moonlight initiative? ESA, November 2022
[255] Comet chaser mission moves from blueprint to reality, UK Space Agency, June 2022

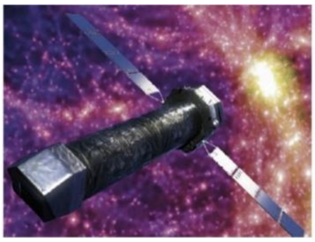
Headwinds for ExoMars Rosalind Franklin Rover

Following the Russian invasion of Ukraine, the ensuing sanctions and fallout led to mission delay and cancellation of ESA - Roscosmos collaboration, which planned for the Rosalind Franklin rover to be delivered to the Martian surface by a Roscosmos lander named Kazachok. After months of examining all options, the decision was made at the Council Meeting at Ministerial level to pursue the construction of a European landing system.

Formation of High-Level Advisory Group on Robotic and Space Exploration

Following the impulse at the February 2022 Space Summit, and a decision by ESA Council, the high-level advisory group was set up, comprised of 12 advisors to "provide ESA's decision-makers with an independent and objective assessment regarding the geopolitical, economic and societal relevance of human and robotic space exploration for Europe, and recommended options for a way forward". The group's Final Report was released In March 2023. The HLAG is described in more detail in section 1.1.2 Revived European interest in robotic and human space exploration.

AESA redesigns X-ray astronomy mission Athena to decrease evaluated costs



Credit: ATHENA

ESA redesigned the X-ray astronomy mission Athena to decrease evaluated costs to €1.3B. ESA was looking for ways to redesign the Athena X-ray astronomy mission by reducing the scope, to decrease the calculated costs down to max. €1.3B. The Advanced Telescope for High-Energy Astrophysics (Athena) mission, planned to launch by the mid-2030s, aims to study supermassive black holes, supernova explosions and other X-rays sources, by using a large X-ray mirror. In 2014, ESA selected Athena and the Laser Interferometer Space Antenna (LISA) mission as two flagship astrophysics missions - initially valued with estimated cost of €1.05B, but the cost estimation decreased up to €1.5B for LISA and to €1.9B for Athena (May 2022). Currently, ESA is preparing to move Athena or LISA into the next development phase in November 2023 - and adopt the other one in 2024 or 2025.

Other European news:

Credit: ESA

- During the ESA Council Meeting in June, ESA DG Josef Aschbacher and NASA Administrator Bill Nelson signed two agreements to enhance cooperation on Earth science and the Artemis lunar missions.[256] NASA will deploy ESA's Lunar Pathfinder spacecraft, on whose development ESA cooperates with SSTL, to lunar orbit to provide communication services on the Moon.
- During the IAC In September, the two executives also signed a joint statement for cooperation on current and potential lunar exploration activities[257], which could enable additional roles and contributions of ESA in Artemis and NASA-ESA cooperation on human space flight activities (ISS, Gateway, ESM for Orion).
- ESA and NASA agreed to replan the Mars Sample Return mission, opting for the use of two landers instead of one to retrieve samples from Mars and changing the schedule of the mission.[258] The original plan only comprised the NASA-led Sample Retrieval Lander, that was supposed to be launched in 2026, together with the ESA-led Earth Return Orbiter.

[256] NASA, ESA Finalize Agreements on Climate, Artemis Cooperation, NASA, June 2022
[257] NASA and ESA sign lunar cooperation agreement, SpaceNews, September 2022
[258] NASA and ESA agree on next steps to return Mars samples to Earth, NASA, October 2022

- ESA signed an MoU with JAXA to provide an instrument for the Japanese rover of the ISRO-JAXA Lunar Polar Exploration Mission (LUPEX)[259], scheduled for 2024. The rover instrument will be used in the exploration of the south pole of the Moon. The mission will launch an Indian lander and a Japanese rover to the Moon. Beyond this, ESA and JAXA agreed on cooperation on over cross support in data acquisition, mission operations as well as space navigation.
- ASI signed a bilateral agreement with NASA[260] to conduct a preliminary design study of the Lunar Surface Multi-Purpose Habitation Module(s).

Developments beyond Europe

U.S. Artemis Program kicked-off with Artemis I launch

After multiple postponements, on November 16th, the Artemis I mission was launched with NASA's Space Launch System (SLS) Artemis I was the first mission of the Artemis Program, in a non-crewed set-up aiming to test the Orion spacecraft (uncrewed) in cislunar space. Ten cubesats were also carried to orbit within the SLS' Interim Cryogenic Propulsion Stage (ICPS).[261]

Credit: NASA

Orion was sent towards the Moon to a distant retrograde orbit - with a maximum distance from Earth of 480,500 km. The spacecraft successfully splashed down in the Pacific Ocean on December 11th.[262]

For the Artemis IV mission, NASA awarded SpaceX a $1.15B contract modification to develop an upgraded version of its Starship lunar lander and fly a second crewed demonstration landing mission in 2027, as part of Artemis IV.[263]

Other NASA exploration and science news

- On September 26th, the NASA's DART Mission successfully impacted Dimorphos, a natural satellite of asteroid (65803) Didymos, marking the first ever planetary defence technology demonstration.[264] The first images of the impact arrived from the Italian minisatellite LICIACube.
- NASA and DARPA announced to cooperate for a demonstration as early as 2027 of an in-space nuclear thermal rocket (NTR) engine.[265] This will be pursued as part of the Demonstration Rocket for Agile Cislunar Operations (DRACO) program which strives to enable crewed Mars missions through a faster transit time reducing health risks for astronauts.
- Implementing the recommendations of the latest decadal survey on Astronomy and Astrophysics. NASA launched a new line of "probe" class missions with a $1 billion cost cap (excluding launch costs and potential international contributions).[266] NASA is planning to select two or three proposals for Phase A concept studies with a value of $5M each in early 2024 and choose the winning mission in mid-2025.

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[259] Europe-Japan sign MoU to provide rover instrument for 2024 ISRO-JAXA lunar mission, RepublicWorld, April 2022
[260] Artemis Mission: Agreement Signed Between ASI and NASA, ASI, June 2022
[261] Artemis I CubeSats Fail to Power Up, Payload, November 2022
[262] SLS launches Artemis 1 mission, SpaceNews, November 2022
[263] NASA awards SpaceX contract modifications for missions beyond Artemis III, Spacewatch.global, November 2022
[264] NASA's DART Mission Hits Asteroid in First-Ever Planetary Defense Test, NASA, September 2022
[265] NASA and DARPA will build a nuclear rocket by 2027, Space.com, January 2023
[266] NASA to start astrophysics probe program, SpaceNews, January 2022

The White House releases National Cislunar Science and Technology Strategy

Developed by an interagency subcommittee of the National Science and Technology Council, the strategy document outlines 4 objectives:

- Support R&D to enable long-term growth in Cislunar space;
- Expand international S&T cooperation in Cislunar space;
- Extend U.S. SSA capabilities into Cislunar space;
- Implement Cislunar comms. and PNT capabilities with scalable & interoperable approaches.

The strategy is also described in section 1.2.1 New space policies, laws and strategies.

China – Growing ambitions in space exploration beyond LEO

China outlined its pathway for robotic and crewed lunar and deep space exploration, including its lunar exploration program's fourth stage through upcoming robotic missions Chang'e-6, 7 and 8.[267] These will include landers, orbiters and relay satellites for the construction of the International Lunar Research Station (ILRS) in the 2030s, planned to be habitable after 2035.

- Chang'e-6 will launch in 2026 to perform China's second sample return mission,
- Chang'e-7 will launch around 2026 to investigate permanently shadowed areas at the South Pole,
- Chang'e-8 will launch by 2028 as a test mission for in-situ resource utilisation and 3D-printing tech.

Additionally, China is preparing for a crewed lunar landing with three astronauts before 2030.

On February 26th, the China National Space Administration (CNSA) reported the official inauguration of China`s deep space exploration laboratory.[268] The new laboratory will be in charge of deep space exploration science and technology research.

It was also reported that China plans to build a communications and navigation constellation around the Moon to support future operations and missions, such as Chang'e-6 (sample return) and Chang'e-7 (search for water-ice). The first launches are scheduled for earliest 2023 or 2024.[269]

According to a new paper in the Chinese Journal of Space Science, the Chinese Academy Sciences (CAS) committee is preparing the selection of 5- 7 new space science missions from 13 proposals.[270] The missions will be part of CAS's third Strategic Priority Programme project "New Horizons Programme" and address 4 major scientific themes:

- Space astronomy and astrophysics,
- Exoplanets
- Heliophysics
- Planetary and Earth Science

In addition, China unveiled new details on a combined near-Earth asteroid defense system demonstration and verification test scheduled to launch in 2026on a Long March 3B rocket for the deflection of the near-Earth asteroid 2020 PN1.[271]

[267] China outlines pathway for lunar and deep space exploration, SpaceNews, November 2022
[268] China's deep space exploration laboratory starts operation, China Daily, June 2022
[269] China to build a lunar communications and navigation constellation, SpaceNews, April 2022
[270] China holds casting of space missions, Universemagazine, July 2022
[271] China announces plans for a new asteroid deflecting mission, The Verge, April 2022

South Korea initiates its Moon Programme

On August 4th, SpaceX launched Danuri (also called the Korean Pathfinder Lunar Orbiter) for the Korea Aerospace Research Institute (KARI). Danuri is the first South Korean mission to the Moon and the first step towards a more ambitious Moon exploration programme.[272] It carries four Korean payloads, aiming at providing data on the Moon surface and at helping the preparation of future human missions.

During a public hearing on August 24th, KARI presented details of a plan of South Korea's second lunar exploration mission and requested a budget of $459M for the mission to build a robotic lunar lander and payload to fly to the Moon with the country's currently developed carrier rocket for a 1-year mission in 2031.[273] The plan proposes the start of the development in 2024.

The UAE launched the country's first Moon mission, agrees on support from SANSA

On December 11th, the UAE's first Moon mission the Emirates Lunar Mission (ELM) was launched.[274] The mission's Rashid Rover was launched as a payload of the iSpace Hakuto-R M1 mission with SpaceX's Falcon Rocket.

The South African National Space Agency (SANSA) signed an agreement with the UAE's MBRSC to support the UAE's Emirates Lunar Mission (ELM). SANSA's Hartebeeshoek (HBK) ground station will be used to establish direct communication between the rover and the ELM Control Centre at MBRSC once the rover lands on the Moon surface after a 5-months journey.

ISRO plans mission to Venus in 2024

The Indian Space Agency ISRO plans a mission to Venus to study the atmosphere.[275] During a meeting on Venusian science on May 4th, ISRO's Chairman Somnath revealed that the project report has been prepared and funding was identified. ISRO expects and plans to use a launch window in December 2024 with an orbital manoeuvre planned in 2025, enabling the spacecraft to enter into Venus's orbit with a minimum amount of propellant.[276]

Successful deployment campaign and start of scientific operations for the JWST

During the first part of the year, a highly complex deployment and commissioning campaign of the James Webb Space Telescope took place, after an extremely accurate launch by the Ariane 5 launch vehicle in late December 2021. The months-long process of preparing NASA-ESA-CSA James Webb Space Telescope for science was completed in early July and followed by public outreach event, revealing telescope's capabilities through the release of first Images and spectra.

Credit: NASA, ESA, CSA

[272] Danuri, South Korea's first Moon mission, The Planetary Society, August 2022
[273] South Korea seeks $459 million for lunar lander project, SpaceNews, August 2022
[274] UAE launches Rashid Rover, the Arab world's first mission to the Moon, Alarabiya News, December 2022
[275] ISRO plans mission to Venus, eyes December 2024 launch window, Deccan Chronicle, May 2022
[276] ISRO plans mission to Venus in December 2024, Scroll, May 2022

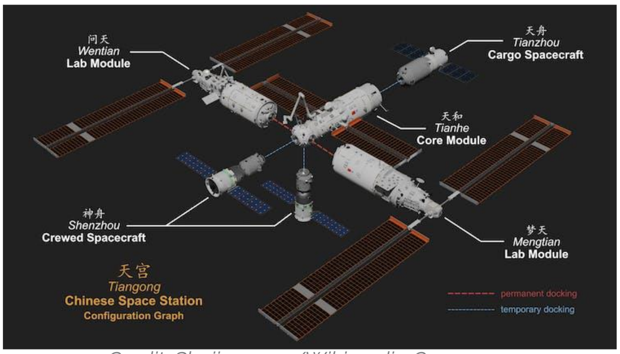
1.7.2 Space Stations

Developments in institutional space stations

Completion of the Chinese Space Station

In October, China launched the final module for its Tiangong space station aboard a Long March 5B from Wenchang spaceport. The module, Mengtian, docked at the space station 13 hours after launch.

The new module provides 32 additional cubic metres of space and a payload airlock. Mengtian joins two other modules already in orbit, the Tianhe core module and the Wentian experiment module. The trio together form the fully completed Tiangong space station.[277]



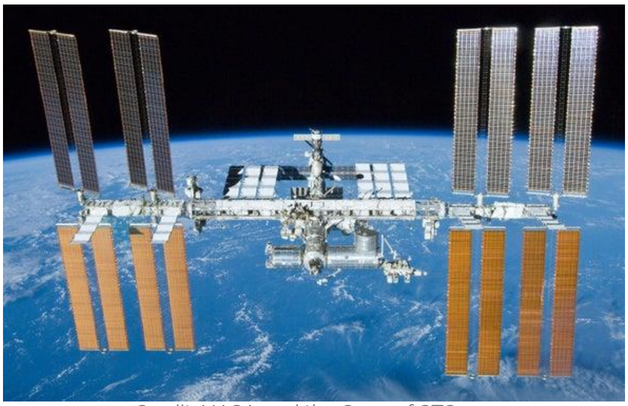
Credit: Shujianyang/Wikimedia Commons

ESA, NASA, JAXA agreed on ISS extension until 2030, Roscosmos stabilises on 2028 timeframe

In July the U.S. Congress officially passed the CHIPS Act, which was subsequently signed by President Biden. Included in the act is a NASA authorisation bill which officially extends NASA's participation in the ISS program up to 2030.[278]

Meanwhile in Europe at the Council Meeting at Ministerial Level held in Paris in November, ministers agreed to extend European participation in the ISS up to 2030.[279]

Russia has yet to commit to the 2030 timeline, initially stating they would leave after 2024, but later confirming participation to 2028.[280]



Credit: NASA and the Crew of STS-132

Japan formally agreed on ISS extension through 2030 and the lunar Gateway contributions.[281]

NASA and Japanese government officials signed an agreement on Japan contributions for the Gateway and NASA to fly a Japanese astronaut to the Gateway on a future Artemis mission. NASA and Japanese government officials signed an agreement on Japan contributions for the Gateway and NASA to fly a Japanese astronaut to the Gateway on a future Artemis mission.

[277] China completes T-shaped Tiangong space station with new Mengtian module move, Space.com, November 2022
[278] Congress approves International Space Station extension to 2030, Space.com, July 2022
[279] Ministers back ESA's bold ambitions for space with record 17% rise, ESA, November 2022
[280] Russia commits to ISS extension to 2028, SpaceNews, April 2023
[281] Japan agrees to space station extension and Gateway contributions, SpaceNews, November 2022

Developments in private/commercial space stations

Post-ISS era: Increasing governmental commercial stations and private providers

Post-ISS and private space station were subject of many discussion and saw various developments in 2022. At a symposium in Washington DC in October, representatives of several private space station developers expressed concern over the lack of regulatory transparency on which U.S government agencies would be responsible for oversight of private station.[282] In addition, NASA's Aerospace Safety Advisory Panel warned that NASA's timeframe for transitioning away from the International Space Station to private stations was "precarious".

While NASA plans to retire the ISS by 2030, the Advisory Panel stated that they did not expect replacement stations to be ready by then.[283]

NASA proper and representatives of all three major station projects, however, rejected these concerns at an event several days later, claiming to be well on schedule for operation before the ISS retirement.[284]

Developments in private space stations missions & development

- The Italian Government, and Axiom Space, signed a MoU to expand the collaboration between Italy and Axiom Space.[285] The areas of cooperation include a variety of domains including the integration of an Italian module with the Axiom Space Station.
- Axiom Space also signed an agreement with the Saudi Space Commission (SSC) to fly two astronauts of Saudi Arabia to space on a future Axiom mission next year.[286]
- 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, also including to fly Canadian astronauts on Axiom missions.[287]

[282] Commercial space station developers seek clarity on regulations, SpaceNews, October 2022
[283] NASA safety advisers warn ISS transition plans on "precarious trajectory", SpaceNews, July 2022
[284] NASA, companies reject concerns over commercial space station development schedules, SpaceNews, July 2022
[285] Axiom Space and Italian Government sign historic MoU to expand commercial utilization of space, SpaceRef, May 2022
[286] Saudi Arabia launches Astronaut program and partners with Axiom to fly two astronauts to space, Spacewatch, September 2022
[287] 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

1.8 International and bilateral collaboration

1.8.1 Multilateral cooperation and initiatives

The table below summarises major bilateral and multi-party cooperation agreements on space activities signed in 2022, including both new partnerships and expanded collaborations between countries and organisations already working together. Moreover, several multilateral space-related initiatives saw more members and nations joining:

- **Artemis Accords** – the list of signatories grew in 2022 with Israel, Romania, Bahrain, the Republic of Singapore, Colombia, France, Saudi Arabia, Rwanda and Nigeria.
- **Space Climate Observatory (SCO)** – the CNES-led effort enlarged the list signatories of SCO's Declaration of Common Interest with institutions from Morocco, Norway, Saudi Arabia, South Africa and Slovakia.
- **ASAT test ban initiative** – The U.S.-led initiative on the self-imposed commitment not to conduct direct-ascent anti-satellite tests, received support from Canada, Australia, New Zealand, Japan, Germany, South Korea, Switzerland, UK, and France who joined the initiative. In addition, the UN General Assembly approved an ASAT test ban resolution in December 2022.
- **Joint Statement on launcher Exploitation signed by France, Germany and Italy. T**he agreement is described in detail in the section 1.5. Access to space.

1.8.2 Bilateral Cooperations

April	**U.S. – South Korea**	The U.S. and South Korea signed an agreement[288] to cooperate on space situational awareness (SSA) for military purposes, which includes sharing intelligence about outer space, training and exercises, and enhance interoperability for combined space operations.
	U.S. – India	The U.S. and India signed a space situational awareness agreement to strengthen space and cyberspace cooperation, implying to expand joint cyber training and to launch a Defence Artificial Intelligence Dialogue.[289]
	U.S. – UK	The U.S. Space Command and the UK Space Command signed a MoU for Enhanced Space Cooperation (based on the 2021 Statement of Intent between the U.S. DoD and the UK MoD) which aims to optimise resources as well as to increase assurance and resilience of missions, and includes information exchange, reconciling military space requirements and the identification of potential collaborations.[290]
	U.S. – Sweden	The U.S. Space Command and the Swedish Airforce signed an agreement for space situational awareness data sharing.[291]

[288] U.S., South Korea agree to cooperate on space situational awareness for military purposes, SpaceNews, April 2022
[289] US, India agree to cooperate on space situational awareness, SpaceNews, April 2022
[290] USSPACECOM deepens cooperation in space with UK, Sweden, Parabolic Arc, April 2022
[291] USSPACECOM deepens cooperation in space with UK, Sweden, Parabolic Arc, April 2022

	Germany – Japan	DLR and JAXA extend cooperation by adopting an extended framework agreement "Inter-Agency Arrangement for Strategic Partnership" to strengthen cooperation in R&D and to promote industry cooperation in aerospace.[292]
May	**European Commission - Canada**	The European Commission signed an agreement on Copernicus with the Canadian Space Agency (CSA) on space cooperation, including a reciprocal EO satellite data exchange. This enables the CSA to provide end-users with simplified Copernicus data access, and Copernicus services and enhances its accuracy. Furthermore, the agreement strengthened EU-Canada cooperation in areas, such as in the Arctic region and climate action.[293]
	France – India	The governments of France and India agreed to set up a bilateral strategic dialogue on space issues to address the contemporary challenges that have arisen in space and maintain a secure access to space for all, bringing together experts from space and defence agencies, administration and specialised ecosystem.[294]
	U.S. – UK	The UK and the U.S. signed a partnership agreement to enhance spaceflight opportunities and to benefit from operating from each other's spaceports, working together on future commercial spaceflight missions, in particular on commercial space launch licensing.[295]
	EUSPA - EFCA	The EUSPA and the European Fisheries Control Agency (EFCA) sign a MoU which confirms that Galileo and Copernicus will further be used to assess the location of fish stocks and to track the location of vessels to prevent illegal, unreported and unregulated fishing.[296]
	Egypt – South Africa	Egyptian Space Agency and SANSA signed a MoU for cooperation in space and the peaceful use of outer space. The MoU's objective is to activate mechanisms for cooperation in space activities, research and exploration for peaceful purposes and to encourage exchange.[297]
	ESA - Switzerland	ESA and Switzerland signed a Memorandum of Cooperation between Switzerland and ESA to establish a new joint centre, the European Space Deep-Tech Innovation (ESDI) Centre.[298]

[292] German-Japanese cooperation in aerospace, DLR, April 2022
[293] Signature of a Copernicus Arrangement between the Canadian Space Agency and the European Commission, European Commission, May 2022
[294] India-France joint statement during the visit of Prime Minister to France, Ministry of External Affairs of the Government of India, May 2022
[295] UK and US sign partnership to boost spaceflight opportunities, Spacewatch Europe, May 2022
[296] EGCA and EUSPA formalize inter-agency cooperation related to the maritime domain, European Fisheries Control Agency, May 2022
[297] Egyptian Space Agency signs MoU with SANSA, Space in Africa, May 2022
[298] ESA and Switzerland establish space deep-tech innovation centre, Spacewatch Europe, May 2022

June	**Italy – Saudi Arabia**	ASI and the Saudi Space Commission (SSC) signed an MoU over a duration of 5 years (that will be subsequently extended for five additional years) to strengthen bilateral collaboration in different areas, incl. EO, communications in deep space, scientific missions and human exploration programmes.[299]
July	**UK – South Korea**	The UK Royal Airforce and the Republic of Korea Air Force (ROKAF) signed a Terms of Reference for future space cooperation between the UK Space Command and the ROKAF. The agreement opens bilateral talks on the integration of space capabilities as defence partners and boost defence space cooperation, incl. collaborative training and operational knowledge sharing.[300]
September	**Germany – Italy**	ASI and DLR signed an 8-year implementation agreement (in the context of the previous framework agreement between the parties, dated back to 2007), committing to share information, strategies and results of their respective hyperspectral missions PRISMA and EnMAP, and to organise workshops and outreach events promoting public awareness of the two missions.[301]
October	**Germany – New Zealand**	The German BMWK and the New Zealand Space Agency signed a space collaboration arrangement for a safe, secure and responsible use of outer space, which enables closer research, policy, regulatory, space security and commercial collaboration.[302]
November	**U.S. – France**	France and the U.S. "agreed to strengthen U.S.-France space cooperation across civil, commercial, and national security sectors" and outlined that they are working together to develop norms for the responsible and peaceful uses of outer space.[303] France and the U.S. signed a Declaration of Intent, which updates the bilateral relation between France and the U.S. in the field of defence.[304] CNES and NASA signed an agreement to host a French instrument on the commercial lunar lander Farside Seismic Suite, which will be sent to the Moon in 2025.[305]
	UNOOSA – Kenya Space Agency	UNOOSA and the Kenya Space Agency have agreed to collaborate under the "Space Law for New Space Actors" project. The collaboration will include a technical advisory mission to Nairobi, Kenya to provide capacity building and legal advisory services tailored to regulatory authorities in Kenya.

[299] Saudi, Italian space agencies sign MoU, Arab News, June 2022
[300] South Korea & UK outline future space cooperation, Orbital Today, July 2022
[301] Orbital twinning between the Italian satellite PRISMA and the German EnMAP satellite, ASI, September 2022
[302] New Zealand signs space agreement with Germany, Spacewatch Asia Pacific, October 2022
[303] France joins ASAT testing moratorium, SpaceNews, November 2022
[304] Signature d'une decleration d#intention sur la relationde defense entre la France et les Etats-Unis, Ministère Des Armees, November 2022
[305] France joins ASAT testing moratorium, SpaceNews, November 2022

December	**Italy - Hungary**	ASI and the Hungarian Ministry of Foreign Affairs and Trade signed a MoU to cooperate in the field of space activities for peaceful purposes and to carry out projects of mutual interest. The MoU is part of a broader cooperation framework between the two European countries.[306]
	Iran – Russia	Iran and Russia signed a space cooperation agreement to strengthen the cooperation of the countries' space industries, including jointly designing and constructing remote sensing and telecommunication satellites as well as the joint infrastructure development and training courses.[307]
	France - Poland	France and Poland approved a €575M deal between Airbus and the Polish Armaments Agency on France's delivery of two reconnaissance satellites and a ground station to Poland by 2027, to strengthen the Polish Army's reconnaissance capabilities.
	UNOOSA – UK	The UN Office for Outer Space Affairs (UNOOSA) and the UK government launched a partnership to study international approaches to the registration of space objects and enhance compliance with relevant international law.[308]
	South Africa – UAE	The South African National Space Agency (SANSA) signed an agreement with the UAEs' Mohammed Bin Rashid Space Centre (MBRSC) to support the UAEs' Emirates Lunar Mission (ELM).

Table 3: New bilateral collaborations signed in 2022 (Source: ESPI database)

[306] Memorandum of Understanding signed between Italy and Hungary, ASI, December 2022
[307] Iran, Russia sign deal to develop space industry, Iran International, December 2022
[308] UNOOSA and UK launch partnership on registering space objects, Spacewatch Europe, December 2022

1.8.3 Notable Developments in the African Space Ecosystem

The year 2022 saw several African countries launching their first satellites, increased international cooperation in climate monitoring, and increased competition on influence in Africa between major space powers, including the U.S. and China. Moreover, Europe is active in Africa through development cooperation especially with projects related to connectivity[309], notably through the Global Gateway Africa Initiative and Investment package.[310]

Developments in Africa's space sector

Institutional developments in Africa to leverage space policy

End of 2022, the African Union Commission prepared the inauguration of the African Space Agency, to sign an agreement with the Egyptian government in January 2023, defining the relation and competencies of both parties. The AfSA is envisaged to serve as a platform for space research and innovation for Africa and strengthening space missions in Africa and will be in charge of Africa's collaboration with Europe and other international non-African partners.

In 2022, the African Space Leadership Institute (ASLI), an African Space Policy Think Tank dedicated to steering African Leadership in Space, was founded. The institute is "committed to harnessing Space science for African socio-economic development". ASLI aims to develop African space leaders and cultivate new talents through courses and public outreach events.

2022 saw several African countries launching their first satellites

In November, a Northrop Grumman Cygnus spacecraft launched to resupply the International Space Station (ISS) with cargo. In addition, several CubeSats were onboard the flight, including the **first satellites of Uganda and Zimbabwe**. The satellites have been built in partnership with Japan, in the framework of the Joint Global Multi-Nations BIRDS Satellite project led by JAXA and the Kyushu Institute of Technology. ZimSat-1, the Zimbabwean satellite, will provide imagery to monitor the status of natural resources and provide information on natural disasters. On its end, the PearlAfricaSat-1 satellite launched for Uganda will support the development of the agricultural sector and the oil and gas business in the country.[311]

Credit: BIRDS-5

Moreover, in October, a satellite named Angosat-2, the second ever satellite developed by Angola, launched on board a Proton-M rocket from the Baikonur Cosmodrome in Kazakhstan. Angosat-2 weighs two tons and has an operational lifespan of 15 years. The satellite was placed into GEO and will be used to provide communication services to the African continent, with an emphasis on southern Africa.[312]

[309] EU to include Africa in USD 6.8 billion high-speed ComSat Network, Space in Africa, February 2022
[310] EU-Africa: Global Gateway Investment Package, EU Commission.
[311] Zimbabwe and Uganda Launched their First Satellites Today, Space in Africa, November 2022
[312] Angola Launches its Second Satellite, Angosat-2, Today, Space in Africa, October 2022

Development cooperation and vying for influence in Africa

The space industry, both upstream and downstream, in Africa is growing, while development cooperation - addressing climate change adaption projects and the digital divide gap - is increasingly supported by space services and applications.

Therefore, the U.S., China, Europe, and Russia, as well as other global actors have started to compete for influence in this industry in Africa and to increase cooperation.[313] Remote-sensing data from Earth observation satellites provide information that is used in agriculture, environment monitoring, land utilization, urban planning, hydrography, geology, and more. Therefore, space has huge potential to contribute to development cooperation.

European-African institutional partnerships

Credit: EUMETSAT

EUMETSAT and the African Union signed a cooperation agreement on climate monitoring to formalise their collaboration under the Intra ACP Climate Services and Related Applications Programme (ClimSA programme), which was initiated by the EU and the Organisation of African, the Caribbean and the Pacific States. The ClimSA programme facilitates African meteorological and hydrological services in renewing their current EUMETCast stations to ensure the reception and processing of Meteosat Third Generation data. As a result, the improved access to information supports decision-making and development planning processes[314].


Credit: ESA

In June, ESA signed an international cooperation agreement with the Agency for Air Navigation Safety in Africa and Madagascar (ASCENA) to deploy a Satellite-based Augmentation System (SBAS) and provide technical support based on EGNOS technology and by using Galileo satellites by ASCENA. It is planned that the system's initial operational capabilities will enter into service from 2025. Already in 2018, ASECNA signed an international agreement with the EU on satellite navigation.[315]

June also saw, ASECNA and CNES signed a new 7-year agreement to develop, deploy and commission ASECNA's Satellite-Based Augmentation System (SBAS). The agreement defines the terms and provisions for providing management assistance in systems engineering for the ground segment, the space segment as well as the system performance for the SBAS.[316]

As part of the EU Secure Connectivity Programme IRIS^2, the multi-orbital satellite constellation is planned to provide connectivity not only to Europe, but also to Africa, by using the constellation's North-South orbits.[317] During the European Union-African Union summit in Brussels, Commissioner Thierry Breton announced that the EU allocated €150 billion in aid package to Africa, as part of the Global Gateway initiative (the EU's competitive programme to China's Belt and Road initiative) for several projects in the areas of green energy, disaster relief, and public health infrastructure improvement – and especially telecommunications. In this context, Breton reaffirmed again that the EU Secure Connectivity Initiative will also include services for Africa.[318] IRIS^2 is described in more detail in section 1.1.1 ESA and EU budgets and priorities for space.

[313] Why China, African Nations are cooperating in space, voanews.com, September 2022
[314] EUMETSAT, African Union Commission Sign Cooperation Agreement on Climate Monitoring, Space in Africa, May 2022
[315] EGNOS technology for Africa – ESA signs deal with ASECNA, ESA News, June 2022
[316] ASECNA and CNES sign Agreement on Africa's First Operational SBAS, Press release of ASECNA, Space in Africa, June 2022
[317] Welcome to IRIS^2, Europe's new Infrastructure for Resilience, Interconnection & Security by Satellites, European Commission, Blog of Commissioner Thierry Breton, November 2022
[318] EU to include Africa in USD 6.8 billion high-speed ComSat Network, Space in Africa, February 2022

Africa's cooperation beyond Europe

U.S. support to provide connectivity for African countries

On December 13, 2022, the U.S.-Africa Leaders Summit featured for the first time a U.S.-Africa Space Forum, which highlighted the U.S.-Africa space partnership and cooperation to address challenges and opportunities, including responding to the climate, biodiversity, and global food crises; promoting responsible behavior in outer space; and reinforcing U.S.-African scientific and commercial space cooperation. The Forum also celebrated the signature of the Artemis Accords by Nigeria and Rwanda as the first African signatories.[319]

This is part of the U.S.'s move to promoted the Artemis Accords initiative towards emerging space nations.[320]

Moreover, SpaceX received licenses to provide space-based connectivity through Starlink in Mozambique, Rwanda, Malawi, and Nigeria. In Nigeria, the service will start from January 2023, in Rwanda in Q1 2023 for the other countries the service is planned to start in 2024.[321] Moreover, Starlink is planned and under negotiation in other African countries, including the Democratic Republic of Congo (DRC), Kenya and Tanzania.[322]

Moreover, in December, Microsoft and Viasat consolidated partnership for Africa, with Microsoft is pioneering the Airband Initiative, through which the enterprise and its partners can monitor the digital divide in developing countries. The programme, embraced by Viasat in a partnership sealed in December, aims to offer satellite connectivity to around 10 million people and 5 million across Africa by 2025. The partnership propels the lasting cooperation between the two companies, that already band together in the Azure Space Initiative to deliver advances in satellite connectivity anywhere on the planet. The first African countries benefitting from the service will be Angola, Egypt, and Senegal, which includes the use of space in healthcare, remote learning, precision agriculture, energy management. On the other side, African governments are welcoming the services by streamlining their licensing procedures.[323]

In August, the Rockefeller Foundation invested in satellite data and AI with the objective to boost economic development and climate resilient infrastructure development in Africa (Kenya, Nigeria, Rwanda, and Uganda), by kicking-off a new 3-year $5.5 million project jointly with the e-GUIDE Initiative and the startup Atlas AI. The project foresees the development of a digital platform by leveraging satellite data and machine learning technologies, which will address the development of the agriculture, energy, and transportation sectors.[324]

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[319] STATEMENT: Strengthening the U.S.-Africa Partnership in Space, White House, December 2022MoreoverMoreover,m
[320] First African nations sign Artemis Accords, SpaceNews, December 2022
[321] SpaceX's Starlink extends reach across Africa after receiving license in Rwanda, technxet24.com, March 2023.
[322] Starlink: SpaceX's new internet service could be a gamechanger in Africa, the Conversation, March 2023.
[323] Microsoft and Viasat Partner to Provide Satellite Internet Services to Underrepresented Communities in Africa, Space in Africa, December 2022
[324] Rockefeller Foundation invests in satellite data and AI to boost economic development in Africa, Spacewatch Global, August 2022

China-African cooperation for space technology development

In 2022, China and Africa adopted the Forum on China-Africa Cooperation-Dakar Action Plan (2022-2024)[325] by the 8th Ministerial Conference of the Forum on China-Africa Cooperation. The Action Plan foresees China and Africa "enhancing cooperation on space technology, promoting Africa's space technology application and infrastructure development, and use the space industry to drive social development and improve people's living standards" and the plan to set up a China-Africa youth space alliance as a student exchange platform for space.[326]

Credit: Forum on China-Africa Cooperation

In autumn 2022, and as a result of the adoption of this Action Plan, China made efforts to strengthen space cooperation with several African countries, **organising a "Talk with Taikonauts" session with the 8 African countries Egypt, Nigeria, South Africa, Namibia, Ethiopia, Somalia, Algeria, and Senegal, with three Chinese Taikonauts answering questions from African youths aboard the China Tiangong Space Station**.[327] In particular, as part of this session, China agreed to intensify space cooperation with Namibia, including assisting in training Namibian engineers on space technology and performing joint space research with Namibia.[328]

Moreover, in September, Egypt and China agreed to strengthen space cooperation, during a speech at the Space Dream Symposium organised by the Egyptian Chinese University in cooperation between the Egyptian Space, Agency and the Chinese Embassy in Cairo and attended by several space scientists from Egypt and China and Chinese astronauts. The envisaged cooperation includes Egypt's involvement in China's Tiangong space station, the establishment of a China-African cooperation centre on remote sensing satellite applications, training African competencies in space technologies in partnership with the Egyptian Space Agency as well as jointly implemented research projects to build student skills in space and satellite technology.[329]

In December, the Republic of Djibouti signed a MoU with Hong Kong Aerospace Technology Group Limited and Touchroad International Holdings Group for the development of an international commercial spaceport located in the region Obock.

The 5-year $1B 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 years 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 2023.[330]

Credit: Djibouti Government

[325] Forum on China-Africa Cooperation Dakar Action Plan (2022-2024), Forum on China-Africa Cooperation, November 2021
[326] China and Namibia Strengthen Space Diplomatic Ties, Spacewatch global, November 2022
[327] China-Africa Space Cooperation: A New-Era of Co-Development and Co-Prosperity, SinAfricaNews, September 2022
[328] China and Namibia Strengthen Space Diplomatic Ties, Spacewatch global, November 2022
[329] Egypt and China to Deepen Space Cooperation, Space in Africa, November 2022
[330] Djibouti Signs MoU to Develop Commercial Spaceport, Spacewatch Global, January 2023

Multilateral and international cooperation in space with Africa

In February, the new ATLAS asteroid alert system telescope based in South Africa, operated by the University of Hawaii Institute for Astronomy and funded by NASA, started operations.[331]

In November 2022, the UNOOSA and Kenya Space Agency (KSA) cooperate under "Space Law for New Space Actors project" to assess Kenya's needs in space law to create a network.[332]

Also in December, the South African Radio Astronomy Observatory reported that the Square Kilometre Array Observatory started construction of Telescopes in South Africa (and Australia).[333]

In December, South African National Space Agency (SANSA) signed an agreement with the UAE's Mohammed Bin Rashid Space Centre (MBRSC) to support the Emirates Lunar Mission (ELM), which was launched with SpaceX Falcon Rocket from the Kennedy Space Center on December 11th. The MBRSC will use SANSA's Hartebeeshoek (HBK) ground station for establishing direct communication between the rover (once landed) and the ELM Control Centre at MBRSC.[334]

Other news related to Africa

- The Federal Executive Council of Nigeria (FEC) approved research and development of the Satellite Internet Broadband Project to promote national development. The project is owned by the National Space Research and Development Agency (NASRDA) and is expected to generate NGN 28 billion in revenue.[335]
- Justdiggit announced to enable nature-based solutions for projects to regreen Africa. The Dutch-based non-profit organisation Justdiggit which supports land restoration in sub-Saharan Africa will be using Planet Lab's high-resolution satellite imagery data for the quantification, evaluation and scaling of their regreening projects[336]. Moreover, Planet Labs and Microsoft expanded their partnership to apply AI technology and satellite data to support climate adaptation projects in Africa. Moreover, this new cooperation will extend the usage to the Global South, making "the use of geospatial data become commonplace in the response to natural disasters", such as hurricanes, wildfires and earthquakes.[337]
- In May, the Egyptian Space Agency and the South African National Space Agency (SANSA) signed an MoU for cooperation in space and the peaceful use of space. The objective of the agreement is to push knowledge exchange and cooperation in space activities, research and exploration for peaceful purposes.[338]

[331] ATLAS Telescope has Begun Operations in South Africa, Space in Africa, February 2022
[332] UNOOSA and KSA collaborate under Space Law for New Space Actors Project, UNI, Space in Africa, November 2022
[333] SKAO Commences Telescope Construction in Australia and South Africa, Press release from SARAO, Space in Africa, December 2022
[334] SANSA signs agreement with the UAE to support its first Moon Mission, Press release of SANSA, Space in Africa, December 2022
[335] FEC approves PPP for satellite internet broadband to promote national development, Space in Africa, December 2022
[336] Planet and Justdiggit enable nature-based solutions to regreen Africa, Space in Africa, November 2022
[337] Microsoft and Planet Partner to Provide AI and Satellite Data for African Climate Adaptation Projects, Space in Africa, November 2022
[338] Egyptian Space Agency signs MoU with SANSA, Space in Africa, May 2022

2 Industry & Innovation

2.1 Space Industry Highlights and Trends

2.1.1 Latest development in satellite connectivity

In the past years, traditional actors in the telecommunications sector faced significant challenges on its established markets due to the rapidly changing user needs stemming from the digital revolution. The market is gradually shifting from GEO satellites providing TV broadcast to the provision of satellite internet broadband, which pushes satellite operators to develop and provide new space solutions.

The digital sector plays an increasing role within the space sector, as space systems are increasingly digitised with software components, digital payloads, and connected through TCP/IP Protocol. In parallel, the space sector plays an increasing role in vitally enabling the digital economy, especially providing internet broadband and satellite-to-cell phone connectivity, while becoming a key component of 5G and 6G mobile networks.[339]

In addition, **space is expected to play a key role in protecting the digital infrastructure against cyber threats**. For instance, space-based Quantum Key Distribution (QKD) may contribute to the establishment of secure communication links, thus allowing the space sector to play a larger role in defending digital systems on Earth.[340]

According to Research & Markets, **the global satellite communication market is expected to be worth $159.6 billion in 2030 compared to $77.1 billion in 2022.** Growth is expected to be derived from developments in 5G networks and the Internet of Things, which will **enable the space sector to reach out to new verticals such as automotive, health, energy, smart cities**, etc.[341]

Several milestones were reached in 2022, in particular regarding:

(1) the deployment of LEO constellations for broadband connectivity;
(2) the developments and contracts for satellite 5G and Internet of Things (IoT) solutions;
(3) satellite-to-mobile connectivity.

Growth of connectivity constellations targeting broadband and IoT markets

LEO constellations for telecommunication applications have continued to grow in size and number in 2022, as proved by the increase in the number of spacecrafts launched. In parallel, partnership-building activities and company restructuring have taken place, with companies aiming at better positioning in the changing telecommunication market.

[339] ESPI, Autumn Conference Proceedings, ESPI, October 2021
[340] ESPI Brief 51, Quantum and Space: The ultimate solution to secured communications?, ESPI, June 2021
[341] Global Satellite Communication Market Size, Share & Trends Analysis Report by Component (Equipment, Services), by Application (Broadcasting, Airtime), by Vertical, by Region, and Segment Forecasts, 2022-2030, Research and Markets, June 2022

Operator	Satellites Launched in 2022	Business Case
SpaceX	1726	B2C & B2B Broadband
OneWeb	110	B2B Broadband
Swarm Technologies	53	IoT / M2M
Fossa Systems	11	IoT
Geespace	9	IoT / M2M
Galaxy Space	6	B2C & B2B Broadband
Kepler Communications	4	IoT / M2M
Astrocast	4	IoT/ M2M

*Table 4: Satellite operators having launched 4 or more operational connectivity satellites in 2022 (Source: ESPI Database) * Numbers exclude technology demonstration satellites.*

In March, **OneWeb signed a launch agreement with SpaceX**.[342]

The first SpaceX's-backed OneWeb mission was accomplished on board a Falcon 9 rocket launch in December, which took additional 40 OneWeb satellites into orbit.[343] The decision came after the suspension of all OneWeb's launches from the Baikonur Cosmodrome in Kazakhstan after the UK Government rejected Roscosmos chief Dmitry Rogozin's conditions for future launches using Baikonur facilities. By suspending all Soyuz launches, OneWeb has been unable to retrieve the satellites worth $50 million from the launch site in Baikonur.[344] Additionally, **NewSpace India Limited (NSIL),** the newly established commercial arm of ISRO, **successfully deployed 36 OneWeb satellites**, launched from the Satish Dhawan Space Centre (SDSC-SHAR) on board a first LVM3 rocket.[345]

In November, **the Council and the European Parliament reached a provisional agreement on the Regulation establishing the EU's space-based Secure Connectivity Programme for the period 2023-2027**, aimed at deploying the IRIS2 constellation.[346] While the timeline is still subject to revisions, the European Union agreed to cover nearly half the €6 billion cost of deploying a secure connectivity constellation by 2027.[347] The financing would come from funding previously earmarked for other European programmes over the period, with the private sector expected to provide the remaining €3.6 billion via public-private partnerships (PPP). In light of this, several **satellite operators, including SES, Hispasat and Eutelsat** have expressed their interest in co-investing in the European programme.[348]

Further information on IRIS^2 can be found in section 1.1.1. ESA and EU budget and priorities for space.

[342] OneWeb turns to SpaceX for help after Russia refused to launch company's satellites, The Verge, March 2022
[343] SpaceX launches rival company's communication satellites into orbit, CBS News, December 2022
[344] OneWeb 'moves on' from Soyuz-stranded satellites as its network nears completion, Reuters, March 2023
[345] OneWeb satellites successfully launched by ISRO/ NSIL from Sriharikota, OneWeb, October 2022
[346] Council and European Parliament agree on boosting secure communications with a new satellite system, Council of the Eu, November 2022
[347] Europe reaches funding deal for sovereign broadband constellation, SpaceNews, November 2022
[348] Satellite operators Hispasat, SES to European Commission: We'll invest in your constellation if we can run it on our terms, Space Intel report, October 2022

In May, **Telesat, having selected Thales Alenia Space as prime contractor for its global "Lightspeed "LEO constellation, ordered 188 satellites plus 10 in-orbit spares from TAS** - 100 less than initially planned to order. Initially, the constellation was to be built of 298 satellites but was needed to change the plan due to increasing costs and delays due to supply chain shortages, in order to keep it €5 million budget. The Lightspeed constellation aims to provide 10 terabits of capacity (with the initially planned 298 satellites it would be 15 terabits). The supply chain shortages delayed the planned start of service provision to 2026.[349]

Omnispace Spark-1 and Spark-2, launched in April and May respectively, have been designed and built by Thales Alenia Space together with its industry partners, including NanoAvionics, ANYWAVES, and Syrlinks, as part of a 2020 agreement.[350] The satellites will contribute to the development and implementation of Omnispace's global non-terrestrial network (NTN). The new-generation satellite constellation (NGSO) in low-earth orbit (LEO) will operate in 3GPP band, which has been standardised for NTN operation, making direct-to enterprise and government IoT, and consumer device connectivity possible worldwide.[351]

In July, the Chinese company **Geespace (a subsidiary of Geely Technology Group) launched the first 9 DeeSAT-1 satellites of its Geely Future Mobility Constellation**, which is expected to be comprised of 240 satellites in total, with a first phase of 72 planned to be completed in 2025. The GeeSAT-1 satellite is considered to be China's first modular, high-resilience, high-performance, mass-produced satellite and provides centimetre accurate precise positioning and IoT support for use by the automotive sector. The Geely Future Mobility Constellation aims to provide services for various areas including autonomous driving, logistics, mapping and drone navigation.[352]

Credit: Omnispace

In March, **China-based Galaxy Space launched 6 satellites** to test broadband services, on-orbit networking, and integrated communications.[353] Notably, the six satellites play an important role in enabling the development of a Chinese LEO broadband large constellation, known as "Guowang". The Chinese government unveiled that the constellation is being overseen by the state-owned enterprise China Satellite Network Group and manufactured by two entities, the China Academy of Space Technology (CAST), a major subsidiary of CASC, and the Innovation Academy for Microsatellites (IAMCAS) under the Chinese Academy of Sciences. China will launch the new LEO satellite network aboard a Long March 5B.[354]

If successful with its first launch planned for 2024. The private company Space Pioneer, while lacking details, will reportedly also contribute to the deployment of the constellation through its Tianlong-3 rocket, planning to be capable of lifting 15 tons of payload to LEO and of launching batches of up to 60 satellites each.[355]

In October, Russia's TASS news agency reported that **Skif is planning to commence deployment of the future Russian satellite constellation in 2025**, following the successful launch of a Soyuz-2.1b carrier rocket with three Gonets-M satellites and a Skif-D module, aimed at completing the system's testing and payload demo. Sfera, the telecommunication project launched by the Russian

[349] Telesat to order 100 fewer satellites for LEO constellation, SpaceNews, May 2022
[350] Thales Alenia Space to build two prototype satellites for constellation venture, SpaceNews, April 2020
[351] Omnispace satellites launched into orbit, Thales Alenia Space, May 2022
[352] Geespace Successfully Launches First Nine Satellites, Geespace, July 2022
[353] China launches test satellites for broadband constellation, SpaceNews, March 2022
[354] The Long March 5B and upper stage configuration to be used to launch satellites for a LEO network, March 2023
[355] Chinese rocket firm Space Pioneer set for first launch, Space News, February 2023

Federation, will consist of at least 162 satellites, including communication satellites Ekspress and Ekspress-RV in geostationary and high elliptical orbits, Skif satellites for broadband Internet access and Marathon satellites.

In addition, the group will include Yamal communication satellites, Smotr remote sensing satellites, and Berkut observation satellites. The satellites are being manufactured by ROSCOSMOS's spin-off Information Satellite Systems (ISS) Reshetnev.[356]

Starship (Credit: SpaceX)

In December, **the FCC issued a key authorisation to SpaceX**, granting approval to launch up to 7,500 Starlink internet satellites, deferring the decision on SpaceX's application to launch the full number of 30.000 spacecraft.[357]

As announced in January, the company aims to deploy its second-generation constellation for broadband connectivity using Starship instead of Falcon 9.[358]

Vigorous cross-industry partnerships in satellite connectivity

Key European actors Eutelsat and OneWeb announced they will combine to provide integrated LEO and GEO connectivity services:

Eutelsat got increasingly involved in OneWeb, following a process kickstarted in April 2021 with **Eutelsat announcing a $550 million equity investment in OneWeb,** and increasing its share in OneWeb in October that same year.[359] In March, **Eutelsat announced a global multi-year Distribution Partnership Agreement (DPA) with OneWeb**, which paved the way for the commercialisation of OneWeb services across key connectivity verticals including maritime, enterprise communications, aviation, consumer broadband, and Government business segments.[360]

Later, in July, **Eutelsat and OneWeb signed an MoU to combine** in an all-share transaction.[361]

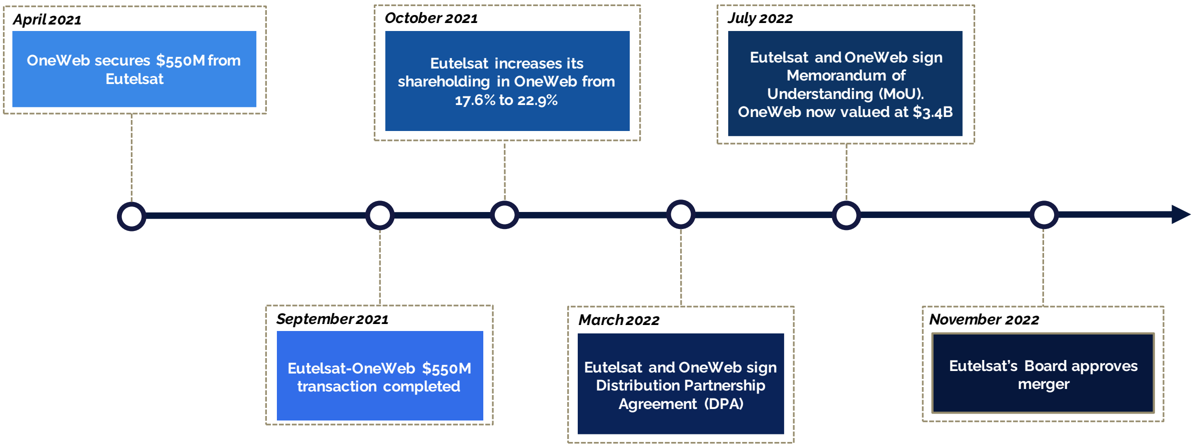
The deal was reported as a merger of equals with shareholders of both companies owning 50% of the combined entity. The two firms will keep their respective headquarters in the UK and in France, while the merged group, listed in France, will also apply for being listed in the UK. The combined entity aims at better positioning in the fast-growing satellite connectivity market by the provision of integrated GEO-LEO solutions. Indeed, the deal highlights the intention of the two companies to leverage the complementarity of Eutelsat's 36 GEO satellites with OneWeb's LEO assets in tackling the growing demand for connectivity services across verticals, such as aerial and maritime mobility, fixed data and government services.

On the one hand, Eutelsat has focused on the B2C market through the $500 million Konnect VHTS GEO satellite, with the aim of improving broadband coverage in Europe. The company has recently launched EUTELSAT 10B satellite, and contracted Thales Alenia Space to build a next-generation Flexsat to increment capacity over the Americas.[362] However, the French company recognised LEO capability's potential for B2B and B2G markets, including mobility, with low-latency requirements.

[356] Russia to start deploying Skif satellite constellation for high-speed internet in 2025 & Russia planned Sfera constellation takes shape, TASS, November 2022
[357] FCC authorizes SpaceX to begin deploying up to 7,500 next-generation Starlink satellites, CNBC, December 2022
[358] SpaceX goes all-in on Starship configuration for second-gen Starlink, SpaceNews, January 2022
[359] OneWeb secures $550M in new funding: Eutelsat to take significant equity stake in the company & Eutelsat raises its shareholding in OneWeb, OneWeb, April 2021
[360] Eutelsat and OneWeb sign global distribution partnership to address key connectivity verticals, OneWeb, March 2022
[361] Eutelsat and OneWeb have signed a MoU to combine OneWeb's LEO technology and Eutelsat's Geo infrastructure, Spacewatch.global, July 2022
[362] Eutelsat selects Thales Alenia Space to build a new Flexible Software-Defined Satellite, Thales Alenia Space, December 2022

On the other hand, **OneWeb's has an interest in securing $2 to $3 billion to deploy its Gen-2 constellation**, leveraging Eutelsat´s interest in LEO-based connectivity solutions and readiness to invest in this field.[363]

Finally, in November 2022, **Eutelsat and main OneWeb shareholders signed the Final Agreement** for the combination of the two companies.[364]



Eutelsat/OneWeb Investment and Partnership Timeline

Established operators advancing to LEO broadband & IoT

GEO satellite operators and large satellite manufacturers are aiming at positioning in the broadband connectivity market by directly entering it or associating with internet broadband providers.

Intelsat is looking to partner with LEO broadband connectivity providers such as SpaceX. For instance, in March, the company announced its intention to proceed to **integrate its geostationary satellites with SpaceX's Starlink** in a new managed network service. In view of the agreement, Intelsat would buy Starlink terminals and services, and resell them as part of a multi-layer, multi-orbit managed network that includes geostationary satcom and LTE connectivity, providing the users with only one interface. Military customers are especially targeted, with their units able to bring the entire network to the field in two large suitcases. One hosting an Intelsat's Satcube geostationary terminal, cables, and a gateway; the other containing the Starlink terminal and cables, and they all plug into the gateway.[365]

Inmarsat is entering the broadband connectivity market with the provision of IoT services

In particular, in November, **Inmarsat Government**, a subsidiary of British GEO satellite operator Inmarsat, has won a USD 410 million, five-year contract extension from the U.S. Defense Information Systems Agency to provide satellite connectivity for the U.S. Army's Blue Force Tracker network services. Inmarsat Government will connect the Blue Force Tracker network using a future network called ELERA, supporting IoT services, that will provide connectivity between Blue Force Tracker transceivers and satellite ground stations using Inmarsat's existing L-band satellites.[366]

[363] Eutelsat nearly ready to seek bids for building OneWeb Gen 2, SpaceNews, February 2023
[364] ESPI Brief 60, Rising Opportunities in the Satellite Connectivity Market: Eutelsat and OneWeb combination, ESPI, December 2022
[365] Intelsat rolls out network service that integrates Starlink and geostationary satellites, SpaceNews, March 2022
[366] Inmarsat wins $410 million U.S. Army contract to connect tracking devices, SpaceNews, November 2022

SES further bolstering its position in the broadband connectivity market

In May **SES** used one of its satellites to secure the frequencies identified by Luxembourg's government application filed to the ITU back in 2015, two days before the deadline. By rescuing spectrum rights for a constellation of 62 proposed satellites called Cleosat.

SES has furthered its **plan to offer 5G services directly to handheld devices** noting that "SES applied for this filing through the Luxembourg government because it recognises the potential of direct-to-handheld 5G satellite connectivity in the years to come. We haven't made any decision to significantly invest in this technology at this stage and will in the coming months do our due diligence of assessing the market and business plans". The proposed Cleosat constellation uses multiple frequency bands from around 1.5 GHz to 29 GHz.[367]

Moreover, in November, **SES and Hughes successfully demonstrated satellite internet service on a General Atomics surveillance drone** at a flight operations facility in California. The MQ-9B SkyGuardian drone connected with SES satellites in MEO and GEO, showing how high-throughput satellite connectivity can transmit live video streams faster and more reliably than traditional single-orbit networks.[368]

Viasat's $7.3 billion acquisition of Inmarsat

Shareholders of Viasat gave their approval for the company's $7.3 billion plan to acquire British satellite operator Inmarsat. The acquisition, backed by private equity, aimed to expand Viasat's broadband network on a global scale, covering multiple orbits and spectrum bands.[369]

Viasat's acquisition of Inmarsat is structured with $850M in cash, approximately $3.1B in Viasat equity, and the assumption of $3.4B of net debt. In 2022, Viasat posted a net loss of $29M primarily due to higher depreciation and partially attributed to the expenses related to the acquisition (non-recurring acquisition-related expenses). In an interview Viasat's Executive Chairman, Mark Dankberg, and Inmarsat's CEO, Rajeev Suri, discussed the deal's implications and future plans. The companies planned to strengthen their approach different vertical and geographic markets, aiming to capture the opportunities within the global connectivity demands.

The focus was on the I'marsat's Orchestra plans, which aimed to integrate L-band and Ka-band networks with terrestrial 5G and with multi-orbit services. In terms of verticals, the aviation market raised particular attention. However, the UK's Competition and Markets Authority (CMA) expressed concerns about the potential impact on competition in the inflight connectivity (IFC) market.[370]

They said that the deal among Viasat and Inmarsat could result in pricier and lower-quality Wi-Fi for airline passengers (IFC). The competition authority stated that the two companies are among the strongest providers of IFC, and the emergence of new players like SpaceX and OneWeb might not be able to compete effectively with the merged company. The CMA was worried that the merged company's vertical integration and existing contracts could lock out potential competition, delaying competition from NGSO providers. The two companies were confident the deal would go through.

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[367] SES mulls direct-to-handheld 5G satellite business, SpaceNews, May 2022
[368] SES, Hughes demonstrate satellite internet on General Atomics surveillance drone, SpaceNews, November 2022
[369] Viasat shareholders approve Inmarsat acquisition, SpaceNews, June 2022
[370] Satellite communication deal raises competition concerns, Gov UK, October 2022

SES completes $450 million acquisition of DRS Global Enterprise Solutions

SES, the Luxembourg-based communications satellite operator, completed its $450 million acquisition of DRS Global Enterprise Solutions (GES) from Leonardo DRS. With this acquisition, DRS GES will now be integrated into SES Government Solutions in Reston, Virginia. Prior to the acquisition, DRS GES was part of the defence contractor Leonardo DRS and was among the few network integrators providing managed satcom services to the Defense Department and other government agencies. SES, which operates a fleet of over 70 geosynchronous and MEO satellites, intended to capitalise on DRS GES's customer base to expand its U.S. defence and government business. The company aimed to serve the U.S. government's satellite communication needs across different terrains - land, sea, and air - with multi-orbit solutions. This acquisition aimed to contribute to SES's revenue from the U.S. government, potentially making it one of the company's largest data business segments. DRS GES's integrator role offered multi-operator network solutions, with a particular focus on SES's upcoming O3b mPower constellation, specifically designed for military and government customers.[371]

Airbus is also involved in the development of new connectivity solutions. Since January, the **SpaceDataHighway**, a public-private partnership between ESA and Airbus enabling data transfer from LEO satellites and airborne platforms to European ground stations via the European Data Relay System (EDRS) laser communication infrastructure in GEO**,** provides **broadband connectivity services between ISS and Earth**, thanks to the installation and testing of the Columbus Ka-band terminal (ColKa), which guarantees relay data in real-time between the ISS Columbus Laboratory and the Columbus Control Centre located in Germany.

The tool aims to increase operational flexibility, allowing more astronauts, scientists, and researchers to benefit from a direct link with Europe.[372] In addition, i**n July, Airbus** has launched a **HAPS Services Business based on Zephyr**, its leading HAPS (High-Altitude Platform Station) technology, to provide low-latency connectivity services for telecommunications (and Earth observation) applications. The solar-powered Zephyr is set to offer telecommunications services via its platform.[373] Moreover, in November, **Airbus HAPS signed a Letter of Intent with the Japanese Space Compass Corporation** to service the Japanese market with 4G/5G low-latency mobile connectivity and EO services from the stratosphere with Zephyr.[374]

5G/6G and the Internet of Things (IoT) sectors see value in satellite connectivity

In 2019, the fifth generation (5G) of mobile networks started to be deployed and commercially exploited. 5G supports data speed of 20 Gb per second, which is 100 times faster than 4G, with the goal to enable fast data transmission, reliability, latency, and energy efficiency. The main use cases for 5G can be divided into three categories: enhanced mobile broadband (eMBB), massive machine-type communications (mMTC), and ultra-reliable low-latency communications (URLLC). To enable these use cases, space systems are poised to play a more important role in mobile networks to provide connectivity in remote areas, support edge server connectivity, fixed backhaul to remote areas, hybrid networks, connectivity in mobile platforms. The complementary development of terrestrial and non-terrestrial technologies also contributes to the more widespread and rapid adoption of 5G across many use cases.

For instance, the **5G Automotive Association (5GAA),** a global, cross-industry organisation of companies from the automotive, technology, and telecommunications industries (ICT), published in

[371] SES closes $450 million acquisition of DRS' satellite communications business, SpaceNews, August 2022
[372] The International Space Station connected via the SpaceDataHighway, Airbus, January 2022
[373] Airbus to deliver connectivity services using its leading Zephyr High Altitude Platform Station (HAPS), Airbus, July 2022
[374] Airbus partners with Space Compass to serve the Japanese market with mobile connectivity, Airbus, November 2022

November a position paper outlining core priorities in the field of space-based connectivity and industry requirements for the European Communication Satellite Constellation.[375] The association advocates for greater awareness of service continuity and the integration of terrestrial and non-terrestrial networks (NTNs) to achieve ubiquitous and uninterrupted connectivity, supporting breakdown or emergency calls, and enabling remote car control and over-the-air updates. Several developments of space-based 5G and IoT technologies took place in 2022:

- In January, an **Intelsat** order was made public, whereby **Thales Alenia Space** will build two software-defined satellites, Intelsat 41 (IS-41) and Intelsat 44 (IS-44), as part of Intelsat's 5G software-defined network.[376] These satellites are scheduled to be operational in 2025 and will be based on the Space Inspire (Instant Space In-Orbit Reconfiguration) product line developed by TAS. The addition of these satellites will enable greater agility, flexibility and orchestration. The additional satellites will contribute to the provision of high-speed dynamically allocated connectivity across Africa, Europe, the Middle East and Asia for commercial and government mobility services and cellular backhaul.
- In February, **Astrocast SA** launched its bidirectional **satellite IoT service for global connectivity** of IoT devices outside of terrestrial networks coverage. The service has the potential to revolutionise the business model for global IoT, with numerous applications in asset tracking, telemetry, and telematics across various sectors such as agriculture, transportation, and environment.[377]
- In January, the **four Chinese companies Geely Automobile Research Institute, Tencent Cloud, China Automotive Data, and Anheng Information signed strategic cooperation for an "Internet of Vehicles Network Security Laboratory"** to develop an intelligent networked vehicle security system. The Internet of Vehicles' network security will address the protection of the integrity of the digital infrastructure, development of risk mitigation and response techniques, and the prevention of unauthorised attack access.[378]

As an indication of the growing interest in IoT, Iridium Communications Inc. reported about their record revenues of the second half of 2022, which growth compared to last year is primarily driven by IoT. The net income was $4.6 million ($3.8 million in second half of 2021) and the revenue was $174.9 million (+17% compared to second half of 2021), comprised of $132.9 million of service revenue and $42.0 million of revenue related to equipment sales and engineering and support projects, including commercial IoT data revenue of $30.6 million (+13% compared to second half of 2021).[379]

Milestones in direct-to-smartphone satellite connectivity

- In August, **T-Mobile and SpaceX have partnered in "Coverage Above and Beyond,"** a new plan to provide mobile connectivity everywhere leveraging Starlink and T-Mobile's wireless network.[380] The goal is to provide near-complete coverage in most areas of the U.S., including remote locations previously unreachable by traditional cell signals.
- In September, Huawei launched its Mate 50 smartphone series that enables users to send short text **messages using China's BeiDou satellite network**, allowing communication in areas beyond cellular coverage.[381]

[375] 5GAA publishes position paper on secure space-based connectivity program, Spacewatch.global, November 2022
[376] Intelsat acquires two Software-Defined Satellites from Thales Alenia Space, Intelsat, January 2022
[377] Astrocast's Cost-effective, Bidirectional Satellite IoT service launches commercially, Astrocast, February 2022
[378] Tencent and Geely team up to build 'Internet of Vehicles' safety system, Car News China, January 2022
[379] Iridium Announces Record Second-Quarter 2022 Results; Updates 2022 Outlook, Talk Satellite, July 2022
[380] T-Mobile Takes Coverage Above and Beyond With SpaceX, T-Mobile, August 2022
[381] Huawei launches Mate 50 series with satellite connectivity ahead of Apple, Business Standard, September 2022

- In the second half of September, **the startup Lynk Global gained regulatory approval from the Federal Communications Commission** (FCC) to operate the first commercial satellite direct-to-cell service globally. The approval is for an initial 10 satellites, designed to provide basic connectivity services directly to standard mobile phones from LEO. However, Lynk needs to deploy more satellites and gain landing rights before it can start its services. For instance, the FCC has placed certain conditions, such as limiting Lynk's use of radio frequencies and preventing the creation of a monopoly or duopoly in the market. Lynk also plans to deploy more than 50 satellites before the end of 2023 to increase revisit times to every 15-30 minutes.[382]
- In October, **Yahsat**, an Emirati fleet operator, has invested in **eSAT Global**, a Californian startup developing a chip to connect phones to satellites in geostationary orbit, acquiring a minority stake in the U.S-based company. Additionally, a longer-term commercial agreement for Thuraya, Yahsat's L-band mobile satellite services business, to use eSAT technology was combined with the deal.[383]
- In November, **Apple** invested in Globalstar with a $450 million infrastructure investment derived from Apple's Advanced Manufacturing Fund, to support a SOS via satellite service run by Globalstar. On its end, Globalstar has upgraded its ground stations with high-power antennas. The move will increase the reliability and coverage of Globalstar's satellite constellation, ensuring that iPhone 14 and iPhone 14 Pro users – and future versions – can make use of emergency services even outside of the area covered by terrestrial networks.[384]
  iPhone users can lock onto one of Globalstar's 24 satellites and send an SOS text message, which is received by a ground station and then routed directly to emergency services providers. Globalstar announced to allocate 85% of its network capacity to Apple, while the remaining 15% will be used for the provision of its own services, such as internet-of-things (IoT) connectivity.[385]
- In November, British handset maker **Bullitt** announced it will release a new smartphone line capable of **sending and receiving messages via GEO satellites** in around 10 seconds, with initial satellite coverage across North America and Europe. The smartphone, capable of connecting to space infrastructure without the need of an external antenna, will run on Google's Android operating system and will also **include a satellite-enabled SOS service**.[386]
- In late November, the U.S-based startup **AST SpaceMobile successfully opened the communication array for its BlueWalker 3 test satellite in orbit**, to demonstrate the feasibility of its planned 168-strong Space Mobile satellite constellation. The first 20 will be for equatorial coverage, the next 90 for substantial global coverage, and the final 58 will have MIMO antenna capabilities. Five more satellites are planned to be launched in 2023, with intermittent service expected. AST's ultimate goal is to connect regular mobile phones via its satellite network.[387]
- In November, the **Japan-based Rakuten Mobile received licenses from Japanese regulators for direct-to-mobile satellite communication testing in Japan**. Rakuten is working with satellite manufacturer AST SpaceMobile and its BlueWalker 3 satellite (launched in September) to provide customers with connectivity including in areas where there is terrestrial cell coverage.[388]

[382] Lynk Global gets first commercial satellite direct-to-cell operating license, SpaceNews, September 2022
[383] Yahsat invests in direct-to-cell enabler eSAT Global, SpaceNews, October 2022
[384] Apple lays the groundwork for emergency SOS via satellite service, SpaceNews, November 2022
[385] Apple to be largest user of Globalstar's satellite network for iPhone messaging, SpaceNews, September 2022
[386] UK firm to release GEO-compatible smartphone early next year, SpaceNews, November 2022
[387] How imminent is mobile phone connectivity via AST SpaceMobile?, Fierece Wireless, November 2022
[388] Direct-to-satellite service tests are planned for the remote mountains on Japan's northernmost island, RCS Wireless News, November 2022

2.1.2 Space as a Service: GSaaS leading the charge

Space-as-a-Service is an umbrella term for several business models revolving around the utilisation of space-based capabilities without designing developing, or owning space systems, but only paying for the service used. Space-as-a-Service is part of the sharing economy, which enables end-users to acquire, provide, or share assets and services through online platforms. Space-as-a-Service is based on the cloud computing technology and enables operators to control a space system or retrieve satellite images or analysed information directly from the cloud.

Three main categories of Space-as-a-Service business models can be identified:

1. Infrastructure-as-a-service consists of the provider owning space systems and enabling users to control the spacecraft and retrieve space data directly. This includes three further subcategories:

- **Ground Segment-as-a-Service (GSaaS):** a cloud computing service wherein the provider grants satellite operators access to a network of ground stations, enabling the operators to control and utilise their satellites without having to build a ground station network. According to Euroconsult's 2022 Ground Segment Market Report, the GSaaS market is expected to reach US$250 million by 2026, though potentially deflating to US$200M by 2030 as the market matures.[389]
- **Satellite-as-a-Service:** a service that enables users to place a payload on a provider's satellite or use and control a satellite through the cloud without developing or owning the satellite itself.
- **Constellation-as-a-Service** is a related concept, under which an entire satellite constellation is built and operated by a company on behalf of another user or several other users.

2. Software-as-a-Service is a cloud-based service that enables users to use an online software solution instead of hosting and processing data on their servers, using or including space-based data. It also includes:

- **Platform-as-a-service** are services that provide a computing environment and infrastructure to access, process and use space-based data as well as data from other sources.

3. Space Data-as-a-Service is a service where a satellite operator operates and controls a satellite, and provides only specific data requested by a client as its service, which also includes:

- **Analytics-as-a-service** is a service that transform space-based data into useful information in more than one sector or vertical.
- **Insights-as-a-service** is a service that convert space-based data into actionable information for a specific sector or vertical.[390]

In 2022, Space-as-a-Service markets kept developing with both established and rising players investing to improve their offering, adding new functionalities to their services, and broadening use cases. These business cases, while only emerging a few years ago, are now increasingly common, in particular for the ground segment market.

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[389] "Ground Segment forecasted at $78 Billion cumulated market value from 2022 to 2031," Euroconsult, September 2022
[390] The State of Commercial Earth Observation: 2022 Edition, TerraWatch Space Insights, August 2022

Cloud service providers keep running the show

Two of the biggest players in the Space-as-a-Service market are companies that were already established providers of Software-as-a-Service and cloud architecture outside the space sector and have over time increasingly moved to establish themselves in the space sector.

Amazon Web Services (AWS) remains a titan of the GSaaS marketplace with its Ground Station service. AWS rolled out several improvements to its infrastructure and services throughout 2022.

AWS Ground Station Locations (Credit: AWS)

- In July, AWS announced the **establishment of a new antenna location in Singapore**. Previously, the nearest antennas serving the South-East Asia were located in Seoul and Sydney.[391]
- In August, **AWS expanded wideband Digital Intermediate Frequency support for its antennas based in Cape Town, Ireland, and Singapore**. This allows ground stations to serve a broader array of customers with software-defined radios operating on frequencies up to 400 MHz.[392]
- In November, AWS announced that they were **delivering Customer Provided Ephemeris support** for AWS Ground Stations, which allows tracking and telemetry operations before a satellite reaches its final orbit, increases the quality of tracking satellites in orbit, and enables to modify antenna pointing when spacecraft conduct manoeuvres.[393]
- In November, **AWS announced that they successfully ran cloud computing and machine learning tasks aboard an ION satellite** operated by the Italian company D-Orbit. In collaboration with D-Orbit and Swedish firm Unibap, AWS developed a set of machine learning tools for in-situ analysis of data gathered by the satellite, which AWS claims will enable much faster data processing and reduced latency.[394]

Microsoft Azure continued to develop in 2022 both in terms of capabilities as well as its network of customers. Azure Orbital launched the **Azure Orbital Cloud Access,** which combines satellite and terrestrial networks to deliver low-latency cloud services.[395]

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[391] AWS Ground Station announces a new antenna location in the Asia Pacific (Singapore) Region, AWS, July 2022
[392] AWS Ground Station adds support for wideband Digital Intermediate Frequency in Africa (Cape Town), Europe (Ireland), and Asia Pacific (Singapore), AWS, August 2022
[393] AWS Ground Station adds support for Customer Provided Ephemeris in preview, AWS, November 2022
[394] AWS successfully runs AWS compute and machine learning services on an orbiting satellite in a first-of-its kind space experiment, AWS, 2022
[395] Microsoft (MSFT) Expands Azure Space Connectivity Offerings, Yahoo Finance, September 2022

Azure Orbital Cloud Access (Credit: Microsoft)

Microsoft also announced the general availability of its **Azure Orbital Ground Station** to satellite operators. Azure Orbital Ground Station to a large extent relies on partnerships with KSAT for the ground segment infrastructure. Microsoft signed contracts with the EO company **Pixxel** to retrieve data in Azure Cloud without data backhaul costs and then process its space data using Azure's AI/ML services to provide space data insights to its own customers. Microsoft also signed a strategic partnership with **Loft Orbital** to support end-to-end customer missions following a demonstration of a test of Azure Orbital Ground Station. In addition, Microsoft signed a partnership with **Muon Space**, which is developing a remote sensing platform to provide climate data, to support its needs for coverage with its network of ground stations.[396]

Microsoft and SES announced the extension of their partnership with the creation of a **joint Satellite Communications Virtualisation Programme** to establish the world's first fully virtualised satellite communications ground network using software-defined hubs, customer edge terminals, new virtual network functions, edge cloud applications, etc. This virtualisation will integrate cloud and satellite network designs and enable commercial satellite networks to employ 5G technology, bridging the gap between terrestrial and non-terrestrial communication networks. It is expected to enable faster standardisation of system interfaces, promoting more automation, API-based control, and cross-industry compatibility. This programme will enable SES to define and apply the pre-production architecture for its future fully virtual ground segment.[397]

In July, **Microsoft announced the Azure Space Partner Community**, which focuses on better integration of its existing network of partners. Microsoft advertises Community members as receiving benefits such as "co-innovation, go-to-market and technical support, industry selling, and solution scaling." The initial cohort of founding members **included several other Space-as-a-Service providers, such as Kratos, KSAT, Viasat, and XPLORE**, as well as other hardware and software producers.[398]

Established space players adapting to the market

Traditional space and/or ground segment operators are adapting to this new business model and entering the space-as-a-service market.

Kongsberg Satellite Services (KSAT), a private company with ownership divided between the Norwegian government and the manufacturing group Kongsberg, is a key player in the GSaaS field. Among its products, KSATlite is a GSaaS for smallsats and constellations. Between August 2021 and August 2022, KSATlite ground station network of 260 antennas in 26 locations achieved 628,863 satellite contacts and increased its data traffic by 45%. In addition, KSAT provides KSATHosted, which is an Infrastructure-as-a-service solution to enable satellite operators delegate all ground networks and operations to KSAT.[399]

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[396] New Azure Space products enable digital resiliency and empower the industry, Microsoft, September 2022
[397] Ibid.
[398] Announcing the Azure Space Partner Community, Microsoft, July 2022
[399] High success rate for KSATlite the last 12 months, KSAT, August 2022

KSAT signed several contracts to provide ground station as a service to satellite operators:

- In April, KSAT announced it was a subcontractor in a consortium bringing together ESA, OHB Sweden, and Thales Alenia Space to provide satellite operations as-a-service for ESA's Arctic Weather Satellite Programme. OHB Sweden will be responsible for constructing the prototype, Thales Alenia Space will provide the ground segment services, and KSAT is subcontracted by Thales to provide the unified interface for all operational control of the satellite.[400]
- In June, KSAT announced that it signed a contract with GHGSat to operate their 5 satellites currently in orbit from its Tromsø Satellite Operations Centre (TSOC).[401]
- Finally, in October, KSAT was subcontracted by Parsons Corporation to provide ground station services as part of a broader contract issued by the National Oceanic and Atmospheric Administration (NOAA) for operating the Polar Operational Environmental Satellites (POES) NOAA-15, NOAA-18, and NOAA-19.[402]

Infrastructure expansion was also on the agenda for KSAT:

- In June, KSAT inaugurated a new 5m antenna based at Maspalomas, Canary Islands, at a facility run by the Spanish Public Research Organisation National Institute of Aerospace Technology (INTA). In future, KSAT plans to open more antennas at the same site. The antenna will be integrated into the KSATmax and KSATlite offering.[403]
- KSAT also announced that they were seeking to install four new antennas at their site in Antarctica, Troll Ground Station.[404]

Kratos Defense & Security continues developing its Open Space Platform

Kratos Defense & Security Solutions is a U.S.-based aerospace and information technology company. Kratos does not operate or license ground stations of its own, but it created and operates OpenSpace, a collection of tools and platforms for hardware virtualisation and virtualised satellite control.

- Kratos added several new features to the OpenSpace platform, including to its OpenSpace's Earth Observation & Remote Sensing Service Chain, emphasising increased automation and optimisation. In November, the OpenSpace system was upgraded to integrate a virtualised Channelizer and Combiner for satellite ground operations. This system splits and defines digitised radio-frequency signals, and is performed in a virtualised system, which Kratos claims to be a significant improvement in speed over modifying hardware to accomplish the same task.[405]
- KSAT is a key customer for OpenSpace products, announcing in February that it had supported over 50,000 satellite passes in a single month using the OpenSpace virtualisation systems Quantum and SpectralNet.[406]
- In May, US satellite operator Intelsat announced that OpenSpace would be used as the basis for unifying ground and space operations for a next-generation network.[407]

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[400] KSAT to provide satellite operations as-a-service for ESA's Arctic Weather Satellite, KSAT, April 2022
[401] GHGSat Signs With KSAT for Satellite Constellation Operations, KSAT, December 2022
[402] NOAA Awards Parsons Team $16 Million Contract For Polar Operational Environmental Satellites Operations, GlobeNewswire, October 2022
[403] Inauguration of new KSAT antenna in Maspalomas, KSAT, June 2022
[404] Troll in Antarctica - the second fastest growing KSAT ground station, KSAT, February 2022
[405] Kratos Continues Leadership in Satellite Ground Segment Modernization with Introduction of Virtual Channelizer and Combiner, Kratos, November 2022 ; Kratos Releases Earth Observation & Remote Sensing Service Chain Enhancements for its OpenSpace Platform, Kratos, January 2022
[406] Sales of Kratos OpenSpace quantum and OpenSpace SpectralNet Ground System Products Continue Growth in 2021 With Strong Q4, Kratos, February 2022
[407] Intelsat Selects Kratos' OpenSpace Satellite Ground Platform as Part of Its Next Generation Network, GlobeNewswire, May 2022

SSC leveraging heritage, targeting future markets

The **Swedish Space Corporation (SSC),** a company established in 1972 and fully owned by the Swedish government, is one of the oldest and most experienced providers of ground station capabilities, having provided ground station support to missions as far back as the U.S. Apollo programme. The SSC is increasingly leveraging this experience and capability to enter the GSaaS marketplace.

- SSC announced its intention to join the race to provide **GSaaS for lunar operations** through the opening of two new ground stations in Chile and Australia. These developments are being conducted through a partnership with French company Safran Data Systems and are expected to become operational next year.[408]
- In addition, SSC signed a 10-year contract with CNES to sustain ground support for the space agency's polar-orbiting missions. This contract is an extension of a previous 10-year contract between SSC and CNES, in which they co-developed and co-managed a pair of antennae in Inuvik, Canada and Kiruna, Sweden.[409]

ViaSat increases capacity through its expanded network

ViaSat is an American satellite operator that operates the Real-Time Earth (RTE) network, which is a ground stations as a service solution.

- The Real-Time Earth network saw an expansion in capacity as ViaSat signed an agreement with Swedish firm Arctic Space Technologies to use up to four antennas at its facility in Piteå, Sweden. The facility lies on the edge of the Arctic Circle and is therefore suitable for providing service uplinks and data downlinks for earth observation and communication satellites in polar orbits.[410] The Swedish facility complements existing ground stations serving the RTE network, including one established in Australia in 2020, and another established in Ghana in 2021.[411]
- In September, ViaSat and Satellite Vu signed a partnership to use ViaSat's RTE service to retrieve and disseminate Satellite Vu's images to enable regular contacts with its constellation and respond promptly to its customers' requests.[412]

Start-ups continue to develop space-as-a-service solutions

ATLAS, a US-based startup, that provides a ground software as-a-service, Freedom™ Software Platform, which is a ground network management system, secured important contractual and funding milestones in 2022:

- In July, **ATLAS received an indefinite delivery, indefinite quantity (IDIQ) contract from NOAA** to provide both ground station services and its Freedom software.[413]
- In August, ATLAS **secured U.S. $26 million in Series B funding, with Japanese trading and investment conglomerate Mitsui as the lead investor.** Mitsui's funding comes as part of a broader push into the space sector, while ATLAS plans to use the money to accelerate its international growth.[414]

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[408] SSC to develop the most advanced ground network for Lunar missions, SSC, September 2022
[409] SSC signs 10-year partnership agreement with CNES, SSC, September 2022
[410] Arctic Space Technologies provides Real-Time Earth ground services for Viasat, SatNews, February 2022
[411] Viasat Real-Time Earth antenna network expands to Ghana, ViaSat, November 2021 ; Latest addition to Real-Time Earth global network generates tech jobs for Aboriginal natives, ViaSat, July 2020
[412] Satellite Vu partners with Viasat to ensure rapid service to customers, Satellite Vu, September 2022
[413] ATLAS Awarded NOAA IDIQ Contract For GSaaS Services, ATLAS Space Operations, July 2022
[414] ATLAS Space Operations Secures $26M in Series B Funding Led by Mitsui, ATLAS Space Operations, August 2022

CONTEC, a South Korean Space-as-a-Service startup spun off from the Korean Aerospace Research Institute (KARI) in 2015, also saw similar expansion of both its financial situation and global infrastructure.

- In June, they **provided ground station services from facilities in Ireland and Antarctica to the second test launch of the KARI-developed Nuri rocket**.[415]
- Later that month, they also announced they had **secured over 61 billion won (US$47 million) in a Series C funding round** intended to support global expansion of their ground station infrastructure ahead of a planned IPO launch in 2023. The company aims to operate 15 radio-frequency ground stations by the end of 2023, as well as opening its first optical ground station in Australia by November.[416]

The Japanese company **Infostellar** operates the StellarStation platform that allows existing ground station operators from around the world to list their capabilities on the platform and be connected with potential users.

- In January, the firm **closed its Series B financing round after raising a total of ¥1.2B** (US$10.36 million).[417] In March, the company announced that it had not only **opened a branch In the United States** to support operations in the American market, but was also **expanding operations in Japan with the provision of a new ground station in the city of Taiki**, on the northern island of Hokkaido.[418]
- In December, the company announced that it had achieved operational readiness for the ground support of an upcoming Japanese commercial launch, though which launch is meant remains undisclosed. Infostellar's exact role in the launch is not clear beyond providing its partners, ViaSat and Azercosmos, access to its network of partner ground stations in Japan.[419]

Leaf Space, an Italian GSaaS provider founded in 2014, is in a more mature stage of development than the majority of its startup competitors and continued its development in 2022:

- In January, **Leaf Space provided ground services for 13 satellites on a SpaceX rideshare mission, Transporter-3**.[420] These included Kepler, a data relay network consisting of four cubesats, ION Satellite Carrier, a cubesat-deploying orbital tug developed by D-Orbit, and three satellites built by Kongsberg NanoAvionics.[421]
- Later, in November, **Leaf Space announced that they had successfully completed two months of ground operations in support of the BlueWalker 3 satellite** built by AST SpaceMobile. The satellite is designed to act as an orbiting relay for terrestrial cellular networks, allowing mobile users to access their mobile data via the satellite.[422]
- In September, the company inaugurated a new S-X band antenna at a facility run by its partner, Capricorn Space, in West Australia. The new antenna constitutes the third that Leaf Space owns in the country.[423]

[415] Korean startup CONTEC's ground stations support the successful launch of KSLV-II by the Korea Aerospace Research Institute, CONTEC, June 2022
[416] South Korean ground station operator Contec raises Series C round for global expansion, SpaceNews, June 2022
[417] Ground Segment as a Service provider Infostellar closes Series B round with ¥1.2B ($10.36M USD), Infostellar, January 2022
[418] Ground Segment as a Service (GSaaS) provider Infostellar announces expansion of services [...], Infostellar, March 2022
[419] Infostellar Achieves Operational Readiness for Upcoming Commercial Satellite Launch, Infostellar, December 2022
[420] Leaf Space Successfully Enables 13 Satellites on SpaceX Transporter-3 Rideshare Mission, Leaf Space, February 2022
[421] Transporter-3 — Third Rideshare mission of SpaceX, eoPortal, January 2022
[422] Leaf Space completes two months of successful Ground Support for AST SpaceMobile's BlueWalker 3 Satellite On-Orbit, Leaf Space, November 2022
[423] Leaf Space adds capacity to the southern hemisphere with a new 3.7m antenna in West Australia, Leaf Space, September 2022

Spire is an American company engaged in Satellite-as-a-Service activities, and one of the few providers of Constellation-as-a-Service via its Lemur constellation. In August, the company announced a partnership with South Korean Earth observation provider Hancom, under which Spire would design, launch, and operate a satellite that integrates an optical imaging payload from Hancom. This deal comes as a follow-on to a similar deal signed in 2021, which culminated in a Spire-designed satellite hosting a Hancom payload launched on a SpaceX rideshare mission in May 2022.[424]

Xplore is another U.S.-based provider, which not only operates GSaaS infrastructure but is seeking to expand into Satellite-as-a-Service capabilities. 2022 featured several developments for the company on both of those fronts:

- In February, **Xplore announced that they raised U.S. $16.2 million in venture capital and contracts since being founded**. One of the most significant investments came in 2021 from the U.S. DoD **Defense Innovation Unit, which awarded a US$2M contract to support development of the company's XCRAFT**, a satellite intended to host several rideshare payloads.[425]
- In April, **Xplore announced that they acquired software developer Kubos**, developer and operator of the Major Tom spacecraft control platform. The cloud-based software was used for control of over a dozen commercial and government satellites, including functions such as telemetry monitoring and ground station scheduling. In addition, several former Kubos employees, including the CEO, joined Xplore as part of the acquisition.[426]
- By June, **Xplore made use of the Major Tom software in a satellite testing mission conducted in cooperation with the National Oceanic and Atmospheric Administration (NOAA) and Microsoft**, integrating the software with the Microsoft Azure space service to demonstrate control of the NOAA-18 satellite.[427]
- Xplore signed a number of agreements in 2022 seeking to integrate its services with various data sharing platforms. In September, **Xplore partnered with US-based startup SkyWatch to integrate the latter's Terrastream service into its operations**. Terrastream is an IT infrastructure for distributing satellite data to ground stations and end users. In November, Xplore announced a data partnership agreement with geospatial developer platform and marketplace UP42. The agreement sees Xplore providing imagery data and tasking opportunities to UP42 via the former's XCRAFT satellite platform.[428]

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[424] Spire Global Partners with Hancom Group in First Commercial Satellite Mission for South Korea, Bloomberg, August 2021 ; Spire Global Announces Space Services Deal to Scale Constellation for HANCOM inSPACE with Second Satellite, Spire Global, May 2022
[425] Xplore banks $16.2 million for space-as-a-service, SpaceNews, February 2022
[426] Xplore acquires Kubos and Major Tom software, SpaceNews, April 2022
[427] Xplore's Major Tom® software delivers satellite operations testing for NOAA with Microsoft Azure Orbital, Xplore, June 2022
[428] SkyWatch Announces Xplore Data Distribution Partnership, Parabolic Arc, September 2022 ; Xplore and UP42 announce Data Partnership Agreement, Xplore, November 2022

2.1.3 The emergence of space cybersecurity markets

In the past few years, it has been increasingly proven that **satellites can be prone to cyberattacks.** This is due to the digitisation of space systems and the space sector at large, which **extended the attack surface**. In addition, space is becoming integrated in the broader digital infrastructure with the shift from satellite broadcast to internet broadband in a context of rising tensions in both cyberspace and outer space. It prompted a new type of demand to emerge, prompting tailored space cybersecurity services and products to be developed and offered. This includes established LSI's who are increasingly requested to address cybersecurity, as well as specialised companies (including startups) who are explicitly targeting the space-cybersecurity nexus.

2022 saw a significant increase in cyberattacks against space systems amid the Russian invasion of Ukraine on February 24, 2022, which started with a cyberattack against ViaSat's KA-SAT GEO satellite network, used by the Ukrainian army.[429] 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.[430]

Developments in Europe

The Belgium company **RHEA Group,** which provides system engineering, space, and cybersecurity solutions, reached several milestones in 2022:

- In May, EUMETSAT awarded RHEA Group a three-year contract for Advanced Information Security Services. RHEA will contribute to the evaluation and upgrade of EUMETSAT's present and future IT security levels for current missions such as Metop, Meteosat, Copernicus and future satellites. EUMETSAT's CERT and Security Operations Centre will also be strengthen under the contract.[431]
- In November, RHEA and the Singaporean company SpeQtral signed a strategic partnership to build a global quantum network; RHEA will use the SpeQtral-1 satellite, scheduled to be launched in 2024, to demonstrate QKD exchange between Singapore and Europe. In addition, the companies signed a larger partnership agreement to examine the coupling of SpeQtral's quantum-safe cryptographic technologies with RHEA's cybersecurity solution suite and service offerings, which will be cooperatively marketed to prospective end-users in Europe and Asia.[432]
- In December, RHEA System Luxembourg S.A. announced having taken the lead of the INT-UQKD project in partnership with Post Luxembourg, Hitec Luxembourg and the Interdisciplinary Centre for Security, Reliability and Trust (SnT) of the University of Luxembourg, as well as the Singaporean company SpeQtral and the Canadian company Evolution, to develop a QKD cybersecurity solution. The project is supported by ESA and aims to demonstrate the use of QKD to secure end-to-end communications.[433]
- In December, RHEA Group was awarded a contract for the second phase of ESA's Threat Risk Assessment on the LEO Satellite Constellation project (TRALEO-2), which aims to understand end-to-end cybersecurity in LEO. By using its cyber-range platform, RHEA will upgrade it and check it for vulnerabilities, assessing potential threats linked to these vulnerabilities and evaluating associated security risks.[434]

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[429] KA-SAT Network cyber attack overview, Viasat, March 2022
[430] Is the satellite industry ready for cyberwarfare, NSR, November 2022
[431] Providing State-of-the-Art Security Services for EUMETSAT, RHEA Group, May 2022
[432] SpeQtral & RHEA Group Partner to Develop First Quantum- safe Link Between Singapore & Europe, The Quantum Insider, November 2022
[433] RHEA, POST, HITEC and SnT establish international consortium to operationalise quantum key distribution, RHEA Group, December 2022
[434] RHEA Group Supports Threat Risk Assessment on LEO Satellite Constellation (TRALEO), RHEA Group, December 2022

The Swiss company **CYSEC** provides confidential computing software solutions to space actors. Its solution, called ARCA SATCOM, is a Performance Enhancing Proxy (PEP) with built-in-encryption and authentication. ARCA SATCOM implements end-to-end TLS-based cryptography over TCP while doubling the link throughput compared to a standard VPN. It includes a router, which is plugged to the ethernet port of the satcom terminal, and a server, which is plugged to the destination server and in which CYSEC's software in hosted. The server has container orchestration capabilities. The company reached a few milestones in 2022:

- In January, CYSEC raised €3.8M in a new funding round led by Line Break Capital and Indaco Venture Partners SGR.
- In May, ESA awarded a contract to Spacebel and CYSEC in order to test on a satellite simulator the deployment of the European Ground Systems Common Core software (EGS-CC) in CYSEC's ARCA environment and assess cybersecurity needs for future missions.[435]
- In October, CYSEC announced it had raised €2 million in a new funding round with Karista in order to further develop cybersecurity solutions dedicated to NewSpace.[436]

Significant developments were driven by companies based in the United States

The U.S company **SpiderOak** provides zero-trust encryption and distributed ledger products to secure space-based communications, remote sensing, terrestrial communications, and mission operations. SpiderOak's cybersecurity software is named OrbitSecure and offers a combination of no-knowledge encryption (unique user key unknown to provider) and distributed-ledger technology (decentralised peer-to-peer digital system that records transactions between parties in multiple places at the same time) to bring zero-trust security (perimeter-less security where no user is trusted by default) to space.

SpiderOak reached a few milestones in 2022:

- In March, SpiderOak signed a contract with Lockheed Martin Space, in order for the defence company to use SpiderOak's OrbitSecure software and make it available to its own customers, as part of an offer to provide additional cybersecurity.[437]
- In July, SpiderOak created a new Space Advisory Board, which will provide guidance to the company in fielding zero-trust products and services to ensure the confidentiality, integrity, and availability of the most sensitive data in space networks. SpiderOak appointed Former U.S Air Force General Ellen Pawlikowski; Predisent of ISBF Fred Boyle; U.S Navy Admiral James A. Winnefeld, Jr.; and former U.S Army Lieutenant Ken Tovo.[438]
- In November, Amazon Web Services, Kuiper Government Solutions, Microsoft Azure Space and SpiderOak Mission Systems signed a partnership with the DoD's Defense Innovation Unit to demonstrate space-based communications using interconnected commercial and government networks. SpiderOak will provide its cybersecurity software OrbitSecure for user authentication and data protection.[439]
- In December, SpiderOak signed a partnership with TriSept for the provision of an end-to-end space cybersecurity solution. SpiderOak will integrate OrbitSecure zero-trust software, which protects data exchange, into TriSept's Security Enhanced Layer security software, for the protection of the satellite bus.[440]

[435] SPACEBEL AND CYSEC team up [...] to test the protection of mission control software on a satellite simulator, CYSEC, May 2022
[436] CYSEC announces a fundraising of 2 million euros, inCyber, November 2022
[437] Lookheed Martin signs deal to use SpiderOak cybersecurity to protect satellite network, SpaceNews, March 2022
[438] SpiderOak Creates New Space Advisory Board, Appoints Highly Decorated Veterans and Industry Experts to Address Cybersecurity Threats, PR Newswire, July 2022
[439] Amazon, Microsoft, SpiderOak join Defense Innovation Unit's hybrid space network project, SpaceNews, November 2022
[440] TriSept and SpiderOak unveil strategic partnership, SpaceNews, December 2022

The U.S company **TriSept Corp.** is a launch integration and mission management company, which provides space cybersecurity solutions. Its Linux-based operative system, called TriSept Security Enhanced Layer (TSEL), provides satellites with an operating system to protect the space system. In addition to the above-mentioned agreement with SpiderOak, TriSept Corp. and the Aerospace Corporation signed a partnership to conduct flight tests of TriSpept Corp.'s cybersecurity software in April. Aerospace Corp. will put the software through rigorous testing to ensure that it adds security without interfering with standard flight-control systems.[441] The software is expected to send alerts to satellite operators whenever anomalies are detected on both hardware and software.[442]

The U.S company **Redwire Corporation** announced that its space cybersecurity platform SpaceCREST, jointly developed with the AI-powered analytics company BigBear.ai, will be used by Mynaric in the development of an advanced satellite communication programme of the Defense Advanced Research Projects Agency (DARPA). Mynaric will use the SpaceCREST platform to ensure the security of its optical communications terminal design for Phase 1 of DARPA's programme, which aim to develop reconfigurable, multi-protocol communications terminals able to connect many different satellite constellations in LEO.[443]

Further developments took place in the field of satellite-based quantum encryption

With the rise of cyber threats and the development of quantum computing, several companies are developing satellite-based Quantum Key Distribution (QKD) solutions to protect against these threats.

Developments in Europe include:

In September, ESA DG Josef Aschbacher and SES CEO Steve Collar **signed the contract for Eagle-1, which will be the first European space-based quantum key distribution (QKD) system**. The mission is led and co-funded by ESA (ARTES), co-financed by the European Commission (Horizon Europe) with costs valued at €130 million. The mission will be implemented by SES, leading a consortium of 20 European companies. The 8 ESA member states Austria, Belgium, Czech Republic, Germany, Italy, Luxembourg, the Netherlands and Switzerland are contributing to the project. Eagle-1 is planned to be launched in 2024 with a European launcher and will complete a 3-year in-orbit validation supported by the Commission. Eagle-1 is connected to the EuroQCI Initiative. Moreover, technologies demonstrated on Eagle-1 could be incorporated into IRIS². SES selected Arianespace to launch its EAGLE-1 satellite on a Vega C rocket as early as Q4/2024.[444]

In December, the British cybersecurity software developer **Arqit**, which aimed at supplying quantum encryption Platform-as-a-Service, announced that it would **drop its plan to build and operate quantum encryption satellites**. The company explained that its encryption keys are as efficient when distributed terrestrially as in space, and therefore does not require the development of a dedicated satellite network. This change of strategy came amid an investigation of the SEC regarding its merger with the Centricus Acquisition SPAC, which enabled Arqit to go public on the NASDAQ in 2021, as well as a class action lawsuit filed against Arqit in May for materially false and misleading statements related to Arqit's business prospects and projections. Arqit now aims to sell its satellite division and license the quantum technology it has developed for satellites to other groups rather than build its own spacecraft.[445]

[441] Satellites to test-fly new cyber software, SpaceNews, April 2022
[442] Ibid
[443] Redwire's SpaceCREST Cybersecurity Platform to Protect Next-Generation Space Communications Hardware for DARPA Program, Business Wire, December 2022
[444] Quantum encryption to boost European autonomy, ESA News, September 2022 ; SES-led group to deploy quantum security satellite for Europe in 2024, SpaceNews, September 2022
[445] Arqit drops plan to operate quantum encryption satellites, SpaceNews, December 2022

Beyond Europe, there were notable developments in China, India and Singapore:

In August, China's orbiting Tiangong-2 space lab transmitted quantum-encryption keys to the four ground stations, which received quantum keys from the Micius satellite, by using the space station as a repeater.[446]

Earlier, in July, China's second quantum-encrypting satellite Jinan 1 of the University of Science and Technology of China, was launched by the Lijian1 launch vehicle as one of 6 experimental satellites as payloads. Jinan 1 conducts key distribution experiments in LEO.[447]

In January, the Indian startup QNu Labs raised fresh funding through an institutional funding round from the deep-tech venture capital firm Speciale Invest. WAOO Partners LLP and another VC fund, accompanied by a few marquee angel investors, with the goal to use the funding for advancements in research and development, and extension of products and technology to a broader range of customers through key Go To Market associations in the U.S. and Europe and building partnerships for QKD technology.[448] Moreover, in December, the Indian National Space Promotion and Authorisation Centre (IN-SPACe) signed a MoU with QNu Labs to develop satellite QKD products and as an overarching objective, to enable Qnu Labs with support from IN-SPACe and ISRO to demonstrate unlimited distance satellite QKD based quantum secure communication.[449]

Moreover, the Singapore-based company **SpeQtral** designs and manufactures satellite-based quantum communication systems and provides end-to-end distribution of quantum encryption keys. It reached a few milestones in 2022:

- In February, SepQtral announced that it will launch a QKD satellite named SpeQtral-1 in 2024 to demonstrate intercontinental out-of-band symmetric QKD key delivery. The mission is supported by Singapore's National Space Office.[450]
- In June, SpeQtral signed a Memorandum of Understanding (MoU) with the space startup Antaris to host SpeQtral's Space-based Quantum-Secure Software Sandbox on Antaris' Technology Demonstrator satellite mission. SpeQtral will be able to validate its post quantum cryptography and QKD software and protocols in space.[451]
- In October, SpeQtral signed a partnership agreement with Rivada Space Networks GmbH, which aims to launch a constellation of 600 satellites, to demonstrate the technical compatibility of integrating a QKD encryption layer on Rivada's laser-connected satellites. When RSN's satellites and SpeQtral-1 QKD satellite are launched, both companies will establish quantum encrypted data links over Rivada's satellites and validate the space and ground station terminals needed for QKD encryption traffic.[452]

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[446] As China's Quantum-Encrypting Satellites Shrink, Their Networking Abilities Grow China starts to build QKD networks as United States pours millions into quantum R&D, IEEE Spectrum, August 2022
[447] Big new Chinese rocket lofts 6 experimental satellites on debut launch (video), space.com, July 2022
[448] QNu Labs Raises Institutional Round Of Financing Led By Speciale Invest, BW Disrupt Business World, January 2022
[449] IN-SPACe inks pact with QNu Labs to develop satellite quantum key distribution products, The Economic Times, December 2022
[450] SpeQtral announces SpeQtral-1 quantum satellite mission for ultra-secure communications, SpeQtral, February 2022
[451] SpeQtral partners with Antaris to deploy a space-based Quantum Secure Software Sandbox to validate technology to be used in building global Quantum Secure Networks, SpeQtral, June 2022
[452] Rivada Space Networks Signs MoU with Quantum Encryption Leader SpeQtral to Develop Ultra-Secure Communications for Government & Enterprise Worldwide, SpeQtral, October 2022

2.1.4 Additive Manufacturing (AM) makes its way into the space industry

Advances in materials and manufacturing processes have always been essential in ensuring space systems could be more resilient in the natural hostility of the orbital environment, lighter or less costly. Lately, progress in Additive Manufacturing (AM) have enabled satellite manufacturers to decrease costs and weight, increase performance, and enable mass customisation of satellite parts.[453]

Additive Manufacturing (AM) can be defined as 3D printing, which is a method of production consisting of successive layers of material layered to produce parts.[454] The 3D printing process includes both direct techniques, in which components are created using the required material, and indirect methods, in which moulds or preforms are created and used to create the final part.[455]

Most satellites and spacecraft **built today are using some 3D printed parts**, but they are often small mechanical bracketing systems and not used at system-level. One of the reasons for a of larger adoption is also the lack of standardisation among satellites is still considered a hurdle for the large-scale adoption of 3D printing.[456]

This notwithstanding, **the global aerospace 3D printing market is projected to witness a CAGR of 20.23%, valued at $1.76 billion in 2021, and expected to reach $9.23 billion by 2030**, according to Strategic Market Research report.[457]

Additive Manufacturing (AM) ramps up in Europe

In Europe, Additive Manufacturing Technologies are being developed in Europe, in 2022 most notably by companies from the United Kingdom, France, Germany, and Switzerland.

The Scottish space manufacturer Alba Orbital launched 3D printed PocketQubes AlbaPod v2, as part of SpaceX's Transporter-3 mission on January 13th, 2022.[458] The five 3D printed AlbaPods v.2 deployers successfully deployed 13 PocketQube spacecrafts into orbit, representing Alba Orbital's biggest cluster to date and the first PocketQubes deployment from Falcon-9 Transporter-3. The deployers were manufactured by CRP Technology using Windform XT 2.0, a carbon fiber reinforced composite material.

The French-American startup Interstellar Lab secured a $5 million seed round with Urania Ventures, Auxxo, 7percent Ventures, Seldor Capital, E2MC, Kima Ventures and BPI.[459] **A partnership with the 3D printing company Soliquid in June 2021, enabled Interstellar Lab to initiate an AM strategy**, which helped scale up the production of BioPods.[460] These are 3D printed inflatable modules that provide optimal climate and atmospheric conditions for plant growth, resulting in higher efficiency, reduced water and energy consumption, and increased yield.

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[453] CEAS Space Journal, Advanced manufacturing for space applications, Springer, November 2022
[454] Sacco, E, Moon, S, Additive manufacturing for space: status and promises, Springer, December 2019
[455] CEAS Space Journal, Advanced manufacturing for space applications, Springer, November 2022
[456] Reaching the tipping point for 3D printed satellites, Space News, January 2022
[457] SRM, Aerospace 3D Printing Market: By Offerings (Printers, Services, Materials, Software), By Technology (Powder Bed Fusion, Polymerization, Fusion Deposition Modeling (FDM), Others), By Application (Tooling, Prototyping, Functional Parts), By Geography, Size, Forecast, 2021-2030, Strategic Market Research, March 2022
[458] 3D printed PocketQube deployers in Carbon fiber filled composite material successfully launched from SpaceX's Falcon 9 rocket, Space Equip, February 2022
[459] Interstellar Lab announces a US $5 million seed round to accelerate BioPod manufacturing, SpaceWatch.Global, March 2022
[460] Interstellar Lab teams up with 3D-printing company Soliquid to build BioPod on Earth and in space, SpaceWatch.Global, June 2021

The German company SLM Solutions expanded global partnerships throughout the year. In January 2022, SLM Solutions sold two 3D printing AM NXG XII 600s systems to an undisclosed California-based rocket company.[461] The machine, with 12 1kW lasers and a 600x600x600 mm build volume, is said to be "20 times faster than the competition". In September, the U.S. Air Force Research Laboratory (AFRL) awarded a $5.2 million contract to SLM Solutions and a partner, Concurrent Technologies, to build a laser PBF printer.[462] In November, SLM Solutions announced a partnership with Sigma Additive Solutions to certify their PrintRite3D quality assurance software to work with SLM's metal additive manufacturing open architecture and SLM.Quality APIs.[463] In December, SLM disclosed a material agreement with Elementum 3D, an AM material developer, to address challenges in aerospace and space industries with difficult-to-print alloys.[464]

SWISSto12, a spin-off of the Swiss Federal Institute of Technology in Lausanne (EPFL), also focuses on AM technologies and reached a few milestones in 2022:

- In March, SWISSto12 **announced it initiated the Active Reconfigurable telecommunication pAyload for Micro- geostationary satellites (ARAMIS) project** with the aim of developing a 3D printed next-generation Ka-band active antenna in support of fully reconfigurable digital payloads for GEO satellite missions.[465] The project received co-funding support from ESA's ARTES C&G Programme, CNES, and the Swiss Space Office. This initiative, also developed in partnership with Thales Alenia Space, positions SWISSto12 among the leading suppliers in Europe to develop a GEO capable active antenna product, which is expected to be ready for a GEO demonstration flight by 2025.
- In March, **Lockheed Martin** selected the Swiss company SWISSto12 and the American company Cobham Advanced Electronic Solutions (CAES) to develop advanced 3D printed Phased Array Antennas for future satellite missions.[466]

The U.S. leads the Global Additive Manufacturing market

Credit: Relativity Space

The U.S.-based company, **Relativity Space** which made inroads into the space sector thanks to highlighting 3D printing, continued garnering interest due to its expertise in 3D printing for the majority of components of its Terran 1 launch vehicles.[467]

Stargate, the largest 3D printer in the world, is the cornerstone of Relativity's 3D printing efforts and can reportedly produce an entire rocket fuselage in just a few days. About 90% of Relativity's rocket parts are 3D printed, using less than 1,000 parts compared to traditional rockets that according to the company use over 100,000 parts. Terran R, a scaled up version of Terran 1, will be a two-stage rocket with a 5-meter payload fairing. **Terran R will be outfitted with 3D-printed 250.000-pound-thrust Aeon-R engines and one Aeon Vac engine** at the upper stage and will be fuelled by liquid oxygen and liquid natural gas.

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[461] Leading Space Company Orders Two NXG XII 600s from SLM Solutions, Accelerating Its Path to Win Space Race, IRT, January 2022
[462] US Air Force Funds SLM Solutions via CTC to Build "World's Largest" PBF Metal 3D Printer, 3D Printing Industry, September 2022
[463] Sigma Additive Solutions Announces Agreement with SLM Solutions, Sigma Additive, November 2022
[464] SLM Solutions' partnership with Element 3D to produce high-performance parts with high-quality alloys for aerospace and space customers, 3D Printing Industry, December 2022
[465] ARAMIS flexible payload, Thales Group, March 2022
[466] Lockheed Martin Space partners with SWISSto12 & CAES for advanced 3D printed Phased Array Antenna, SWISSto12, March 2022
[467] Relativity is 3D printing rockets and raising billions. Will its technology work?, CNN, February 2022

- In June 2022, Relativity announced the **signing of a multi-launch Launch Services Agreement (LSA) with OneWeb**, for the deployment of its Gen 2 satellite network.[468]
- In July 2022, **Relativity Space and U.S.-based Impulse Space disclosed their partnership** for a joint mission to Mars to deliver the world's first commercial payload to the planet's surface. Relativity will launch Impulse's Mars Cruise Vehicle and Mars Lander aboard a Terran R rocket by 2024.[469]

Millennium Space Systems, now owned by Boeing, is set to launch a 3D printed metal flight structure to be used in building the company's next generation of satellite buses.[470] The test satellite bus is made of aluminium and titanium, which was 3D-printed in about 100 hours and is expected to be launched as soon as Millennium secures a rideshare mission. Millennium considers that the 3D-printed metal bus enables to reduce manufacturing costs by about 30% of the traditionally manufactured honeycombed aluminium panels that make up spacecrafts, and cuts manufacturing time from six months to one month.[471]

Furthermore, **Boeing** has been using 3D printing to produce components for its satellites since 2017 and has recently integrated 3D printing to reduce production time from ten to five years for the U.S Space Force's next generation of Wideband Global SATCOM (WGS) military system. The system is expected to be delivered by 2024. The Space Force considers that rapidly manufacturing satellites and gaining time through 3D printing is giving them a competitive edge on the battlefield.[472]

Credit: Boeing

The Californian 3D printing technology company Velo3D made its debut in 2014 and has since being contracted by customers like SpaceX, Astra, and Launcher. Its products include the **Flow Software**, which is a flow print preparation software directing the manufacturing process of the metal 3D printers; **the Sapphire printers**, which include the **Sapphire 1MZ** capable of printing low angle prints down to zero degrees, high aspect ratio structures up to 3000:1, large inner diameters up to 100 mm as well as **the Sapphire XC** and **XC1MZ** printers capable to build volume to 600 mm diameter by 1000 mm z-height; and the **Assure software**, which enables to monitor each layer printed through real-time sensors, detection algorithms, and optical measurements.

- In April, the company was selected by Lockheed Martin to provide an end-to-end AM solution, including its Sapphire printer and Assure quality assurance software, for Lockheed's Additive Design & Manufacturing Center in Sunnyvale, California.[473]
- In June, Velo3D made a $250,000 in-kind investment in the U.S-based propulsion startup Plasmos. Plasmos will use Velo3D printers to build 95% of their chemical-electric engine, including the cooling mechanism, a space tug and space tug components, and potentially to develop a vehicle to transport spacecraft to LEO.[474]

[468] Relativity and OneWeb sign multi-launch agreement for Terran R, OneWeb, June 2022
[469] Impulse and Relativity Space to launch 3D printed rocket to Mars in breakthrough mission, 3D Printing Industry, July 2022
[470] Millennium Space to launch to orbit a 3D printed satellite structure, SpaceNews, March 2022
[471] Millennium drills down on 3D printing, as MEO missile tracking effort progresses, Breaking Defense, April 2022
[472] Boeing deploys 3D printing to halve the lead time of US Space Force asset, 3D Printing Industry, March 2022
[473] Velo3D puts manufacturing capabilities to work for aerospace company, Velo 3D, April 2022
[474] Velo3D makes in-kind investment in Plasmos, SpaceNews, June 2022

Moreover, **the American company 3D Systems, established in 1986 and providing 3D printing services, selling 3D printers, and 3D printing materials was contracted by Airbus** to produce "critical components" of the software-defined satellite **OneSat**.[475] 3D Systems will use its AM DMP Factory 500 platform to serially produce parts of the satellite's antenna arrays, which are expected to increase its performance.

In addition, Lockheed Martin is also exploring additive manufacturing with new partnerships. In December, Lockheed Martin and Sintavia announced a new partnership to explore the potential of metal additive manufacturing (AM) as an alternative to traditional castings and forgings. Sintavia already supplies AM parts to Lockheed Martin and the new collaboration will explore further AM technologies, such as laser powder bed fusion, electron beam-directed energy deposition, and friction stir AM.[476] The partnership supports the White House AM Forward initiative, which aims to strengthen US supply chains by promoting the adoption and deployment of AM by US-based suppliers.

Public sector conducting demonstrations on the ISS to demonstrate 3D printing capabilities:

- In July 2022, SpaceX's 25th commercial resupply services (CRS-25) mission delivered new science experiments, supplies, and equipment for the International Space Station (ISS) crew, including 3D printed electroplated samples. Once on the ISS, the 3D-printed parts will be tested, including exposure to outer space and its harsh environment. To design the parts, **NASA used the Boston-based Formlabs' Form 3 stereolithography (SLA) platform** and the brand's Rigid 10K Resin, a glass-filled material ideal for stiff, thermally, and chemically resistant parts. NASA engineers at Goddard relied on generative design software to render an organic supportive design for the 3D printed sample components to maximise load-bearing capacity. Then, they worked with Formlabs printed parts to optimise the bracket design for higher strength.[477]

The Asia-Pacific region to advance in Additive Manufacturing

In China, several companies entered the Additive Manufacturing (AM) industry:

- In March, the Beijing-based **Galactic Space Technology** announced the successful test flight of its Welkin 50-ton reusable rocket engine, which utilises AM to produce key components such as the turbo pump and LOX/kerosene main valve housing. The engine's ignition, starting, and transition were tested during the flight, and all components worked as expected. The engine is the highest thrust LOX/kerosene engine in China's commercial aerospace field and the first large-thrust liquid rocket from China to adopt pintle injection technology. AM improved production efficiency by 5% during the design phase of the turbo pump and shortened the manufacturing cycle by 80% for the turbine disks.[478]
- In September 2022, **Xi'an Bright Laser Tech (BLT)**, an original equipment manufacturer (OEM) for metal additive manufacturing (AM) based in northwest China, **announced the release of its first 12-laser machine, the BLT-S1000.** The S1000 is a laser powder bed fusion (BPF) system, specially designed for large-format applications with a build chamber of 1200 x 600 x 1500 mm. While the standard version of the S1000 is an 8-laser model, the company offers 10- and 12-laser upgrades for increased production power.[479]

[475] 3D Systems selected to 3D print "critical components" of Airbus' OneSat satellites, 3D Printing Industry, May 2022
[476] Lockheed Martin and Sintavia team up to advance metal additive manufacturing, Lookheed Martin, December 2022
[477] NASA sends Formlabs parts to Space Aboard the SpaceX Dragon Resupply Capsule, Formlabs, June 2022
[478] China's largest reusable rocket engine success thanks to Additive Manufacturing, 3D Printing Industry, January 2023
[479] Xi'an Bright Laser announces 12-laser metal 3D printer, 3DPrint.com, October 2022

In Australia, the 3D printing business is also developing rapidly:

- The Australian Additive Manufacturing company **Titomic** and **Boeing** teamed up to explore the use of sustainable titanium powders for 3D printing parts for space systems. Titomic, which recently won an AU$2.325 million ($1.5 million) Modern Manufacturing Initiative grant from the Australian government, will research and commercialise components for space vehicles and satellites using local titanium mineral resources. The company's Titomic Kinetic Fusion (TKF) 3D printing process involves spraying a fine metal powder onto a solid substrate using kinetic energy, rather than lasers or heat-based energy sources, to deform and bond layers.[480]
- **Fleet Space**, Australian nanosatellite leader partnered with the Japanese Konica Minolta to implement 3D printing for the production of its Alpha satellites and received its first metal AM platform at its Western HQs.The IoT Alpha satellites, which will be launched in 2023 in LEO, will also integrate Titomic Kinetic Fusion radiation shielding from local cold spray AM technology manufacturer Titomic, with a view to prolong the satellite's lifespan.[481] Once in orbit, the Alpha satellites will form a constellation to backhaul customer data from remote areas not serviced by terrestrial communications. In March, Fleet Space received approx. U.S $20 million from the Australian Government to develop the Space Manufacturing Hub in Adelaide.[482]

[480] Boeing and Titomic partner to investigate sustainable titanium 3D printing for space, 3D Natives.com, January 2022 ; Titomic awarded $2.325 million grant, Titomic, August 2021
[481] Fleet Space chooses Konica Minolta to provide 3D printing solution to underpin Australian innovation for space and defence, Konica Minolta, June 2022 ; Titomic ramps up commercialisation, Space and Defense, July 2022
[482] Australian Government grants US $20 million for space manufacturing hub, SpaceWatch.Global, March 2022

2.1.5 Energy generation in and from space

Energy production is at the heart of sustaining human activities on Earth and beyond. Space activities make no exception in requiring more advanced power generation for the accomplishment of increasingly complex missions. Not only do satellites require advanced power generation capabilities to cope with increasingly complex missions which can lead to spin-off technologies and improvements of terrestrial system, in parallel, space solutions could offer an opportunity for direct power generation for conducting activities on Earth.

Interest in space-based nuclear reactors heats up

Nuclear reactors in space are not a novel concept, with the U.S-made SNAP-10 satellite demonstrating the capability as far back as 1965 and the Soviet Buk (BES-5) following. Nevertheless, the use of this technology for extra-terrestrial surface power and power for onboard spacecraft systems has gained new interest. As interest grows in establishing crewed bases on celestial bodies such as the Moon, and potential interplanetary missions following in future decades, the technology appears to be experiencing a renaissance.

In particular, several milestones were reached during 2022:

- In March, **UK** Science Minister George Freeman announced support for the Power to Explore – **Rolls-Royce Space Reactor Programme**, developing a uniquely deployable, safe, and autonomous Micro-Reactor for use in the space domain.[483]
- In May, the U.S. **Defense Innovation Unit** announced two prototype contracts to demonstrate the next generation of nuclear propulsion and power capability for spacecraft. The ultimate aim is an orbital flight demonstration in 2027, DIU officials said in a statement.[484]
- In June, **NASA** and the **Department of Energy** issued three awards, valued at $5 million each, for three concepts on utilising nuclear fission reactors for electricity provision on the lunar surface. The prizes were awarded to Lockheed Martin, Westinghouse, and IX (a joint venture of Intuitive Machines and X-Energy), all of whom will partner with separate consortia to develop preliminary designs across 12 months.[485]
- In August, the **Chinese Ministry of Science and Technology** completed a performance review of a spaceborne nuclear reactor claimed to be capable of providing 1 Megawatt of electricity. There is as of yet no information available on the technical specifications or intended purpose of the reactor.[486]

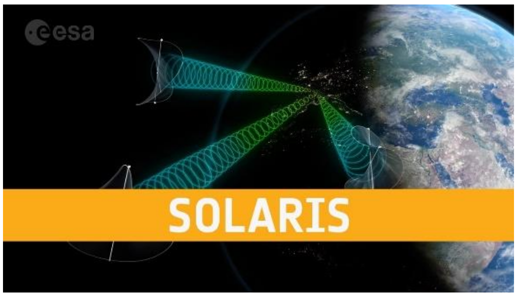
Beyond fission-based nuclear technologies, two notable developments took place in Europe, in the **UK** the UK Space Agency and the National Nuclear Laboratory (NNL) are to collaborate on the world's first **space battery powered by Americium-241**.[487] In **Belgium**, Tractebel will lead the **PULSAR consortium conducting research on dynamic radioisotope power systems** (RPS) fuelled by plutonium-238 (Pu-238) for space applications.[488] The project is being funded by the Euratom Research and Training Programme, and is in addition to the study Tractebel is already carrying out for ESA.

[483] New space funding paves the way for pioneering approaches to energy, communication and resources, gov.uk, March 2022
[484] US military wants to demonstrate new nuclear power systems in space by 2027, space.com, May 2022
[485] NASA Announces Artemis Concept Awards for Nuclear Power on Moon, NASA.gov, June 2022
[486] Chinese megawatt-level space nuclear reactor passes review, SpaceNews, August 2022
[487] UK Space Agency and NNL work on world's first space battery powered by British fuel, gov.uk, December 2022
[488] PULSAR project to research nuclear technology for Europe's space missions, world-nuclear-news.org, June 2022

A sunny outlook for space-based solar power is witnessed

Space-based solar power (SBSP) is a proposed technology for using satellites to generate renewable energy, to be then used in terrestrial networks. Due to the lack of atmospheric phenomena in outer space, solar panels can collect power much more efficiently in space than on the ground – especially due to the predictable solar exposure. If this power can be efficiently and cheaply transmitted down to earth (typically through radio signals or microwave radiation), it may represent a revolution in clean energy.

2022 was a banner year for the technology, with several initiatives launched around the world:



Credit: ESA

- In Europe, the **SOLARIS programme** was launched by **ESA** as an initiative to conduct feasibility studies on space based solar power, ideally laying the foundation for a full SBSP program to be launched after 2025. The programme was successfully adopted during the Council Meeting at Ministerial Level in November.[489]
- In the United States, a team of researchers at **Caltech** launched the **Space-based Solar Power project (SSPP)**, which seeks to develop and launch a large constellation of 10x10 cm tiles with a total surface area of 9 square kilometres.[490] The first set of tiles was successfully launched on January 3rd, 2023.[491]
- In November, the **China Academy of Space Technology (CAST)** announced plans for a multi-phase approach to the introduction of SBSP, with the launch of a **LEO test platform** scheduled for 2028. Further phases, scheduled for 2030, 2035, and 2050, would see a gradual move towards satellites based in geostationary orbit and with much higher energy throughputs.[492] In a separate presentation the chief designer of the Tiangong space station at CAST, said that the station would be used for on-orbit assembly of the test platform using a set of robotic arms.[493]
- In December, **Northrop Grumman** completed ground tests for key components of its **Space Solar Power Incremental Demonstrations and Research (SSPIDR) programme**. The company is aiming to launch a full technology demonstration satellite in 2025.[494]

[489] SOLARIS activity plan, European Space Agency, December 2022
[490] Beaming Clean Energy From Space, Caltech, October 2022
[491] Caltech launches space-based solar power prototype, Energy Monitor, January 2023
[492] China aims for space-based solar power test in LEO in 2028, GEO in 2030, SpaceNews, June 2022
[493] China to use space station to test space-based solar power, SpaceNews, November 2022
[494] Northrop Grumman clears key hurdle for space-based solar power, SpaceNews, December 2022

2.1.6 Boosting in-orbit servicing, assembly & manufacturing

In-orbit operations include in-orbit servicing, in-orbit assembly, and in-orbit manufacturing. In-orbit servicing can be defined as the provision of support services by a spacecraft (servicer) to another space object (serviced) while in orbit. In-orbit assembly can be described as the assembly or combination of modular platforms to form a new object as well as the integration of upgrade payloads in orbit. Finally, in-orbit manufacturing can be characterised as the use of innovative techniques, such as space resources or 3D printers, to build items and components directly in space.[495]

According to NSR, the in-orbit operations' market is expected to generate $14.3 billion by 2031, especially driven by life extension services and last-mile delivery.[496] These activities, such as in-orbit refuelling, are one of the only in-orbit services with a proven use case to date, in particular, following Northrop Grumman's MEV missions. For other types of in-orbit services, the commercial market is expected to start slowly due to the challenges related to currently low technological readiness level, despite potentially profitable business cases.[497]

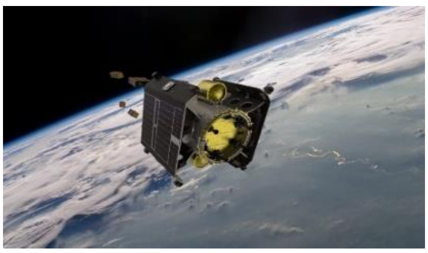
In fact, the majority of contracts and **main developments that took place in 2022 concern demonstration missions.**

Developments in Europe

Several milestones were reached in Europe:

- In January, the **UK Space Agency** awarded £1.7 million to 13 new projects to support in-orbit operations. These initiatives include an AI-based tool that can take autonomous action to avert a collision as well as spacecraft designed to be fired at debris to deorbit them.[498]
- In September, the UK Space Agency shortlisted groups led by Astroscale UK and ClearSpace, who won £4 million in combined follow-on contracts for an active removal mission to remove two spacecraft from LEO in 2026.[499]
- In early October, **Exotrail** was awarded a contract by the French Government to conduct an orbital logistics demonstration mission to change a satellite's altitude by 2025 and an in-orbital delivery by 2025 to move a satellite to its final orbital destination. The contract is part of the France 2030 public investment plan launched in 2021.[500]
- Later in October, **D-Orbit** signed a launch contract with **AAC SpaceQuest**, the U.S subsidiary of the Swedish company AAC Clyde Space. The contract includes the launch and deployment of two satellites by the end of 2023 with an option for two additional satellites by 2024. The launch and deployment mission will leverage D-Orbit's ION Satellite Carrier, a spacecraft capable of transporting satellites to orbit and releasing them into separate orbital slots.[501]

  The news comes after **D-Orbit cancelled its** plan to go public through a SPAC by merging with Breeze Holdings Acquisition Corp., due to changing conditions on financial markets following rising interest rates, inflation, and the war in Ukraine. The plan had been announced in January.



Credit: D-Orbit

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[495] ESPI Report 76 - In-Orbit Services - Full Report, ESPI, December 2020
[496] NSR's in-orbit services report projects $14.3 billion in revenues as non-geo constellations grow demand, NSR, February 2022
[497] NSR's in-orbit services report projects $14.3 billion in revenues as non-geo constellations grow demand, NSR, February 2022
[498] Government announces new funding for space sustainability projects, techUK, January 2022
[499] UK shortlists Astroscale and ClearSpace for multi-debris removal mission, SpaceNews, September 2022
[500] ExoTrail wins contract to demonstrate orbital transfer for French agencies, SpaceNews, October 2022
[501] D-Orbit Signs Launch Contract with AAC SpaceQuest, Spaceref, October 2022

Moreover, in January, D-Orbit launched the mission "Dashing Through The Stars" with the carrier ION SCV004 Elysian Eleonora aboard a Falcon 9 rocket from Cape Canaveral. [502]

- Still in October, **Arianespace** signed a partnership with the Australian startup **Space Machines Company** to explore the compatibility between its launchers and Space Machines' orbital transfer vehicles (OTVs). The objective is to potentially provide joint services in the future.[503]
- In November, **ClearSpace** announced it was preparing to conduct a life extension mission for Intelsat to refuel one of its satellites sometimes between 2026 and 2028.[504]
- In December, **UK Atomic Energy Authority (UKAEA)** signed a partnership with **Satellite Applications Catapult** to demonstrate how advanced remote handling and robotics technology developed for fusion energy research can be also used to provide maintenance to satellites in orbit. The goal of the partnership is to prove the return on investment on fusion energy research.[505]
- Later in December, **Thales Alenia Space** signed a contract with the Luxembourgish company **Space Cargo Unlimited** to develop the REV1 vehicle, a reusable and pressurised space factory that would be owned and operated by Space Cargo Unlimited. The REV1 vehicle is expected to carry up to 1,000 kg payload in LEO, subsequently docking with a Reusable Orbiting Service Model that Thales is also developing.[506]
- In May, Astroscale signed a partnership with **OneWeb** and **ESA** to conduct a demonstration of Astroscale's ELSA-M servicer satellite by the end of 2024 and launch an active debris removal service. The partnership is based on OneWeb and ESA's Sunrise Partnership Programme and provides Astroscale with a €14.8 million investment to complete the design and manufacturing of ELSA-M.[507]

Developments beyond Europe

Relevant developments took place in the United States

Significant support from public actors, in particular the Department of Defense (DoD), yielded a number of milestones in 2022:

- In March, the **DoD Defense Innovation Unit** (DIU) announced it will test three low-cost commercially built robotic arms, expected to enable in-orbit services, as part of its Modularity for Space Systems project. The prototypes are built by DIU's contractors Tethers Unlimited, Maxar Technologies and Motiv Space Systems.[508]
- Later in March, **Northrop Grumman**-owned **SpaceLogistics** successfully ignited the electric propulsion system for the Mission Extension Pods (MEPs), planned for launch in 2024. MEPs are propulsion jet packs that will be deployed on customer spacecraft in orbit by a Mission Robotic Vehicle (MRV) that SpaceLogistics is also developing.[509]
- In April, the **Space Force** launched a call for bids for a $50 million experiment called Tetra-5 to demonstrate in-orbit refueling of satellites in GEO to support the Space Force's plans to launch three small satellites in GEO, with the possibility to be refueled in orbit.[510]

[502] D-Orbit cancels SPAC merger plan, SpaceNews, August 2022
[503] Arianespace partners with Australian space tug startup, SpaceNews, October 2022
[504] ClearSpace announces life extension collaboration with Intelsat, SpaceNews, November 2022
[505] Fusion robots at work in the UK space industry, Gov.UK, December 2022
[506] Thales Alenia Space studying reusable spacecraft for in-orbit manufacturing
[507] OneWeb, Astroscale, and the UK and European Space Agencies Partner to Launch Space Junk Servicer ELSA-M with €14.8 million Investment, Astroscale, May 2022
[508] DIU to Test Tether, Maxar, Motiv Robotic Arm Prototypes for On-Orbit Servicing Program, ExecutiveGov, March 2022
[509] Northrop Grumman says customers are 'lined up' for on-orbit satellite servicing, SpaceNews, March 2022
[510] Space Force looking at what it will take to refuel satellites in orbit, SpaceNews, April 2022

- In May, the **Space Force**'s technology branch also chose 125 industry teams and awarded them $250,00 as part of the first phase of the Orbital Prime program, which aims to develop technologies for orbital debris removal processes.[511]
- In August, **Varda Space Industries** signed a partnership with **NASA** to secure access to key technologies for Varda's demonstration to manufacture materials in-orbit. The mission includes a manufacturing module and a heatshield-protected capsule that is supposed to re-enter in the atmosphere and land on Earth.[512]
- Moreover, in October, **Varda** announced to have successfully completed its first microgravity test mission, which demonstrated the descent and landing capability of its re-entry capsule. The mission is set to prepare an in-orbit manufacturing mission to be conducted in 2023.[513]
- In October, the U.S-based **Embry-Riddle Aeronautical University** received a Small Business Technology Transfer award from the U.S Air Force to continue research within the Embry-Riddle's Advanced Dynamics and Control Lab (ADCL). The University partnered with Modularity Space to address multi-agent, systems-based applications in in-orbit servicing, assembling and manufacturing operations.[514]
- In November, **Starfish Space** announced its plans to perform the first satellite-docking test using electric propulsion in LEO by the end of 2023. According to the company, Starfish's Otter Pup demonstrator is cheaper and smaller than chemical propulsion-based servicers.[515]
- Finally, in November, **DARPA** announced that its robotic arm, developed as part of the Robotic Servicing of Geosynchronous Satellites (RSGS) programme, had completed tests. The arm is expected to be integrated into a **Northrop Grumman** spacecraft, planned for launch in 2024.[516]
- In January, Astroscale signed a contract with **Orbit Fab** to become a customer of its "gas stations in space" refuelling service. Astroscale's LEXI servicer satellites will therefore be allowed to dock Orbit Fab's fuel shuttle to be refuelled. To ensure that refuelling is feasible, the two companies intend to integrate the hardware device called the Rapidly Attachable Fluid Transfer Interface (RAFTI) into the LEXI servicer. The contract was considered by the two companies as the "first on-orbit satellite fuel sale agreement".[517]

ADR remains the key focus in Japan, yet new avenues for in-orbit servicing are opening

- In January, Astroscale was awarded funding from the Japanese research and development agency "New Energy and Industrial Technology Development Organization" (**NEDO**) to advance on-orbit servicing technologies.[518]
- In late January, Astroscale, **the Bank of Tokyo-Mitsubishi UFJ, Ltd.** and **Japan Finance Corporation** signed a 3 billion yen loan agreement in order to fund the Active Debris Removal by Astroscale-Japan (ADRAS-J) mission.[519]

[511] Space Force selects 125 industry proposals for on-orbit servicing technologies, SpaceNews, May 2022
[512] Space factory startup Varda secures NASA partnerships ahead of demo flight next year, CNBC, August 2022
[513] Exclusive: Varda Completes Vehicle System Test, Payload, October 2022
[514] Eagle-Designed Space Drones Target In-Orbit Construction, Embry-Riddle Aeronautical University, October 2022
[515] Starfish books launch for in-orbit satellite docking mission next fall, SpaceNews, November 2022
[516] DARPA's robot could start servicing satellites in 2025, SpaceNews, November 2022
[517] Astroscale US Taps Orbit Fab to Refuel Servicing Satellites, Satellite Today, January 2022
[518] Astroscale to Advance On-Orbit Servicing Interface Technologies Supported by Latest Award from Japanese National Research and Development Agency, Astroscale, January 2022
[519] Astroscale Japan Signs Loan Agreement with Bank of Tokyo-Mitsubishi UFJ and Japan Finance Corporation for JPY 3 Billion, Astroscale, January 2022

- In April, Astroscale announced it signed a contract-renewal for a one-year period with the **Japanese Ministry of Economy, Trade, and Industry** to conduct R&D on general-purpose robotic arm and hand technology, advanced and low-load autonomous control software technology as well as interface technology that can enable the arm to change its end-effector. The contract also encompasses research activities about the in-orbit services market and standardisation trends to provide guidance to the government.[520]
- In December, Astroscale announced it was developing satellite refuelling service activities in collaboration with **JAXA** under the JAXA Space Innovation through Partnership and co-creation (J-SPARC). As part of this partnership, Astroscale conducted a feasibility study on a refuelling mission concept for serviceable and non-servicable spacecraft using the rendezvous and proximity operations technology, which was used in the ELSA-d demonstration mission as well as robotic technology still under development.

[520] Astroscale and Ministry of Economy, Trade and Industry Renew Robotic Arm and Hand Technology Development Contract, Astroscale, April 2022

2.2 Other Outstanding Developments

2.2.1 Developments in Commercial Space Situational Awareness

Over the past ten years, the number of active satellites has multiplied by 7 and multiplied by 12 in LEO. The number of debris doubled in 15 years. The density of debris between 700 km and 110 km is becoming increasingly saturated.

In this context, Space Situational Awareness (SSA) is becoming essential to monitor the space environment and distinguish active satellites and debris.

While SSA had long been the sole domain of governments, often managed by the military, private actors are rapidly entering this business with new ground-based capabilities, in-orbit instruments, or SSA data analytics offerings amid an increased demand for SSA data.

The year 2022 recorded significant developments of civil and commercial SSA services to augment national and military capabilities or directly provide data to satellite operators.

Space Situational Awareness and Space Traffic Management

Space Situational Awareness (SSA) and Space Traffic Management (STM) should not be misunderstood.

SSA refers to the capacity to detect, identify and track objects in orbit, which is an essential element for ensuring security, safety and sustainability. Generally, SSA encompasses the following three main areas:

- Space Surveillance and Tracking (SST) of artificial objects;
- Monitoring of Near-Earth (natural) Objects (NEO), especially asteroids and comets;
- Space Weather (SWE) monitoring and forecast.

STM is the umbrella term for the set of technical provisions for promoting secure access to space and entire operations of space objects from launch to disposal. STM involves monitoring, regulating, and coordinating space traffic for safe operations (e.g., manoeuvres, etc.).

While SSA entails learning about the space environment, STM focuses on making operational decisions.

Commercial SSA capabilities and solutions are rising in Europe

National space agencies took initiatives to support the development of commercial SSA data/services.

In January 2022, the UK government announced it would provide £1.7 million for 13 new projects to enhance space sustainability and debris removal. The initiatives are led by Astroscale, Magdrive, Oxford Dynamics, Rocket Engineering, ODIN Space, D-orbit, Lumi Space, UK Launch Services Ltd, GMV NSL and four universities aim to develop, among other things, space surveillance and tracking, including an AI-based tool for autonomous collision avoidance.[521]

In December 2022, **CNES launched a call for tenders for "Data catalogue for space surveillance"** as part of the national investment plan France 2030, which allocated €1.5 billion to the space sector. CNES awarded five projects for a first phase: [522]

[521] New funding to support sustainable future of space, UK Space Agency, January 2022
[522] Sécurité des opérations spatiales : 5 lauréats de l'appel d'offres "Catalogue de données pour la surveillance de l'espace" de France 2030, Ministre de l'Enseignement supérieur et de la Recherche, December 2022

Project descriptions	Partners
SSA data service by multi-orbit optical sensors and a GTO orbit optical space segment.	Ariangroup, Eutelsat, Magellium, Sodern
Deployment and operation of innovative optical and radar sensors.	ShareMySpace, ONERA, CS-GROUP
Extension of space surveillance service by radio frequency in LEO and MEO.	Safran Data Systems
Space environment monitoring by a specialised satellite to monitor space debris and objects in orbit.	U-Space, Airbus Defence and Space
SSA service from observation satellites based in GEO.	Infinite Orbits, Telespazio, IMCCE (Paris Observatory), IRT Saint Exupery

Table 5: SS-related projects awarded by CNES under France 2030

Swedish space services provider **SSC** partnered with **Baader Planetarium, Planewave and Andor** and achieved a first successful demonstration of its SSA programme to capture the photons of a star using a satellite tracking ground station. The test aimed to ensure its ground station's effectiveness in generating SSA data. The ground station was then installed at the Western Australia Space Center near Perth.[523]

The German startup Vyoma announced it partnered with Atos to develop a database of tiny space objects in orbit. Vyoma already provides satellite tracking services to European defence customers by using third-party networks of ground-based sensors (e.g., telescopes, laser, etc.).

Atos and OHB were also awarded a contract by the German Federal Office of Bundeswehr Equipment, Information Technology, and In-service Support to provide the German Armed Forces the "Space Situational Awareness Center Expansion Stage 1" to develop an SSA system. OHN will ensure that the SSA system is interoperable, and Atos will integrate both the software and hardware components to establish interfaces to external sensors and ensure the performance of the SSA system.[524] The SSA system will be based on GMV's COTS software for SST with object catalogues, re-entry prediction, and other multiple functions.[525]

Portuguese startup **Neuraspace** launched an AI-powered STM platform that aggregates a large amount of data from various sources, such as space debris images, CDMs, ephemeris files, and state vectors. The product also includes AI solutions to improve detection accuracy in high-risk collisions and minimise human intervention by up to 75%. The target customers are satellite operators, insurers, regulators and policy makers.[526]

The Italian company **Telespazio** concluded a Distribution and Partnership Agreement with the Canadian startup **NorthStar Earth & Space** to deliver solutions to enhance European Space Domain Awareness initiatives. NorthStar objective is to launch the first commercial space-based SSA system. Telespazio will integrate NorthStar's solutions into its offering for government customers.[527]

[523] First light for SSC's satellite tracking ground station, SSC, March 2022
[524] Atos develops Space Situational Awareness Center for the German Armed Forces, Atos International, April 2022
[525] GMV Provides Core Software for German Armed Forces' SSA Center, GMV, May 2022
[526] Neuraspace Unveils AI-Powered Space Traffic Management Platform, Via Satellite, July 2022
[527] New Space Domain Awareness Services for European Governments Provided by a NorthStar and Telespazio Partnership, Telespazio, September 2022

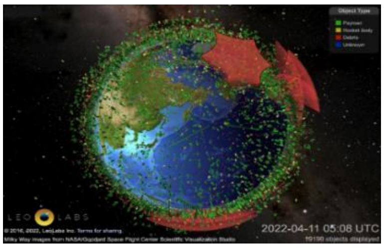
NorthStar Earth & Space also signed partnerships with **Spire Global** to develop 12 cubesats that are expected to be launched in 2023, which will integrate SSA sensors.[528] NorthStar Earth & Space also signed a partnership with **SES** to further develop NorthStar's SSA product. SES will use NorthStar's SSA products for its satellite operations.[529] NorthStar also signed a partnership with Astroscale that will enable to combine NorthStar's SSA service with Astroscale's spacecraft for in-orbit services.[530]

Policy and Industrial SSA developments in the U.S.

In the U.S. where parts of responsibility related to STM recently moved from the Department of Defence to the Department of Commerce took a significant step to promote commercial SSA**.**

- In July 2022, the National Oceanic and Atmospheric Administration (NOAA) of the U.S. DoC issued the Request for Proposal (RFP) to establish an Open Architecture SSA Data Repository, following the February 2022 Request for Information (RFI).[531] The requests hope to close gaps in the current government-owned data, particularly over the southern hemisphere, and to enhance the ability to refine orbit estimates and track calibration satellites.[532]
- In September 2022, in accordance with the 2018 U.S. National Space Policy Directive-3, the DoD and the DoC signed an agreement to define how the two departments will implement SPD-3 and transfer responsibilities for SSA and STM to Commerce.[533]
- In December 2022, NOAA awarded contracts to seven commercial partners as part of a space traffic coordination pilot project, which aims to provide spaceflight safety mission assurance to some space systems in MEO and GEO. COMSPOC Corp, ExoAnalytic Solutions, Kayhan Space, KBR, NorthStar Earth & Space Inc, Slingshot Aerospace, and the Space Data Association will provide SSA data analysis.[534]
- The Space Force awarded the startup **SCOUT Space** a $750,000 Phase 2 Small Business Innovation Research contract to provide commercial SSA data from space-based sensors. Scout Space will attempt to demonstrate that commercial in-orbit SSA data can be combined with radar data to increase the accuracy of space debris tracking. The startup will use digital twin data in this second phase to work on this demonstration in a simulated digital environment.[535]

On top of public initiatives, U.S. industry made various advancements on developing SSA capabilities, notably:



Credit: LeoLabs

LeoLabs, the global commercial leader of SSA and LEO mapping services, reached significant milestones in 2022 with additional contracts and product launches:

- It signed a multi-year operational agreement with OneWeb to provide them with their *LeoLabs Collision Avoidance* service which provides real-time data and analytics of other satellites and space debris trajectories It can track more than 18,000

[528] Spire Global Announces Landmark Space-as-a-Service Contract with NorthStar Earth & Space for a Dedicated Constellation, NorthStar Earth & Space Inc, March 2022
[529] SES Partners with NorthStar Earth & Space to Tackle Space Sustainability Challenges, NorthStar Earth & Space Inc, March 2022
[530] Astroscale and NorthStar Partner to Develop In-Space Technology to Support Space Sustainability, NorthStar Earth & Space Inc, September 2022
[531] NOAA Issues RFP for Commercial SSA Data, NOAA, July 2022
[532] National Oceanic and Atmospheric Administration (NOAA) Space Object Commercial Data Request for Information (RFI), SAM.GOV, February 2022
[533] Commerce and Defense Departments sign agreement on space traffic management cooperation, SpaceNews, September 2022
[534] Commerce Department awards contracts for space traffic coordination pilot project, NOAA, December 2022
[535] Scout wins defense contract to demonstrate utility of commercial data from sensors in space, Space News, July 2022

space objects in LEO. A 3D visualisation of the OneWeb constellation including about 400 satellites was also released in February 2022.[536]

- The Japan Air Self Defense also awarded LeoLabs a contract to provide SSA data and services, including tracking, monitoring, and collision avoidance in May 2022.[537]
- Leolabs launched a new SSA tool for space insurance to quickly and accurately assess the collision risks of orbital debris in LEO by its global radar network in September 2022.[538]

L3Harris Technologies, a global defence and aerospace firm, was awarded a $117 million contract from the U.S. Space Force and U.S. Space Command to continue maintaining and modernising infrastructure to track space objects and command and control (c2) system to better understand space threats using upgraded radar and optical sensors under the MOSSAIC program.[539]

Slingshot Aerospace, a space simulation and analytics provider established in 2017, reached significant milestones in 2022 with fundraising and major defence contracts:

- In March, Slingshot raised $25 million in Series A-1 funding round, which was co-led by Draper Associates and ATX Venture Partners. The funding round also included Edison Partners, Embedded Ventures, Valor Equity Partners and Lockheed Martin Ventures. The funds will be used to commercialise its space collision avoidance platform Slingshot Beacon where commercial, government, and civil operators can share their SSA and collision data.[540]
- In December, Slingshot raised $40.85 million in Series A2 funding round, which was led by Sway Ventures and included C16 Ventures, ATX Venture Partners, Lockheed Martin Ventures, Valor Equity Partners and Draper Associates.[541]
- Slingshot won $25.2 million, 39-month contract from the U.S. Space Force to develop the industry's first Digital Space Twin, a virtual platform that displays real-time space environment mapping including orbital objects and space weather data.[542]
- After its acquisitions of Numerica's SDA division and a UK space data analysis firm Seradata, Slingshot released a free version of Slingshot Beacon in September 2022.[543]

The Hawaiian startup **Privateer Space**, established in 2021 by (i.a.) Steve Wozniak, developed a data engine called Wayfinder, which is a near-real time visualisation tool of satellite and debris currently in orbit. It reached another milestone in 2022 when it launched Crow's Nest, which is a free and open collision risk assessment tool, integrated into Wayfinder.[544]

[536] LeoLabs Announces Operational Agreement with OneWeb, LeoLabs, February 2022
[537] LeoLabs Wins Contract Award to Support Japan Air Self Defense Force with Commercial Space Domain Awareness, LeoLabs, May 2022
[538] Tackling risk in LEO: Introducing LeoLabs' space insurance tool, LeoLabs, September 2022
[539] L3HARRIS AWARDED $117 MILLION SPACE OBJECT-TRACKING MODERNIZATION CONTRACT, L3Harris, April 2022
[540] Slingshot Aerospace closes $25 million fundraising round, SpaceNews, March 2022
[541] Slingshot Aerospace completes $40.8 million funding round, SpaceNews, December 2022
[542] Slingshot Aerospace Announces Industry's First Digital Space Twin; U.S. Space Force Space System Command's SpaceWERX Awards $25 Million Contract to Slingshot Aerospace, Slingshot, March 2022
[543] Slingshot Aerospace Offers Free 'Air Traffic Control for Space' Solution to Prevent Satellite Collisions in Orbit, Slingshot Aerospace, September 2022
[544] Privateer Launches Most Comprehensive and Accessible Space Debris Collision Prevention Platform to Keep Space Safe for All, GlobeNewswire, October 2022

2.2.2 Edge Computing making strides in the space sector

As the number of satellites in orbit continues to increase, the volume of data produced by space systems keeps rising, which, while enabling new opportunities, creates a data processing challenge for many operators, service providers, and customers of satellite data. To solve data processing issues, edge computing is poised to be increasingly used in the space sector. It can be defined as **capturing, storing, processing, and analysing data near the place where the data is created**. An edge device is any piece of hardware, which controls data flow at the boundary between two networks. In space, **edge computing means processing satellite data directly in-orbit**, where it is generated in order to reduce latency and only send the data requested by the customer back to Earth, thereby reducing the processing time on the control segment and reducing the distribution delays to the customers.[546]

The 5 Vs of Big Data

The increasing generation of satellite data creates a Big Data problem for operators and customers. Big Data can be defined as *"a combination of unstructured, semi-structured or structured data collected by organizations. This data can be mined to gain insights and used in machine learning projects, predictive modelling and other advanced analytics applications".*

Big Data can be characterised by the 5 Vs:

- the **velocity** of data, which is the speed at which the data is generated by space systems and distributed to the ground or through inter-satellite links;
- the **volume** of data, which is the increasing amount of data generated by space systems;
- the **variety** of data, which refers to the diversity of satellite data, including images, radar, PNT data, etc;
- The **veracity** of data, which is the accuracy and quality of the data such as the increased resolution of satellite images;
- The **value** of data, which refers to the worth of the satellite data and the insights that can be generated from them.[545]

Digital giants are leading edge computing efforts

Throughout the year, Amazon Web Services (AWS) conducted edge computing experiments in orbit in partnership with the space logistics company D-orbit and the Swedish AI company Unibap. AWS unveiled an experiment, which demonstrated how in-orbit processing can enable satellite operators to deal with high volumes of imagery and sensor data before delivering them to the cloud to customers. AWS IoT Greengrass, Amazon's Machine Learning tool, was integrated into a processing payload developed by Unibap, which was placed on D-Orbit ION spacecraft to conduct the experiment in LEO. According to AWS, its AI/ML capabilities enabled the reduction of image size by up to 42%, resulting in faster processing rates. The AI system could determine in real time which satellite images should be prioritised for downlinking and which should be ignored. AWS, Unibap, and D-Orbit are continuing to explore additional capabilities on the ION platform, such as new ways to process raw data in orbit and more sophisticated data distribution mechanisms.

[545] 5 V's of big data, TechTarget, March 2021
[546] How Edge Computing Is Changing Space from Terminal to Satellite, Kratos Defense, January 2023

Credit: Amazon Web Services (AWS)

AWS also collaborated with the U.S startup Axiom Space on a private mission to the International Space Station to test the Snowcone device, which is an edge computing and storage device that can collect, process, and transfer data to AWS's cloud offline by moving the device or online using AWS DataSync. Amazon successfully interacted with the Snowcone on the ISS and proved the consistent capacity to execute edge processing on space-based datasets.[547]

Hewlett Packard Enterprise reported the completion of 24 experiments on the ISS using HP's Spaceborne Computer-2 (SBC-2), reported as the first commercial edge computing system to operate on the ISS. As part of a drive to boost astronaut autonomy, the tests included real-time data processing and testing of novel applications to establish reliability in space. These trials included the demonstration of use cases in healthcare, image processing, natural disaster recovery, 3D printing, 5G, and artificial intelligence-enabled solutions. SBC-2 enables to compress 92 KB and send it to the ground in two seconds, representing a 20,000X increased in processing and distributing time according to the company.[548]

Microsoft is also developing edge computing in space and signed a partnership with Thales Alenia Space to validate on-orbit computing technologies on the ISS by 2023. The partnership will allow to collect faster, to-the-point EO insights. Thales Alenia space will deploy an edge computing payload, which runs on Microsoft Azure Cloud on the ISS. Thales Alenia Space will be in charge of developing the payload and deliver it to the ISS. Microsoft will be in charge of the in-orbit software. The demonstration will enable to develop in-orbit data processing applications for climate data.[549]

The two companies will further strengthen their cooperation also on behalf of ESA. ESA outlined in its Agenda 2025 that **"new technologies like AI and quantum computing will be integrated upfront to translate big data into smart information and services"**.[550]

As a result, the Agency is fostering the advent of Cognitive Cloud Computing in Space (3CS) by capitalising on high-performance AI accelerator chips directly onboard satellites. **ESA Φ-lab will launch a challenge with Microsoft and Thales Alenia Space** to develop new Machine Learning (ML) models for a hyperspectral optical sensor. The first Φ-sat mission demonstrated the use of an AI processor in-orbit to filter cloud from hyperspectral optical sensors for EO data. The Φ-sat-2 satellite, will deliver a platform for inflight uploading, deployment and updating of third-party Machine Learning (ML) models aboard the ISS.[551]

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[547] How do you process space data and imagery in low earth orbit?, Amazon, June 2022
[548] Hawlett Packard Enterprise drives innovation at the extreme edge on the International Space Station with 24 completed experiments, Hewlett Packard Enterprise, April 2022
[549] Thales Alenia Space with help from Microsoft demonstrate on-orbit compute technologies onboard the International Space Station to gather unmatched Earth observation insights, Thales, April 2022
[550] ESA Agenda 2025: Make Space for Europe, ESA, March 2021
[551] ESA continues to explore the value of AI in space in partnership with Thales Alenia Space and Microsoft, ESA Philab, January 2023

In addition, on April 1st, **the U.S. data company Palantir and the Uruguayan space company Satellogic partnered to integrate Satellogic's NewSat platform with Palantir's Edge AI technology**. The system represents the culmination of a six-month project to process imagery data on orbit, separating signal from noise in high-scale data to make the best use of limited bandwidth.

Deploying Edge AI on NewSat introduced new challenges, including on how to tackle constrained computation runtime and random restarts due to the finite amount of power available, the scarcity of existing data in the AI architecture, and limited uplink bandwidth. The companies understood that several innovations needed to adapt Edge AI were to be brought such as image pre-processing to improve model accuracy, fault tolerance design to achieve better data reliability guarantees, AI integration with multiple third-party models to improve adaptability, post-processing to prepare the data for downlink, in-orbit upgrade to enhance the onboard AI capabilities, and cryptographic mechanisms to augment the validation of data.[552]

Ultimately, on May 25th, **the Bulgarian startup EnduroSat, the American company IBM, and the Emirati company Red Hat Technologies launched edge computing payloads on EnduroSat's NanoSat**. It enables developers to directly process satellite data on IBM's cloud environment in order to save bandwidth and download only the needed data and send it to Earth.[553]

Edge Computing and in-orbit datacentres are being developed by European actors

Europe made progress in 2022, with public and private entities acknowledging the future promise role of edge computing in space.

As a result, **the European Commission announced its plans to move data centres into space as a way to target the Green Deal objectives** of carbon neutrality by 2050 and tackle the rising electricity prices.[554]

Credit: Thales Alenia Space

Within the Horizon Europe Programme, the Commission initiated the **Advanced Space Cloud for European Net zero emission and Data sovereignty (ASCEND)** study with Thales Alenia Space as prime contractor and a budget of more than €2 million.[555] The consortium, which brings together major players in the fields of environment analysis (Carbone 4, Vito), data centres architecture, hardware and software (Orange, CloudFerro, HPE), space systems development (Thales Alenia Space, Airbus, DLR), and access to space (ArianeGroup), is tasked to demonstrate whether placing solar energy-powered data centres outside the Earth's atmosphere will substantially lower the carbon footprint of data processing and storage.

Ultimately, following the success of the Φ-lab, ESA is replicating such model across Europe to boost innovation in emerging commercial space domains. In March, **ESA and AI Sweden partnered for the establishment of a Φ-lab in Sweden**, which will focus on developing commercially viable edge computing and AI solutions onboard satellites.[556]

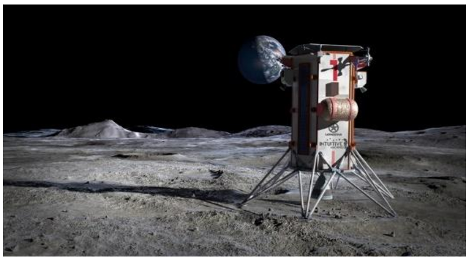
552 Palantir and Satellogic partner for Edge AI in Space, Palantir, April 2022
553 IBM and red Hat Technology Launch to Space on EnduroSat's Shared Sat Service, IBM, May 2022
554 The European Union wants to move data centres into space, Techmonitor, November 2022
555 Advanced Space Cloud for European Net zero emission and Data sovereignty, European Commission, October 2022
556 ESA and AI Sweden sign letter of intent for the establishment of Φ-lab@Sweden, ESA Philab, March 2022

Edge Computing developments beyond Europe

The U.S. currently holds a prominent position in the edge computing industry, with many of the major global players and innovative startups in the space sector based in the country.

Sidus Space and **Exo-Space signed an MoU to commercialise satellite edge computing technology** by integrating Exo-Space's FeatherEdge Data Processing Platform into Sidus Space's LizzieSat™. The technology will provide near-real-time intelligence derived from EO data, enabling effective action in time-sensitive operations such as identification of unregistered marine vessels, natural disasters, and events contributing to environmental crises. The collaboration will establish integration processes for future missions and increase the product's Technology Readiness Level through on-orbit testing in a space environment.[557]

The U.S.-based lunar venture Lonestar Data Holdings announced that it conducted data storage and edge processing tests on the ISS. The test relied on hardware already on the ISS to task an existing computer server to become an edge of network node, reconfigure it to launch a virtual machine that stored data an ran an application that generated results, which were sent to the ground. Lonestar is now developing Lunar-based data storage capabilities in order to support lunar edge processing needs as well as archive data produced on Earth to avoid data loss in case of natural disasters. The company will take part in NASA's Nova-C lander mission to the Moon's South Pole with a hardware prototype device with a capacity of 16TB of storage to conduct demonstrations. Lonestar also plans to launch a small server during another NASA mission in 2023.[558]



Credit: Lonestar

On December 12th, **Vaya Space, C8 Secure, Orbits Edge, and Space Prep revealed the formation of the In-Space Computing Alliance (ISCA)**. The joint venture aims to enable faster, lower cost, and more secure data processing capabilities in space for end users across the industry.[559] It follows the footsteps of a previously announced alliance, the U.S.-led **"Edge Computing in Space Alliance" (ECSA)**. The joint effort, which currently enjoys 32 industrial partners, aims to democratise access to space for every industry sector by providing expertise in edge computing, develop common technical standards and protocols, and cooperate in joint projects. [560]

Globally, entities in Australia, China and Japan also announced developments in edge computing capabilities in 2022:

- On January 13th, **the Australian company Spiral Blue successfully launched its Space Edge Zero (SEZ) computers into space** onboard Polish satellite manufacturer SatRevolution's SW1FT satellite. RGB and NIR images captured by SW1FT are passed to SEZ that processes and delivers them in real time, providing a full end-to-end service.[561] On July 12th, the startup announced the integration of its Space Edge One computer (SE-1) on the Uruguayan satellite operator and manufacturer Satellogic's NewSat spacecraft. The SE-1 is tasked to carry out onboard processing of high-resolution images for governmental and commercial organisations operating in the meteorological, agricultural, and maritime sectors.[562]

[557] Sidus Space and Exo-Space partner for satellite edge computing, Businesswire, August 2022
[558] Lonestar to Develop Lunar-Based Data Storage, SatNews, April 2022
[559] In-Space Computing Alliance Formed to Transform the Speed and Security of Data Transfer, GlobeNewswire, December 2022
[560] "Edge Computing in Space Alliance" advances space computing, ECSA
[561] Spiral Blue reports initial results of in orbit testing Satrev, Spiral Blue, May 2022
[562] Spiral Blue and Satellogic complete payload integration, Spiral Blue, July 2022

- **Spiral Blue and Esper Satellite Imagery announced the integration of Spiral Blue's control and processing payload Space Edge One - Hyperspectral (SE-1H) into Esper's Esperesso** hyperspectral imager, developed as part of Project Rainbow Python.[563] SE-1H supports direct interfacing with an imager for power and communication, flexible power supply options, various interfaces for satellite communication, and includes the small and energy-efficient supercomputer "Jetson Xavier NX System On Module" and large onboard storage options.
- **The Chinese company Huawei Cloud achieved a ground-breaking feat with the world's first cloud-native satellite**, which features the "Sky Computing Constellation" computing platform and was successfully deployed in orbit in December 2022. The Sky Computing Constellation project, jointly initiated by the Beijing University of Posts and Telecommunication and the Shenzhen Graduate School, aims to deploy Huawei Cloud's solution in batches of six experimental satellites to serve a range of applications, including emergency communications, environmental monitoring, disaster prevention and mitigation, and urban building. The coordination between the satellite and ground stations increased calculation precision by over 50%, and the use of on-orbit AI resulted in better quality pictures usually obscured by clouds and snow.[564]

Credit: Huawei Cloud

- **JAXA contracted the Swedish payload processing solutions provider Unibap to employ its SpaceCloud infrastructure** for the upcoming GOSAT-GW (Advanced Greenhouse Gas and Water Cycle Observation) EO satellite mission set to launch in 2024.[565]
  Unibap's solutions will facilitate in-orbit cloud services, storage, and edge data processing of EO data for the mission. This marks the second phase of onboarding SpaceCloud systems onto JAXA missions, and under the agreement, Unibap will supply the engineering model hardware of the next-generation SpaceCloud infrastructure solution, iX10.

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[563] Spiral Blue and Esper Satellite Imagery bring supercomputer at the edge, Spiral Blue, December 2022
[564] Huawei Cloud achieves historic milestone with first cloud-native satellite in orbit, Huawei, December 2022
[565] JAXA partners with Unibap for edge computing solution in space, Unibap, December 2022

2.2.1 Rising interest in laser communications for military applications in the U.S.

In a context characterised by the need to transfer high amounts of data both in satellite-to-ground, satellite-to-aircraft and notably intersatellite links, new communication technologies are explored and demonstrated.

To address needs of higher data rates and reduced risk of interference by making use of higher carrier frequencies and reduced beamwidth, improved RF, microwave and **optical inter-satellite links** (i.e. laser communications) are being developed. Growth in the development of the latter has been particularly present over recent years, notably for security applications as laser communications are considered more secure and less vulnerable to interception.

According to NSR Optical Satellite Communications report, 5th Edition, the total market demand for Laser Communication Terminals in the space sector for the next decade will outweigh 8.500 units, with a spike in demand in the shorter term (approx. 2025) driven by military customers.[566]

The revenue generated during the decade by the space-based laser communication market is $2.6M over the decade, with CAGR of 67.3%., taking into account the decrease in pricing and the increase in the number of units. The largest share of the market is expected to be taken by devices for laser intersatellite links.

Laser or optical communication?

Optical communication in space is commonly used as a synonym of laser communication. The first term underlines the specificity of the higher carrier frequency used for this type of communication. Indeed, infrared waves are part of the optical band, together with the visible light and ultraviolet radiation. Using the term laser communication, instead, highlights the reduced width of the beam.

Nevertheless, even if the two terms are both technically speaking correct, this section will use the term "laser communication", which better identifies the type of technology referred to and avoid misunderstanding with other types of communication technologies making use of the optical band.

In 2022, **laser communications attracted the interest of several military actors**, especially in the U.S. In this frame, laser intersatellite links have been demonstrated in particular through the contracts awarded by the Space Development Agency and DARPA, but several developments are also recognised in the demonstration of laser links for satellite-to-aircraft communications.

SDA, DARPA, AFRL proceeding with parallel projects on laser intersatellite links for U.S military

The U.S Space Development Agency (SDA), a unit of the U.S. Space Force responsible for operationalising innovative and disruptive space technologies, initiated the Transport Layer programme in 2021, with the aim of developing a network of LEO satellites connected by laser communication links. In 2022, the programme saw several significant steps forward.

- In June, **Northrop Grumman announced that it had successfully completed a ground test of a CONDOR Mk2 terminal supplied by Germany-based laser terminal supplier Mynaric**. The test, which also involved avionics provider Innoflight, involved encryption and decryption at a high data rate over optical link.[567]
  Mynaric also announced that it would be the sole supplier of laser terminals to Northrop Grumman, which was earlier selected by the SDA to provide 42 Tranche 1 satellites for the SDA's Transport Layer.[568]

[566] Gov/Mil: Optical Satcom Ignitor or Propellant?, NSR, February 2023
[567] Northrop Grumman demonstrates Mynaric laser terminals for military constellation, SpaceNews, February 2022
[568] Mynaric Acts as Sole Laser Communication Supplier for Northrop Grumman as Part of Milestone U.S. Government Program, Mynaric, June 2022

- In July, **Airbus U.S. Space & Defence announced that it had won a contract to provide Northrop Grumman with 42 satellite platforms**, based on its ARROW platform, for the U.S. Space Development Agency's Tranche 1 Transport Layer constellation. Tranche 1 is intended to follow up the Tranche 0 prototype constellation as a service-ready iteration of the Transport Layer programme.[569]
- In February, the **SDA awarded BridgeComm and Space Micro a $1.7 million Small Business Innovation Research contract** to demonstrate point-to-multipoint laser communications technology over the next two years. This is sought as an integral component of the Transport Layer programme.[570]
- At the MilSat symposium in October, SDA director Derek Tournear displayed a presentation slide that **revealed the names of the four laser terminal suppliers that the SDA was working with for Tranche 0 of the Transport Layer programme**, not all of which had previously announced their participation. The companies are Mynaric, SA Photonics, Skyloom, and Tesat.[571]

The Defense Advanced Research Projects Agency (DARPA), another key investor in developing satellite laser communications for military purposes, made progress on its flagship programme: the space-based adaptive communications node (Space-BACN).

Credit: SpaceLink

- In August, **DARPA selected 11 entities**, including five commercial satellite operators (SpaceX, Telesat, SpaceLink, Viasat, and Amazon's Kuiper), to participate in the **first phase of its Space-BACN project** that was announced in September 2021. The project aims to create a network of LEO satellites that can communicate with each other seamlessly. The selected organisations will work on developing laser terminals and technical standards to connect satellites in space, including enabling communication between government and commercial satellites. The first phase of the project will last 14 months and will conclude with a preliminary design review and a connectivity demonstration in a simulated environment.[572]
- In September, Blue Canyon Technologies, a subsidiary of Raytheon Technologies, delivered the **first of ten satellite buses to DARPA for the Blackjack programme**, which was launched in 2020 and seeks to demonstrate the feasibility of a network of satellites in space connected by optical links. SEAKR Engineering, another Raytheon subsidiary, has also delivered the first two of its Pit Boss data processing payloads that will allow the Blackjack constellation to operate autonomously.[573]
- In December, **Mynaric announced a partnership with Redwire and BigBear.ai to use their cybersecurity tool**, Space Cyber Resiliency through Evaluation and Security Testing (SpaceCREST), as part of its contribution of laser terminals to the Space-BACN programme. SpaceCREST will use AI and machine learning to predict and protect against vulnerabilities that could disrupt terminal operations.[574]

[569] Airbus to Provide 42 Satellite Platforms and Services to Northrop Grumman for U.S. Space Development Agency, Airbus US, July 2022
[570] DoD space agency funds development of laser terminal that connects to multiple satellites at once, SpaceNews, March 2022
[571] SDA slide reveals Tranche 0 optical terminal manufacturers, SpaceNews, October 2022
[572] DARPA selects companies for inter-satellite laser communications project, SpaceNews, August 2022
[573] Blue Canyon delivers first satellite bus for DARPA's Blackjack constellation, SpaceNews, September 2022
[574] Mynaric, Redwire, BigBear.ai partner for DARPA's laser communications program, SpaceNews, December 2022

The Air Force Research Laboratory (AFRL), while not as prolific in its work on laser communications as the SDA and DARPA, is increasingly active in the domain.

- In May, laser terminal supplier **CACI announced that two satellites launched by the Defense Advanced Research Projects Agency (DARPA) successfully established an optical link** using CACI-supplied equipment. The experiment, called Mandrake 2, was funded by the Space Development Agency (SDA) and the Air Force Research Laboratory.[575]
- In June, **BlueHalo was awarded an $11m contract from the Air Force Research Laboratory** to develop two laser communication terminals and a ground station for on-orbit experiments with delivery scheduled for 2025. The technology will support the demonstration of optical communications between satellites in geostationary and low Earth orbits, as well as space-to-ground links.[576]

Satellite-to-aircraft links promise to take off

While satellite-to-satellite laser communication sees expansion, another opportunity presents itself in the creation of satellite-to-aircraft laser links. While seeing less activity than intersatellite links, this segment still saw attention from the U.S. military in 2022.

- In January, **Space Micro, a subsidiary of Voyager Space, won a contract from the U.S. Air Force to develop a laser communications terminal** connecting military aircraft to geostationary satellites. The contract, issued by AFWERX, calls for a terminal capable of transmitting 10 gigabits per second of data without revealing aircraft positions, and will be based on an existing Space Micro design. The terminal will also integrate adaptive optics technology developed by Johns Hopkins University.[577]
- In August, the **SDA issued a "special notice" requesting proposals** for a live demonstration of how its Tranche 0 Transport Layer satellites could communicate with aircraft in flight. Successful candidates would be expected to demonstrate pointing, acquisition and tracking, and the capability to acquire and maintain a stable link to transmit up to 1 gigabit per second of test data.[578]

[575] Military experiment demonstrates intersatellite laser communications in low Earth orbit, SpaceNews, May 2022
[576] BlueHalo wins $11 million Air Force contract for laser communications terminals, SpaceNews, June 2022
[577] AFWERX to fund development of laser terminal that connects military aircraft with satellites, SpaceNews, January 2022
[578] Space Development Agency to take another stab at space-to-aircraft laser communications, SpaceNews, August 2022

2.2.2 Space tourism and private space stations keeps developing

In a context of increasing cadence and changing nature of human spaceflight, space tourism developments represent a crucial component of the overall trend.

Private spaceflight or tourism?

Clarification is needed in view of the lack of consensus around the definition of "space tourism". While some publications label all privately-funded space travel as "space tourism" even if participants conduct operational or scientific activities as part of their mission, the proper use of the term "tourism" should be made exclusively with regard to space travel conducted for leisure purposes.

U.S companies dominate private spaceflight

The U.S. remains the country with the highest number of private companies vying to develop commercially viable human spaceflight services. For several of these companies, 2022 was a year of both success and setbacks.

- In March, **Blue Origin** launched its fourth crewed flight, carrying six people on a 10-minute suborbital flight with the New Shepard rocket, followed by a fifth and sixth flight in June and August 2022 respectively.[579] Nevertheless, plans to convert a former cargo ferry into a seaborne landing platform were abandoned due to costs in June, with the company reportedly assessing options on whether to keep the ship or sell off.[580] In September, an uncrewed New Shepard test flight suffered an automatic launch abort a minute after take-off. While the capsule and its payload were able to abort and parachute safely back to Earth, the New Shepard fleet as a whole was grounded in the aftermath to investigate the cause of the abort.[581] As of January 2023, the fleet remains grounded.[582]
- **SpaceX**, in addition to providing launch services for Axiom missions to the ISS, also secured a commitment by the billionaire entrepreneur Jared Isaacman, who led the first all-private-citizen crew to orbit in September 2021. Isaacman commissioned 3 additional spaceflight missions - amounting to a privately funded space program dubbed Inspiration4.[583]
- Moreover, **SpaceX** is seeking to bolster its space tourism ambitions through its future Starship system. In October, businessman **Dennis Tito,** who became the **first space tourist in 2001,** purchased two seats on the Starship for a **future flight around the Moon.**[584] Tito is not alone in his lunar ambitions: in December, **Japanese billionaire Yusaku Maezawa announced the names of the eight artists he intends to take with him for a journey around the Moon**. In 2017, Maezawa became the first private buyer of seats aboard the **SpaceX Starship**, and in 2021, applications were opened to the public to join the crew.

[579] Jeff Bezos' Blue Origin launches 6 people to space in fourth crewed flight, Space.com, March 2022
[580] Blue Origin Abandons Plan to Use Ro/Ro Named for Jeff Bezos's Mother, Maritime Executive, June 2022
[581] New Shepard suffers in-flight abort on uncrewed suborbital flight, SpaceNews, September 2022
[582] After a failure 4 months ago, the New Shepard spacecraft remains in limbo, Ars Technica, January 2023
[583] Jared Isaacman, who led the first all-private astronaut mission to orbit, has commissioned 3 more flights from SpaceX, Washington Post, February 2022
[584] Space tourism pioneer Dennis Tito books private moon trip on SpaceX's Starship, CNBC, October 2022

Private spaceflight in the rest of the world

U.S. dominance of the space tourism market is not going unchallenged. In **China, Yang Yiqiang, former general director for the Long March 11 programme and founder of CAS Space**, announced his intention for the company to **begin tourism flights by 2025**. Yang Yiqiang expects Chinese space tourism to reach **"full bloom" by 2027.**[585]

On its end, Russian state-owned manufacturer **RSC Energia**, the production arm of Roscosmos, unveiled a model of their planned **Russian Orbital Service Station – including a module for tourists**.[586]

Private space stations

In addition to private individuals being launched into space for leisure purposes, the race to build and launch space stations continued throughout 2022, attracting considerable interest from both the public and private sectors.

To kickstart this process, NASA granted development contracts to three projects to build privately-owned and operated space stations in 2021. All three of the stations are intended to be constructed for use by both NASA and non-NASA customers and allow for a wide range of commercial and scientific use cases.[587]

- **Starlab,** a space station programme initiated by U.S companies **Voyager Space**, its operating company **Nanoracks**, and **Lockheed Martin**, announced in September that **Hilton Hotels would be designing the accommodations and common recreational spaces** aboard the station, and eventually aiming to offer a luxury "ground-to-space astronaut experience."[588]
- This clears the way for the project to proceed further into development. In addition, in September, Blue Origin announced a partnership with U.S.-based movie studio Centerboro Productions to **have the Orbital Reef play a key role in the plot of an upcoming science fiction movie**.[589] Finally, in November, a key module in the station design, the Large Integrated Flexible Environment (LIFE) inflatable habitation module, passed an important structural test. Further testing is expected in 2023.[590]
- **Axiom Space** signed a deal in January with UK-based Space Entertainment Enterprise to build the **world's first movie studio in space** aboard its as-of-yet unnamed space station. The module, called SEE-1, is planned for launch in 2024 and will initially be used for the filming of a movie starring U.S actor Tom Cruise.[591]

Additional developments of private space stations and especially agreements with national space agencies or national institutional actors, are included in the section 1.7.2 Space Stations.

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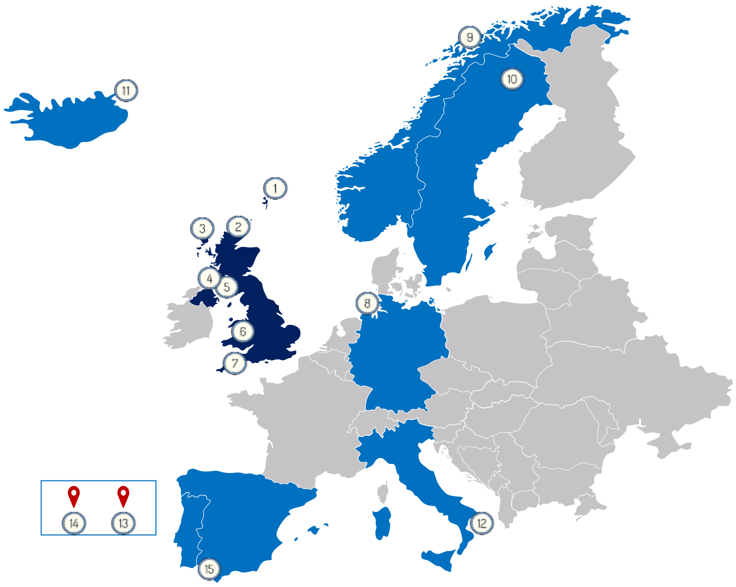
[585] Next stop: space? Chinese firm aims for suborbital tourist trips by 2025, South China Morning Post, September 2022
[586] After quitting the ISS, Russia reveals its next-gen space station, Inverse, August 2022
[587] Commercial Destinations Development in LEO, NASA, March 2021
[588] Hilton hotels will design astronaut suites on private Starlab space station, Space.com, September 2022
[589] Sci-fi Thriller HELIOS to Feature Orbital Reef, Orbital Reef, September 2022
[590] Sierra Space Successfully Completes Series of Major Development Milestones for First Commercial Space Station, BusinessWire, November 2022
[591] Tom Cruise space movie producers sign deal with Axiom to build studio in orbit, CNBC, January 2022

2.2.6 Spaceports in Europe: Developments continue, operations on the horizon

At least 15 commercial spaceports are currently proposed, planned or under development in Europe. Half of them, admittedly at different levels of maturity, are located in the **United Kingdom**, where significant competition for hosting the first launch from UK's soil is witnessed. Other spaceports in **Norway, Sweden, Germany, Italy, Portugal**, and **Iceland** are also expected to contribute to enhancing European launch capabilities. In particular, two overarching types of spaceports can be identified:

Both in terms of vertical and horizontal launch operations, only small satellites are currently expected and planned to be launched from European soil, with vertical launch sites primarily addressing the micro-launcher segment.



No.	Country	Spaceport	Launch mode
1	United Kingdom	SaxaVord Spaceport	Vertical
2	United Kingdom	Space Hub Sutherland	Vertical
3	United Kingdom	Spaceport 1 (Western Isles Spaceport)	Vertical
4	United Kingdom	Spaceport Machrihanish	Horizontal
5	United Kingdom	Prestwick Spaceport	Horizontal
6	United Kingdom	Spaceport Snowdonia	Horizontal
7	United Kingdom	Spaceport Cornwall	Horizontal
8	Germany	German Offshore Spaceport	Vertical
9	Norway	Andøya Space Centre	Vertical
10	Sweden	Esrange Space Center	Vertical
11	Iceland	Langanes Peninsula	Vertical
12	Italy	Airport of Taranto Grottaglie	Horizontal
13	Portugal	Azores	Vertical
14	Spain	El Hierro	Vertical
15	Spain	El Arensoillo Launch Base	Vertical

Table 7: A number of operational, planned, and considered spaceports in Europe

United Kingdom

The race to inaugurate the first commercial spaceport on UK's soil has heated up in 2022, right after having been boosted by the 2021 National Space Strategy. Currently, five of UK's spaceports are located in Scotland, one in Wales, and the seventh in England.

In early January 2023, the U.S-based Virgin Orbit attempted the first launch from **Spaceport Cornwall**, resulting in a failure, after reaching critical milestones in 2022:

- In September, Spaceport Cornwall opened the Space Systems Integration Facility, for the integration of satellites into the fairing of the launch vehicle, as the first step towards the completion of the Centre for Space Technologies, which will also encompass the creation of the Space Systems Operations Facility, as an R&D centre and office space. The Centre will serve as an innovation hub for collaboration between academic partners, SMEs, multinationals, and environmental organisations.[592]
- In November, Spaceport Cornwall obtained the UK's first-ever spaceport licence from the UK Civil Aviation Authority after meeting the safety, security, environmental and other operational requirements.[593]

The **SaxaVord Spaceport** (formerly Shetland Spaceport) successfully conducted a launch simulation in July 2022, thus making a crucial step in preparation of the three launches scheduled from SaxaVord in 2023: ABL Space Systems' RS1, Lockheed Martin's UK Pathfinder satellite launch system, and the German rocket maker HyImpulse Technologies' rocket powered by a paraffin-based fuel. Other significant developments took place throughout the year: [594]

- In early February, SaxaVord signed an agreement with the Met Office to install a weather station to determine the best equipment and location for the launch on the Lamba Ness peninsula.[595]
- In February, SaxaVord received planning approval by the local authority, the Shetland Islands Council, to start building the £43 million spaceport with three rocket pads for the launch of small satellites into either polar or sun-synchronous, LEO.[596]

  Subsequently, in June, the Scottish government finally approved the Spaceport and Range Licence applications, which were submitted to the Civil Aviation Authority (CAA) in March.[597] Therefore, the construction of SaxaVord Spaceport entered into its final phase.[598]
- In March, SaxaVord reached a MoU with the French launch startup Venture Orbital Systems to launch the first two-stage 15m rocket, Zephyr by 2024.[599] Additionally, in May, SaxaVord teamed up with the orbital launch service provider Astra Space to launch its Rocket 3.[600]

Credit: SaxaVord Spaceport

[592] Countdown to Cornwall: Spaceport Cornwall Officially Open for Business, Spaceport Cornwall, September 2022
[593] Spaceport Cornwall receives first-ever UK spaceport licence, UK Civil Aviation Authority, November 2022
[594] Successful test exercise and launch simulation, SaxaVord UK Spaceport, July 2022
[595] Spaceport and Met Office reach forecasting agreement, SaxaVord UK Spaceport, February 2022
[596] Work set to begin on UK's first vertical launch spaceport in Shetland, SaxaVord UK Spaceport, February 2022
[597] Licence applications submitted to regulator, SaxaVord UK Spaceport, March 2022
[598] Construction To Commence For SaxaVord Spaceport, Orbital Today, June 2022
[599] SaxaVord Spaceport agrees deal with French rocket developer VOS, SaxaVord UK Spaceport, March 2022
[600] Astra Space looks to expand launch capacity with SaxaVord UK Spaceport, SaxaVord UK Spaceport, May 2022

- Finally, in August, SaxaVord and the UK government began discussing the North East Scotland Green Freeport (NESGF)'s bid to create a freeport where usual tax and customs rules would not apply to the partners, as a subzone of the NESGF.[601]

The **Space Hub Sutherland** aims at becoming the world's first carbon-neutral spaceport. In 2022, the orbital launch services company Orbex, headquartered in Forres, Scotland, put the basis for the construction of the Sutherland spaceport:

- In February, Orbex applied for its first launch license to the UK Civil Aviation Authority.[602]
- In November, Orbex signed a 50-year lease with the Scottish community and economic development agency Highlands and Islands Enterprise (HIE) to develop and operate its home spaceport in northern Scotland, namely Space Hub Sutherland.[603]

Regarding the construction of **Spaceport 1**, the Western Isles Council announced in November the intention to order a 'review' of its partnership with one of its project consortium members, the UK-based consultancy firm Commercial Space Technologies (CST), due its long-standing relations with Russian launch providers.[604]

The **Prestwick Spaceport** is planned to be located in southwest of Glasgow, in the Scotland's largest and most established aerospace cluster. The horizontal spaceport project will enable space tourism, satellite launches, and gravity free flying. The first rocket launch is planned for the end of 2023 and the potential job-creation is estimated to approximately 4,000 units.

- In January, local government South Ayrshire Council kickstarted the process for the development of the Prestwick Spaceport by submitting a formal planning application. The goal is supported by funding from the Ayrshire Glowth Deal government package.[605]
- In July, the Prestwick Spaceport launch service provider Astraius teamed up with Northrop Grumman and Exquadrum, two industry leaders and strategic suppliers, to gear up for the first take-off from the Prestwick Spaceport. In particular, Northrop Grumman will develop the first and second stage engine, and Exquadrum will provide the upper-stage engine.[606]

Spaceport Snowdonia is located in Wales. While not been much progress was reported since the spaceport received a funding from the UK Space Agency Horizontal Spaceport Development Fund in 2020, the 2022 publication of the Welsh government on "a sustainable space nation" announced the first launch for 2023, and full operational status by 2025.[607]

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601 Spaceport discussions make Green Freeport bid out of this world, SaxaVord UK Spaceport, August 2022
602 Orbex applies for licence to launch first 'Prime' rockets from Scotland's Space Hub Sutherland, Satellite Evolution Group, February 2022
603 Orbex to Lead Construction and Operational Management of Sutherland Spaceport, Orbex, November 2022
604 Western Isles spaceport firm could face 'review' over Russia links, The Press & Journal, November 2022
605 Prestwick Spaceport Progresses Plans for Horizontal Launch from Scotland, Via Satellite, January 2022
606 "Ready for take-off" as Prestwick Spaceport takes a giant leap forward in rocket launches, Prestwick aerospace, July 2022
607 Wales: a sustainable space nation, Welsh Government, February 2022

Norway

The Andøya Space Centre saw several developments and milestones in 2022:

Credit: Brian Bonsteel, NASA

- In January, Andøya Spaceport and Korean-based INNOSPACE signed a MoU to launch into polar and sun-synchronous orbits from Norway. On its end, INNOSPACE is currently developing Hanbit, a series of mini, micro and nanosatellite launch vehicles.[608]
- In May, NASA launched its suborbital research rocket Endurance from Andøya to study and measure water leaks in the Earth's electrical field.[609]
- In June, Andøya Spaceport signed a cooperation agreement with SEKK (Sortland Entreprenør and Karstein Kristiansen Entreprenør) and LNS for the first construction phase of the development of the spaceport on Andøya.[610]
- In July, the German Aerospace Center (DLR) launched a three-stage sounding rocket to test reusable booster technology. The testing included the component structures, measurement methods as well as evaluation algorithms for the re-entry phase with the STORT (key technologies for high-energy return flights from carrier stages) flight experiment.[611]
- In November, two U.S suborbital research rockets to measure a stable auroral arc were launched from the Andøya spaceport, as part of the ACES II mission.[612]

Sweden

Preparation towards inauguration of Esrange's new orbital launch facility

End of 2022, the inauguration of the Esrange Spaceport to take place on January 13th 2023 was prepared. The space launch facilities will enable vertical orbital launches. So far, the Esrange Space Center enabled suborbital launches and testing in various facilities. In particular, the new launch site will feature a launch vehicle integration facility and three pads: for suborbital rockets and "microlaunchers" capable of placing up to 300 kg into SSO, for launcher vehicles that could put up to 1,200 kg into SSO, and for testing of reusable vehicles. The new launch facility will enable vertical launches of small vehicles – providing European autonomous access to space to launch its microlaunchers.[613]

Rest of Europe

In **Iceland**, the Scottish company Skyrora tested its suborbital Skylark L rocket from **Langanes**, in October, as a test launch for its future Skyrora XL rocket, which is scheduled to launch from the Saxavord Spaceport (1) in 2023, potentially representing the first vertical orbital launch from UK soil. The test encountered an anomaly landing in the Norwegian Sea approximately 500 metres away from the launch site.[614]

[608] INNOSPACE signs an MoU with Andøya Spaceport, Andøya Spaceport, January 2022
[609] Lift-off for Endurance, Andøya Spaceport, May 2022
[610] Construction Contracts Signed for Orbital Launch Complex at Norway's Andoya Spaceport, Parabolic Arc, June 2022
[611] DLR Launches Sounding Rocket to Test Reusable Booster Technology, Parabolic Arc, July 2022
[612] NASA ACES II launched from Andøya Space, Andøya Spaceport, November 2022
[613] Sweden opens orbital launch site looking for users, SpaxceNews, January 2023
[614] skyrora Attempts First Rocket Launch To Space With Icelandic Mobile Spaceport, Skyrora, October 2022

In **Italy**, Regione Puglia Region, the Italian National Civil Aviation Authority (ENAC) and Airports of Puglia signed a MoU to establish a new legal entity called 'Criptaliar Spaceport', including the allocation of €50 million for the construction of the infrastructure and €30 million for research. The **Airport of Taranto Grottaglie** is therefore confirmed as a logistics and technical platform for national strategic development.[615] The engineering company Aeroporti di Roma was awarded a €120 million contract for the construction of the infrastructure and flight areas, expected to begin in 2024.[616]

In **Portugal**, the debates on a spaceport on the island of Santa Maria (Azores) was ongoing. The Os Verdes party suggested to conduct a "strategic environmental assessment" of the potential spaceport operation's impacts on the island's territory and the population.[617]

In **Germany**, the German Offshore Spaceport Alliance which pushes the initiative to build a German offshore spaceport in the North Sea close to Bremerhaven, continued stating that they envisage to see a first launch from this spaceport in 2023.[618]

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615 Spazioporto Grottaglie, siglata intesa Aeroporti Puglia-Enac, Grazzetta del Sudonline, July 2022
616 L'Italia più vicina ai viaggi nello Spazio: aggiudicato il bando da 120 milioni per il primo spazioporto nazionale a Grottaglie, la Repubblica, December 2022
617 Study needed into Azores space port, the Portugal News, April 2022
618 Geplanter Weltraumbahnhof in der Nordsee: Erste Rakete soll schon 2023 starten, Tagesspiegel December 2022

3 Global Space Economy

3.1 Overview and main indicators

Each year, the Satellite Industry Association (SIA), 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 breaks down the value of the global space economy.

SIA estimated the global space economy in 2021 to be worth $386 billion,[619] **whereas the Space Foundation estimated it in the order of $469 billion.**[620]

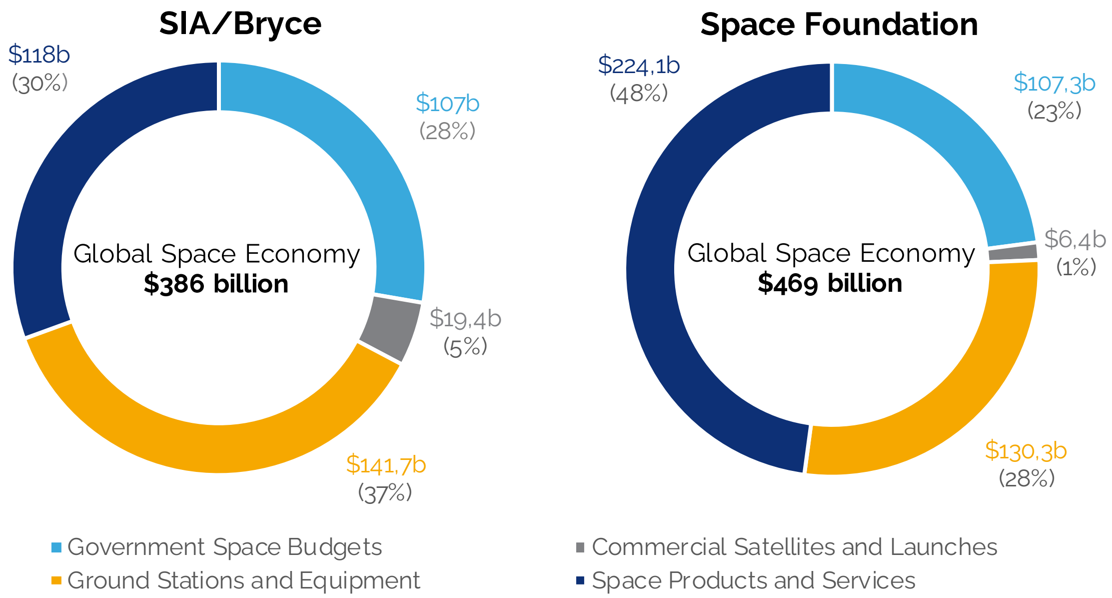


Figure 1: Global space economy estimations by SIA/Bryce (left) and the Space Foundation (right)

These two estimations can be 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.

[619] 2022 State of the Satellite Industry Report (prepared by Bryce Space and Technology). Summary, Satellite Industry Association, 2022. https://brycetech.com/reports/report-documents/SIA_SSIR_2022.pdf
[620] The Space Report 2022 (Q2), Space Foundation, 2022.

The following table provides a more detailed overview of the global space economy estimations made by SIA/Bryce and the Space Foundation for each segment:

Global Space Economy	SIA/Bryce			Space Foundation		
	$386 billion			$469 billion		
Government Space Budgets	$107B	U.S. budget	-	$107.3B	U.S. budget	$59.8B
		Non-U.S. budget	-		Non-U.S. budget	$47.5B
Commercial Satellites and Launches	$19,4B	Satellites	$13.7B	$6.4B	Satellites	$4.3B
		Launches	$5.7B		Launches	$2.1B
Ground Stations and Equipment	$141.7B	GNSS[1]	$109.7B	$130.3B	GNSS	$97.7B
		Others[2]	$32B		Others	$32.6B
Space Products and Services	$118B	Consumer (TV, Radio, Broadband)	$98.4B	$224.1B	Television	$84.9B
		Enterprise[3]	$17.2B		Communications	$18.7B
		Remote Sensing	$2.7B		Remote Sensing	$3.3B
		Satellite Radio	-		Satellite Radio	$8.7B
		PNT[4]	-		PNT	$108.5B
Others	-	-	-	$1B	Insurance Premiums	$0.5B
					Commercial Human Spaceflight	$0.4B
					SSA, On-orbit Servicing	$0.1B

Table 1: Detailed comparison of space economy estimations by the SIA/Bryce and the Space Foundation

1 Includes GNSS chipsets and navigation devices
2 includes network stations and user equipment such as satellite TV dishes or satellite mobile phones
3 Includes Transponder Agreements, Managed Services over FSS Bands, Mobile Voice and Data over MSS bands
4 Positioning, Navigation and Timing services, enabled by GNSS and augmentation system

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.

Both reports estimate the total volume of government space budgets at approximately $107 billion. SIA did not break down between U.S. and non-U.S. budgets, but according to SF, the U.S. made up 57% (ca. $60 billion) of global space budgets in 2021. While the distribution remained the same in relative terms in 2021, SF contends that budgets grew by a total of $17 billion. By contrast, according to the SIA estimates, government space budgets grew only by approx. $7 billion in 2021.

The two reports **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 estimates satellite manufacturing to be worth $13.7B, which is more than three times larger than SF's valuation of $4.3 billion. In 2021, SF had put the figure at $16 billion, but revised the estimates due to methodological changes. Moreover, SF valued the launch market at $2.1 billion, while SIA estimates it to be more than twice the size at $5.7B.

Overall, the SIA and the Space Foundation respectively estimate the total revenues stemming from ground stations and equipment segments to be $141.7 and $130.3 billion, which represents an increase of 4.7% and 12% over 2020, respectively. Moreover, the SIA and Space Foundation estimate that the revenues from network stations and user equipment (included in the "other" category) stand between $32 billion and $32.6 billion.

However, their estimations of the revenue from GNSS chipsets and navigation devices differ substantially, with the SIA estimating $109.7 billion of revenues and the Space Foundation estimating them around $97.7 billion, a difference of $12 billion. The difference in their estimated revenue from GNSS chipsets and navigation devices has thus declined throughout the years. The difference had remained at around $19 billion since 2019, while in 2018 it was even larger at $30 billion.

The Space Products and Services segment represents the revenues stemming from applications enabled by space systems, also known as **the 'downstream' segment**. This segment **constitutes the largest share of the space economy**, representing respectively 31% and 48% of the total value according to the SIA and the Space Foundation. The largest portion of this economic activity is direct-to-home television, which both reports estimate just under $90 billion (the Space Foundation uses the SIA as its primary source here). 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 $108.5 billion, making it the largest component of this segment, the SIA does not take it into account in its analysis.

Furthermore, the Space Foundation also includes the value of insurance premiums at $0.5 billion, and the Space Situational Awareness (SSA) segment valued at approx. $100 million. For the SIA and Space Foundation, the year-on-year growth of global space economy stood between 4.9% and 4.9% in 2020-2021.

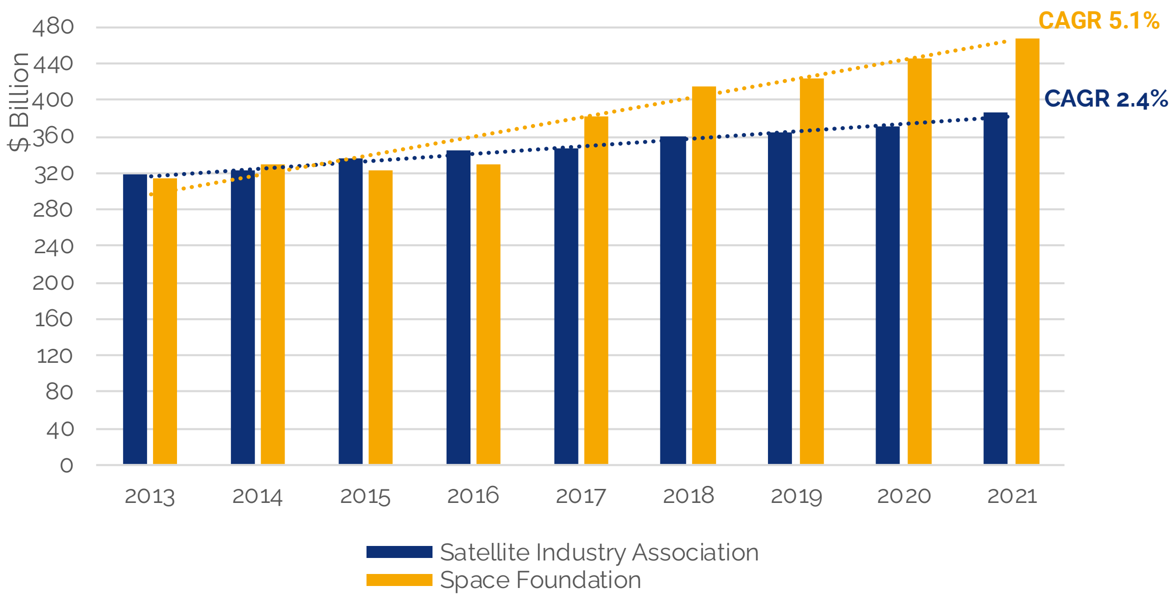


Figure 2: Global Space Economy Evolution (Source: SIA, Space Foundation, ESPI

The compound annual growth rate (CAGR) for the global space economy since 2013 is estimated to be 2.4% for the SIA and 5.1% for the Space Foundation. Whilst the SIA and Space Foundation held broadly similar figures from 2013 to 2016, the inclusion of PNT services by the Space Foundation in 2017 widened the gap with SIA 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.

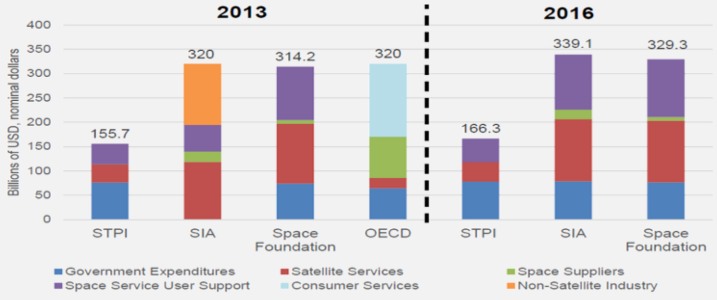
Measuring the space economy: budgets, revenues, gross value added… what is measured and how?

The measurement of the economic value of the goods and services produced by the space sector is another major challenge. 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.

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.



STPI Measuring the Space Economy: Estimating the Value of Economic Activities in and for Space

3.1.1 Commercial satellites and launches

In 2021, the market for commercial satellites and launches was worth $19.4 billion according to the SIA and $6.4 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 $13.7 billion, while according to SF amounted to $4.3 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 4%.

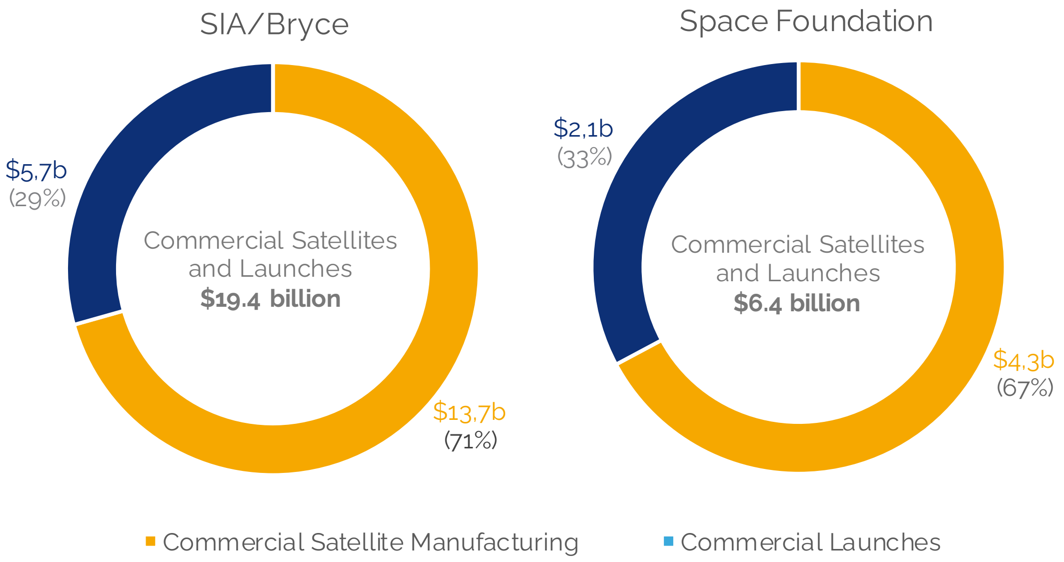


Figure 3: Commercial satellite and launch industry revenues (Source: SIA, Space Foundation)

The methodology used by the Space foundation to estimate revenues from commercial satellite manufacturing and launches has changed considerably, leading to a significant review of the 2020 data. Accordingly, the estimated total revenues of $6.4 billion in 2021 represents a 12.3% increase over the estimated $5.7 billion in revenue in 2020. The SIA reports a significant increase of 10.9% in revenues from $17.5 billion in 2020 to $19.4 billion in 2021.

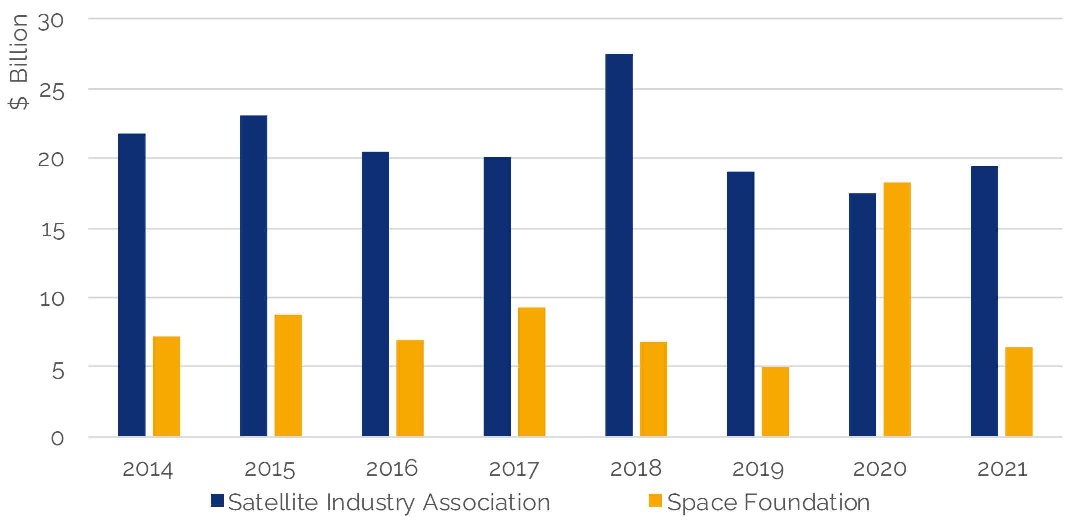


Figure 4: Commercial satellite and launch industry revenue evolution (Source: SIA, Space Foundation)

3.1.2 Commercial launches

To estimate the economic activity related to commercial launches, both SIA and the Space Foundation rely on a market valuation of launches operated during the year that they qualify as "commercial". The SIA and the Space Foundation have documented a different amount of launches: 146 and 145, respectively (commercial and governmental). ESPI recorded a total of 144 launches.

The SIA and the Space Foundation differ in their methodology for qualifying and counting commercial launches. The SIA considers that 113 of the 146 launches were "commercial", with an estimation of the total value of these launches at $5.7 billion. On the other hand, the Space Foundation considers that only 55 out of the 145 launches were "commercial", with an estimation of the total value of these launches at $2.1 billion.

The SIA seems to define "commercial launches" as those involving a financial transaction, including for governmental payloads. This corresponds to 77% of 146 launches in 2021. Just over one third (36%) of this revenue was captured by U.S. industry.

On the other hand, the Space Foundation defines commercial launches as launches carried out for non-government customers, representing 36% of fully or partially successful launches. The economic value of launches for government customers should be covered by the government space budget segment according to Space Foundation's methodology. The Space Foundation estimates the value of governmental launches in the order of $7.6 billion.

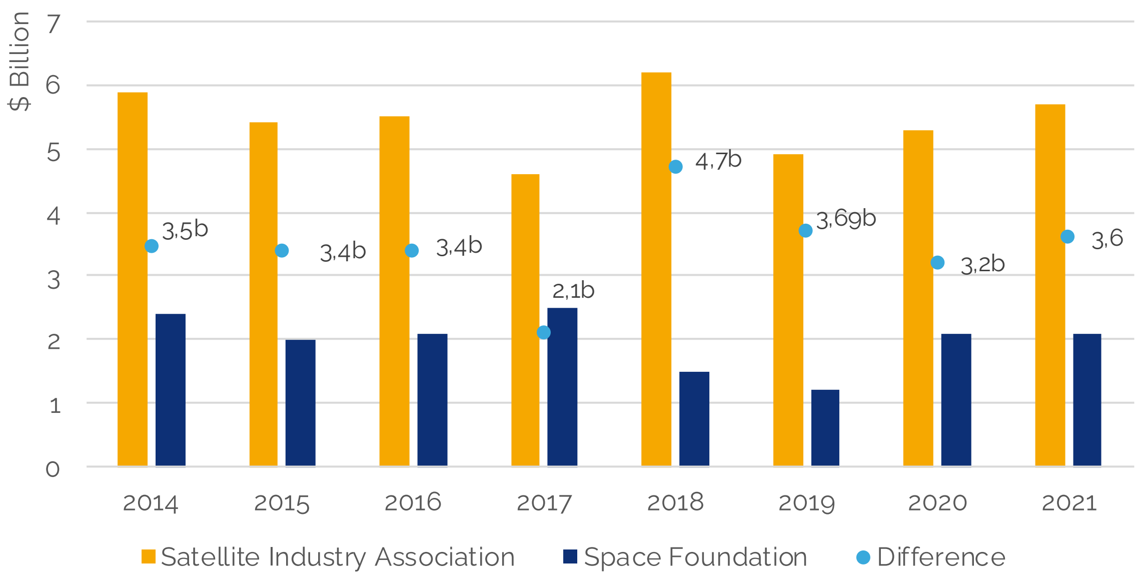


Figure 5: Commercial launch revenues evolution (Source: SIA, Space Foundation)

The difference in estimations between SIA 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 measure in 2017 with only $2.1 billion between the two estimates. The highest revenues from commercial launches were measured in 2018 for the SIA at $6.2 billion, with the 2017 having the lowest at $4.6 billion. On the other hand, the Space Foundation estimates that the higher commercial launch revenues were in 2017 at $2.5 billion, with revenues in 2019 being the lowest at $1.2 billion.

3.1.3 Commercial satellite manufacturing

According to SIA, revenues of the commercial spacecraft manufacturing industry rose from $12.2 billion in 2020 to $13.7 billion in 2021. This represents a major growth of 12% as compared to 2020, but still under the peak of $19.5 billion recorded in 2018 by almost 30%. 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 $4.3 billion in 2021, which represents an increase of 6% compared to the approx. $4 billion revenue recorded in 2020.

Both the SIA and of 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 2021, ESPI recorded a total of 1843 spacecraft put in orbit, including 1576 commercial spacecraft (i.e. spacecraft primarily intended to serve a commercial market and to make profit).

The SIA included 1713 satellites in its estimation in 2021. Out of these satellites, 9% were used for remote sensing and 82% for telecommunication. The Space Foundation, on the other hand, included 1730 spacecraft in its estimation in 2021, out of which 1557 spacecraft were considered commercial for a staggering 90% of commercial payloads.

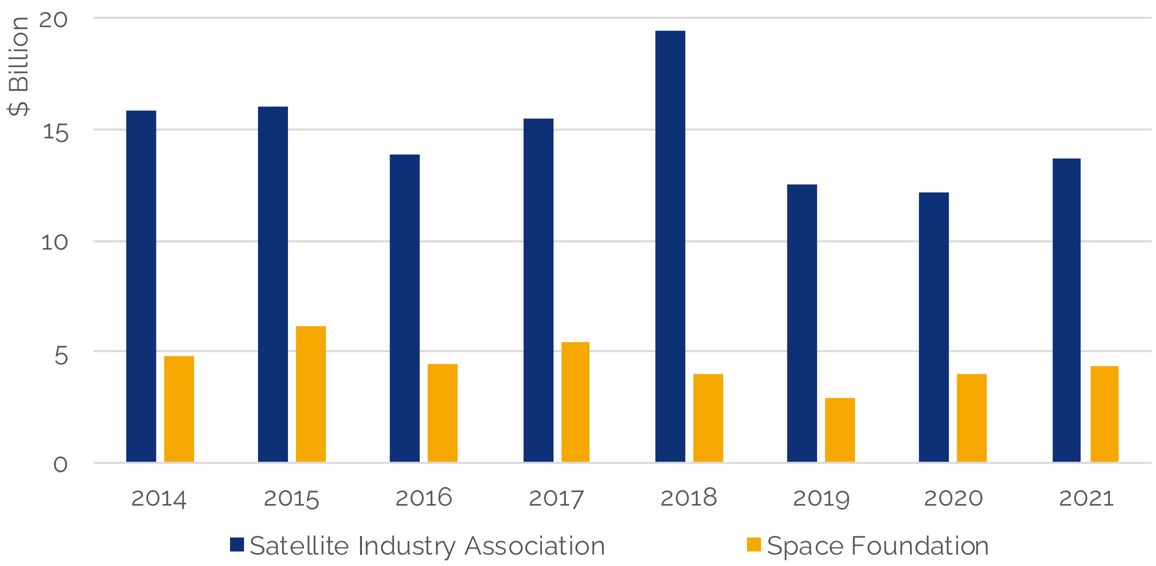


Figure 6: Commercial satellite manufacturing revenues evolution (Source: SIA, Space Foundation)

3.1.4 Ground stations and equipment

The SIA and the Space Foundation estimate the total value of ground stations and equipment revenue in 2021 to be $141.7 billion and $130.3 billion respectively. The difference between these two estimations is related to the value of GNSS chipsets and software, with a difference of $11.4 billion.

Accordingly, this segment represents $98.3 billion, or approx. 75% of the total revenues reported by the Space Foundation, resulting in 16% year over year estimated growth. The SIA reports a similar proportion, at 77% of the $141.7 billion total revenues or a total of $109.7 billion for GNSS equipment. The rest of the segment includes network stations and user equipment such as satellite TV dishes or satellite mobile phones, which both reports estimate to be valued at $32 billion.

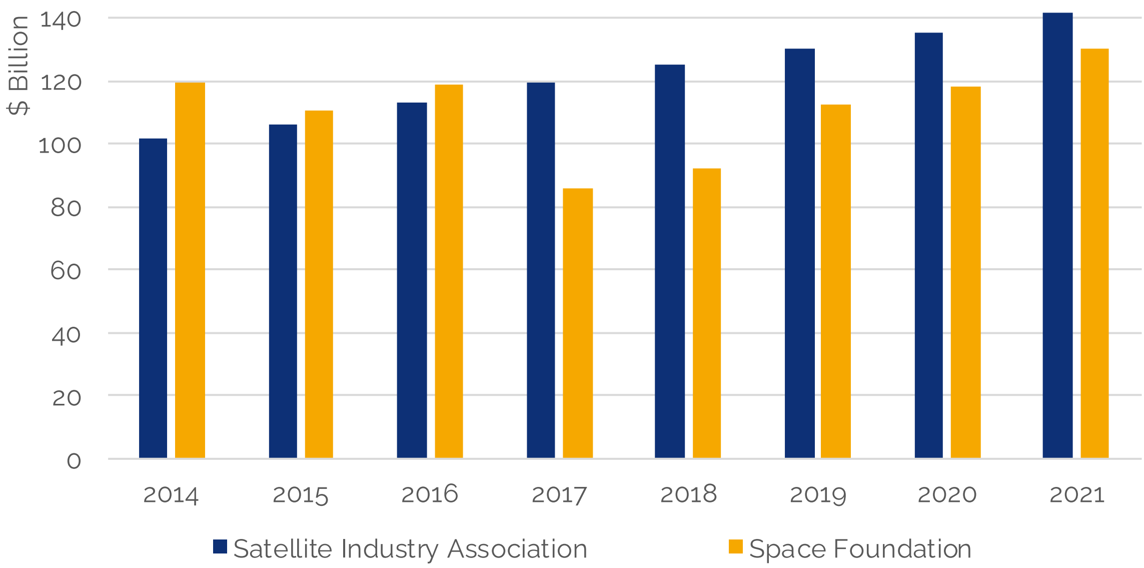


Figure 7: Ground stations and equipment revenues evolution (Source: SIA, Space Foundation)

The SIA data show a continuous growth with a year-on-year increase from 2020 to 2021 of 4.7% This represents an increase from the growth rate between 2019 and 2020 which was of 3.8%. The Space Foundation data show a large drop between 2016 and 2017. However, after this, the segment continued to grow, with a year-on-year increase of 10% between 2020 and 2021.

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 in their assessment).

The space products and services segment are estimated to be $118.3 billion by the SIA and $224.1 billion by the Space Foundation. For the SIA, revenues from space products and services segment increased marginally by 0.4% in 2021 compared to 2020, going from $117.8 billion to $118.3 billion. The Space Foundation's estimate, on the other hand exhibited a more significant growth of 2.1%, from $219.5 billion in 2020 to $224.1 billion in 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 $108.5 billion in 2021, making it the category with most revenues, representing nearly 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 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.

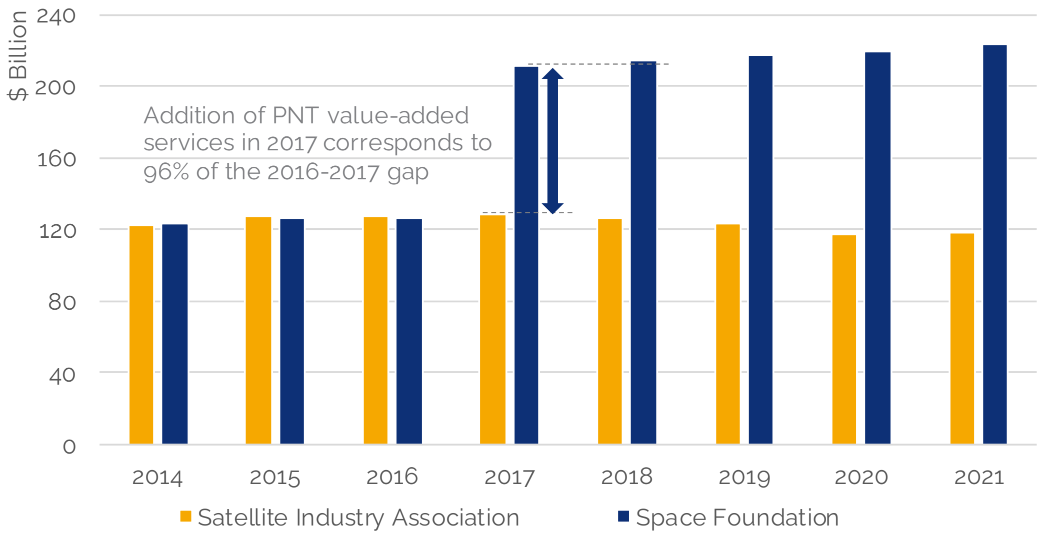


Figure 8: Commercial space products and services evolution (Source: SIA, Space Foundation, ESPI)

Accordingly, the total revenues estimated by the Space Foundation for this sector jumped by almost $85 billion between 2017 and 2018 due to PNT activities being included in the calculation for the first time. PNT activities are also the main drivers behind the increase in revenues from 2018 to 2019 according to the Space Foundation, with an increase in revenues stemming from these activities estimated at approx. 5.3%. Based on data form the GSA, the Space Foundation expects the PNT value added services segment to grow significantly over the next 10 years.

Notably, if we exclude PNT services from the Space Foundation data, the estimated 2021 revenues from space products and services are very similar between the two reports, $118.3 by the SIA and $115.7 by the Space Foundation. The SIA estimates that direct-to-home television was the category with most revenues in 2021, while the Space Foundation data places it in second place, after PNT activities.

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 liability 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.[621] The liability insurance, on the other hand, may be mandatory in some countries for the obtention of a license, depending on their national legislations.[622] 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.[623]

There are currently approximately between 30 and 35 insurers operating in the space industry across the world[624] with an estimated capacity between $650 million and $700 million.[625] In 2022, 38% satellite launches worldwide had insurance, with only approx. 4% of satellites insured. Overall, GEO satellites are more often insured than satellites in LEO.

Accordingly, in 2022 only 63 satellites out of 6100 satellites in LEO were insured for a total of $3.1 billion, representing only 1% of the potential market. On the other hand, out of 870 satellites in GEO, MEO and HEO, 238 were insured for $24.7 billion, representing 27% of the potential market.[626]

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 is 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.

[621] Space Insurance Update, AXA XL, 2019.
[622] Third Party Liability and Insurance Innovation in the Smallsat Era, Mathieu Luinaud, Virgile Salmon, December 2020.
[623] The Space Insurance Landscape, Payload, October 2022
[624] Space Insurance and Collision Risk, AXA, March 2021.
[625] More space insurers head for the exit: Allianz & Aspen Re, Seradata, September 2021.
[626] Connecting the Dots | Space insurers toast another profitable year, SpaceNews, January 2023.

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 packages 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 property 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.[627]

Even third liability insurance, required for launch in the U.S.,[628] 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, instead of buying insurance from a third party.[629]

Still, **space insurance companies are trying to adapt their business practices to New Space companies**.[630] 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.[631]

Revenue growth trend in 2022 amidst worrying market conditions

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 2022, space insurance companies confirmed the trend of a return to profits, recording $654 million in premiums and only $294 million in claims. Nevertheless, $75 million in premiums are connected with the Russian space industry, and cannot be executed by the space insurance companies due to the sanctions. Therefore, the net premium in 2022 amounted to $285 million.[632]

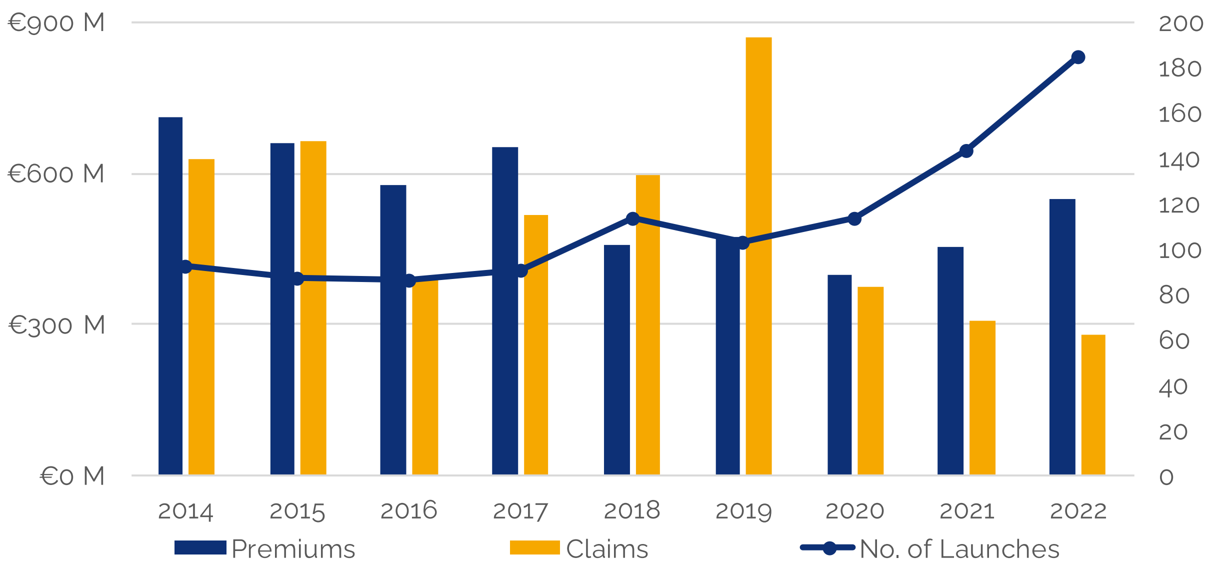


Figure 9: Insurance premiums and claims 2014-2022 (Seradata, AXA XL, ESPI)

[627] Space insurance premiums rose by 2x-3x in late 2019 and the increase is holding — so far, Space Intel Report, March 2020.
[628] Section 16 of the Commercial Space Launch Act, 1984.
[629] Blue Origin to perform first New Shepard launch under updated license. SpaceNews, August 2021.
[630] Insurers to New Space: Be patient with us as we adapt and learn to price your risk, Space Intel Report, December 2021.
[631] Space insurers just might book 2020 as a gross profit, but with the lowest premium volume, Space Intel Report, May 2021.
[632] Connecting the Dots | Space insurers toast another profitable year, SpaceNews, January 2023

However, despite the positive results observed in the last three years, some trends are worrying the insurance market. Firstly, many New Space companies focuses on smaller (and cheaper to replace) LEO satellites instead of the traditionally insured GEO satellites. Secondly, the insurance rates have been decreasing 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.[633]

2019 saw big losses, pushing insurance companies to bring their premiums rates up, after a multi-decade downward descend since the inception of the market in the 1960s.[634]

But this did not reverse the underlying downward trend of premium rates, which seem increasingly more connected to supply and demand by insurance providers than the actual risk. Even though in recent times, various insurance providers, big and small, left the market (such as Swiss Re, AIG, Allianz, Aspen, Assure Space), they were quickly replaced by others, which kept the premium rates low. Accordingly, the volume of premiums in 2022 is still lower than in 2017, and well below the peak of the market achieved in 2012, just shy of $1 billion.

Thirdly, space insurers are worried of the increasing dependence of the space market on a single launch vehicle (SpaceX's Falcon 9), while the current backlog for new launchers will take time to mature and thus present themselves as insurable assets.[635]

The positive results of these last 3 years are thus not a result of a change in the underlying conditions but because claims have been at historic lows. Therefore, if there is a high profile claim, like the Falcon Eye-1 in 2019, there could be a repeat of the same negative scenario, and it is uncertain how the space insurance market would fair in a return to those market conditions.[636] Indeed, such a scenario can turn into reality in 2023 as the Viasat-3 Americas communications satellite failed to deploy its main mesh antenna, which can result in an insurance claim of $420 million.[637]

2018	Reported claims	Cause
WorldView-4	$183 million	In-orbit failure
Angosat-1	$121 million	In-orbit failure
Al Yah 3	$115 million	Partial launch failure
Soyuz MS-10	$71 million	Launch failure
Turksat-4b	$25 to $60 million	Partial launch failure
2019		
Falcon Eye-1	$415 million	Launch failure
ChinaSat-18	$250 million	Post-launch anomaly
Eutelsat 5 West B	$192 million	Partial failure

[633] More space insurers head for the exit: Allianz & Aspen Re (Corrected), Seradata, September 2022
[634] The Space Insurance Landscape, Payload, October 2022
[635] Space Insurance: Premium rates remain stable for now but underwriter sentiment turns against Arianespace, Seradata, March 2023.
[636] Space insurers: Lower premiums, rate declines and new launchers means market's heading into danger zone again, Space Intel Report, June 2023.
[637] Viasat confirms that its Viasat-3 Americas comsat has serious Ka-band antenna deployment issue, Seradata, July 2023.

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

Table 2: Major insurance claims in the space sector 2018-2022 (ESPI compilation)

There were also some notable positive developments for space underwriters. OneWeb's decision in 2021 to insure more than $1 billion in assets during the launch flight phase of its LEO constellation was a positive development for underwriters in their expansion into the LEO market.[638]

The public push towards new space sustainability policies could also 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.[639]

Moreover, there are new potential markets to explore, such as commercial human spaceflight and insurance for moon assets. Notwithstanding the risks involved, which are being analysed by the market, insurance companies see these developments as opportunities where their services can be provided, especially regarding commercial space stations.[640] As an example, JAXA and Mitsui Sumitomo Insurance announced in 2022 that they would jointly develop insurance products for space tourism.[641]

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".[642]

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638 OneWeb signs a mission critical launch insurance agreement through Marsh, OneWeb, October 2021.
639 Space insurance underwriter sees a turnaround in premiums starting this year, Space Intel Report, October 2022.
640 The Space Report 2022 (Q1), Space Foundation, April 2022.
641 JAXA and Mitsui Sumitomo to sell insurance for civilian space travelers, The Japan Times, August 2022.
642 ispace Reaches Agreement with Mitsui Sumitomo to Become World's First User of Commercial Lunar Insurance, ispace, November 2022.

3.2 Institutional Space Budgets

The following section makes use of Euroconsult data for national space budgets with their permission.

Data are extracted from the Euroconsult Government Space Programs report which provides a comprehensive assessment and analysis of national space programs and space budgets. Various sources of information are collected by Euroconsult on government space programs and budgets from government agencies' primary information, public sources, and estimates. This information is harmonised and processed to form a coherent set of data.

Government Space Programs (Source: Euroconsult)

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 Euroconsult report is available **here.**

3.2.1 Global overview and evolution

The total governmental budget for space programmes in 2021 is estimated to be $107 billion by SIA/Bryce, $107.3 billion by the Space Foundation, and $92.4 billion by Euroconsult.

Even though in 2021 the Sia and Space Foundation estimates were very similar, the variation in relation to Euroconsult's data is notable, mainly due to the difference in the definition and the perimeter selected in the scope of each study. In terms of year-on-year evolution, while Space Foundation records an increase of $16.8 billion (19%) in 2021, Bryce reported an increase of $6.3 billion (6.3%). And Euroconsult reported an increase of $9.5 billion (8%).

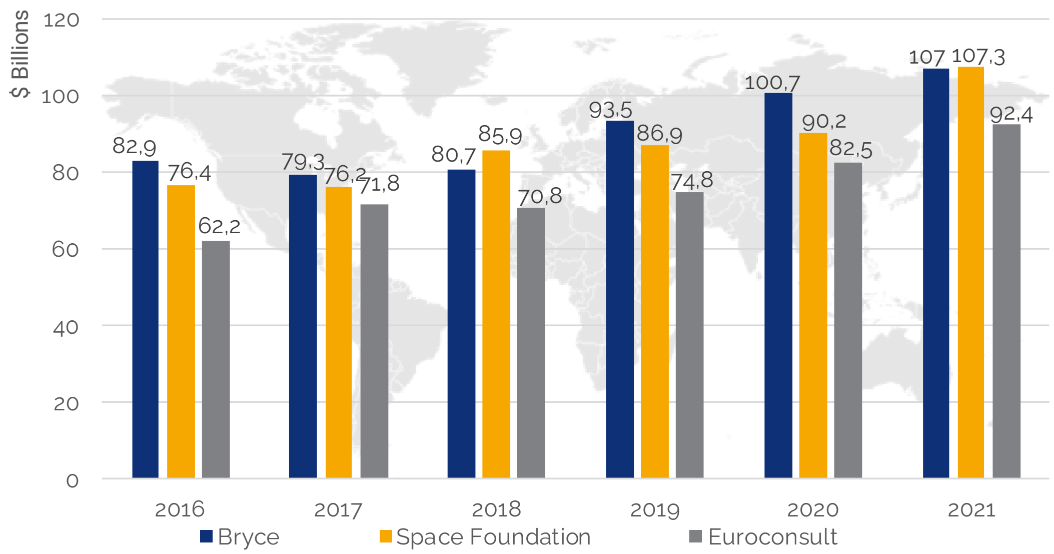


Figure 10: Global institutional space budget evolution (Source: SIA, Space Foundation, Euroconsult)

It is important to note that institutional budgets provide an incomplete perspective on governments' respective investment 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.

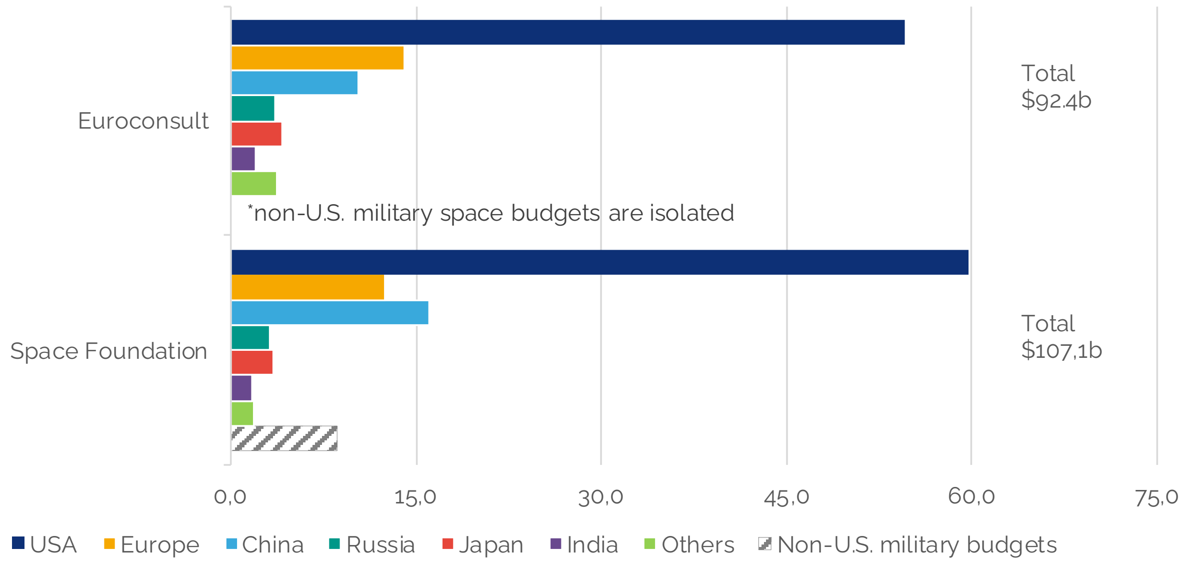


Figure 11: Institutional space budgets in 2021 (Source: Space Foundation, Euroconsult)

When comparing the specifics of institutional space budgets, **Euroconsult diverges from the Space Foundation in its estimation of China's and Europe space budget, considering Europe's budget to be significantly larger than China's by 37% or $3.8 billion. This is contrary to the Space Foundation estimate that sees China's budget as larger than Europe's by a total of $3.7 billion or almost 30% larger**. This divergence can be caused my multiple factors and notably by the fact that China's real budget is unknown.

With regard to the world military space budget, the Space Foundation indicates significant growth from $32.1 billion to $42.7 billion between 2020 and 2021 or a $10.6 billion increase originating 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 its estimate of the world civil budget increased from $60.3 billion to $64.2 billion between 2020 and 2021. This increase in civil budget is a result of increased civil expenditure in most of the countries with largest budgets, such as the U.S. and China.

Euroconsult have slightly lower figures in total; however, it highlights a 20% increase of military budgets in 2021, reaching a total of $38.9 billion in comparison with $32.4 billion in 2020. Euroconsult also shows a growth in global civil budget growing from $50.1 billion in 2020 to $53.5 billion in 2021.[643]

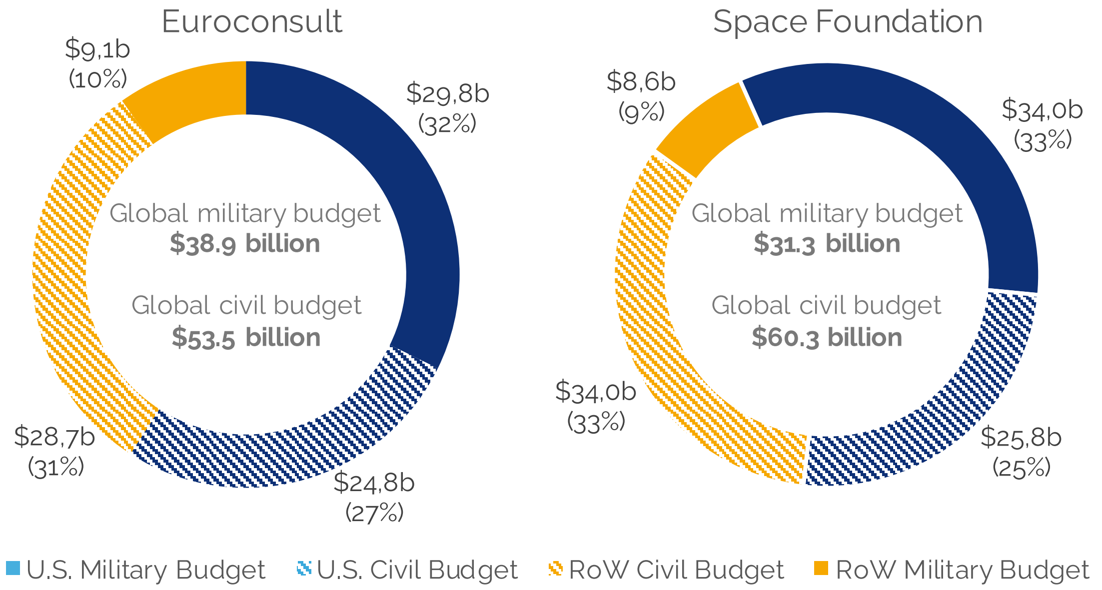


Figure 12: Civil vs Military budgets in the U.S. and Rest of the World in 2021 (Source: Space Foundation and Euroconsult)

In comparison with the previous year, in 2021 the United States share of the global space budgets jumped by almost 20%, accounting for approx. 58% to 59% of expenditures on global space programmes, depending on the organisation assessing. Nevertheless, when performing a long-term analysis, there is a gradual decrease observed in the last few years these figures are far from the share of 75% in the early 2000s. This can be explained by the growth rate of budgets for other nations, which has increased at a faster rate over the last two decades.

The prominence of the United States in the space sector is boosted by its military budget. The U.S. military budget is estimated by the Space Foundation to be $34 billion, significantly higher than the civil budget of $25.8 billion. Moreover, it was the increase in military budget the main driver in the overall U.S. space budget, increasing by 21.8%, from $26.6 billion in 2020, while the civil budget only increased by 2.3%, from $25.2 billion in the previous year. More than half (56.9%) of the U.S. space budget goes to military departments. In contrast, only 20.2% of the space budget for the rest of the world goes to military budgets, at $8.6 billion. This makes the U.S. military budget approx. 4 times larger than that of the rest of the world.

Euroconsult reports similar proportions, although the overall budget is reportedly smaller. The U.S. military budget was recorded as $29.8 billion in 2021, with the rest of the world spending $9.1 billion. This means the **U.S. spends 3.3 times more than the rest of the world on military space**. The U.S. spends $24.8 billion on civil programmes, with the rest of the world spending $28.7 billion.

[643] Government Space Budgets Surge Despite Global Pandemic, ViaSatellite, 2021.

3.2.3 Space budget per country

Nominal space budgets

In 2021 Euroconsult estimated the total global institutional space budget at $92.4 billion. As in the previous years, in 2021 the U.S. budget is larger than all the other combined. The second largest spender is China, which budget is estimated at $10.29 billion. Similarly, to 2019, the next places are taken by France, Russia, and Japan. These top five largest space budgets represent over 80% of the global total.

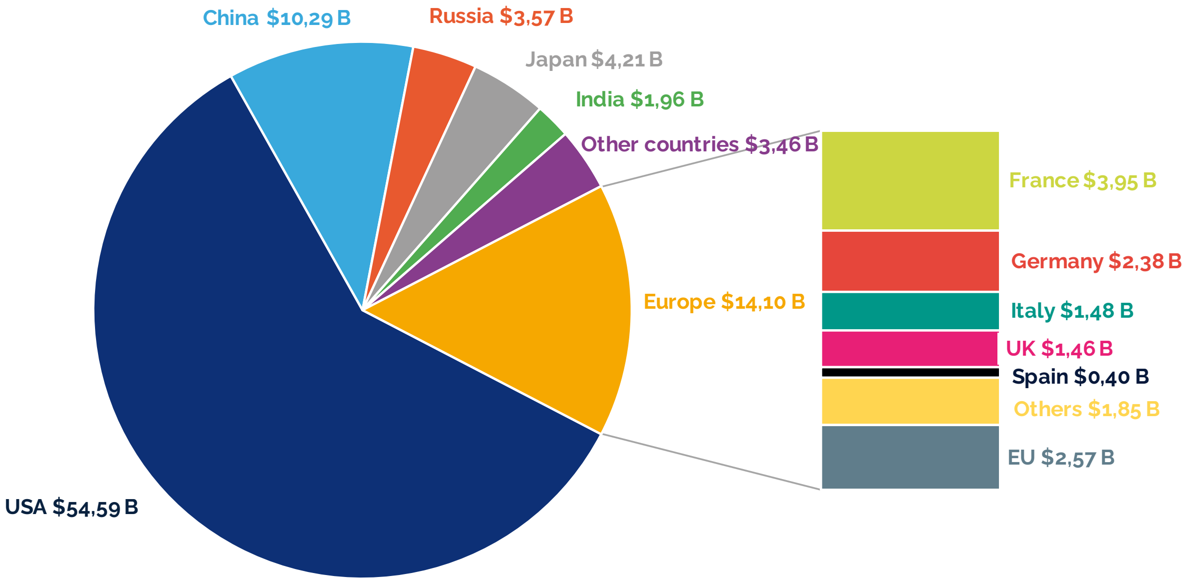


Figure 13: Institutional space budget per country in 2021 in USD (Source: Euroconsult)

In 2021 the U.S. remained the country with the largest institutional space budget, which reached $54.59 billion. Between 2020 and 2021 the budget grew by $6.9 billion (14.4%). This increase is three times the $2 billion growth already seen in 2019. In contrast, the Space Foundation reports slightly smaller numbers than Euroconsult. The Space Foundation estimates that the U.S. budget reached $51.8 billion in 2021, a 9.8% increase year over year.

There was no change either in terms of the second place, which has been taken by China since several years. Euroconsult estimates the Chinese budget at approx. $10.29 billion, whereas the Space Foundation gives it a much higher valuation of $13.4 billion. Interestingly, even though the Space Foundation estimation is higher than the one provided by Euroconsult, it claims to include only civil budgets.

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 with valuating 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.

The **3rd place, not taking aggregated regional budgets into account, is taken by Japan, which budget is estimated by Euroconsult at $4.21 billion**. Japanese spending increased by 27.6% year over year. The growth was so significant that the Japan now ranks before Russia in terms of governmental space budget.

Euroconsult reports French budget as $3.95 billion, which makes it the fourth largest in the world in 2021. According to the estimates, the public spending in France decreased at -1.25% year over year. The estimated French budget includes French contributions to ESA and EUMETSAT but does not cover the share of the EU space budget provided by France.

The 2021 Russian spending is estimated at $3.57 billion, which means it is the 5th largest budget worldwide observed by Euroconsult. The valuation remains nearly the same as the one from 2020, estimated to be $3.6 billion.

The European space budget, understood here as the sum of ESA and EU member states budgets (excluding Canada) reached $14.10 billion according to Euroconsult. The valuation of each country's budget includes contributions to ESA and EUMETSAT (wherever applicable) and the EU space budget is reported separately. The French budget estimated at $3.95 billion is the largest in Europe and stands for almost 30% of the total European space budget. The EU spends the second largest sum of $2.57 billion which represents 18.3% of the European total. Third comes Germany with an estimated institutional spending of $2.38 billion, and represents 16.8% of the total. Other European countries with significant space budgets are Italy ($1.48 billion, 10.5% of total), the United Kingdom ($1.46 billion, 10.4%) and Spain ($399 million, 2.8%).

It was previously highlighted which country spends most in nominal values. However, countries across the world vary considerably in terms of their economic and demographic potential. Clearly, **what is a large budget for a smaller economy may be a marginal one for one of the global leaders**.

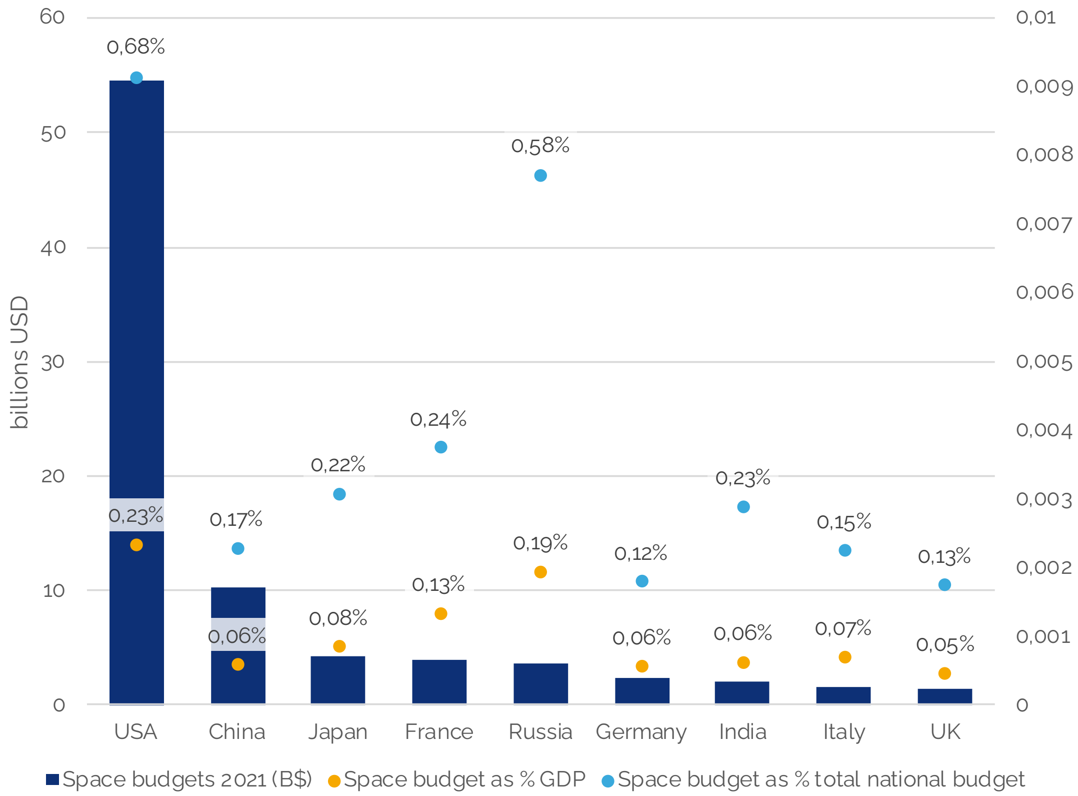


Figure 14: Space budgets as % of GDP and as % of total government expenditure in 2021 (Source: Euroconsult, IMF, ESPI)

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 a 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 0.68% of the national budget on space related initiatives. Second highest result is obtained by Russia, which allocates 0.58% of the budget on space programmes. The third place is taken by France, which allocates 0.24%, followed by India and Japan, allocating 0.23% and 0.22% 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, 0,13% and 0.12% respectively.

If national space budgets are compared with the total GDP, the U.S. comes first again. The U.S. space budget represents the 0.23% of the GDP. Russia boasts a lower ratio of 0.19%. **Third place is taken by France, whose space budget value is equal to 0.13% of the French GDP. All the other countries' space budgets represent somewhat between 0.08% of the total GDP (Japan) and 0.05% (the UK)**.

In 2021, the U.S. boasted both the largest nominal space budget, the highest share of space budget in the total national budget, and in the GDP. Interestingly, in 2020, the U.S. was second both in terms of the share of the space budget in the total budget (0.66%) and in the GDP (0.23%). Conversely, Russia, which in 2020 had the fourth largest nominal space budget ($3.58 billion), came first in those metrics (0.72% and 0.24%). Although the relative measures for Russia were only slightly larger than the U.S. ones, this difference gained much more significance when combined with the fact that the Russian nominal budget was over 13 times smaller than the American. The conclusion can be drawn that the space budget is equally important in both countries, but contrary to 2020 the U.S. reversed the trend in its favour. Another interesting observation can be made about India. The **Indian space budget is the seventh largest in nominal values, however, the share of the space budget in the total national expenditure is the fourth largest in the world. A conclusion may be drawn that even though China, Japan and Germany boast larger space budgets in nominal values, the priority of space funding in India is higher**, which is illustrated by a higher share of the space related spending in the total volume.

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.

However, adjusting the space budgets for purchasing power parity may have stronger limitations than usually, since the prices on the space goods market are less elastic than on 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.

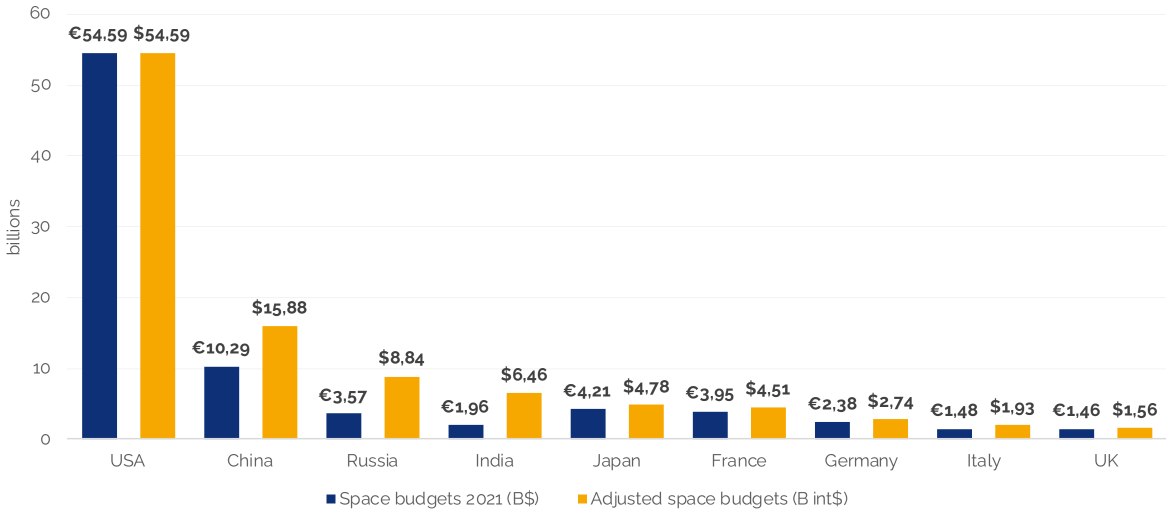


Figure 15: National budgets per capita adjusted for PPP (Source: Euroconsult, IMF, ESPI)

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 Russia and India, which adjusted budgets tripled compared to nominal ones. 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. Despite a significant raise China remained second, however, the other emerging economies advanced significantly. Russia solidified its 3rd position and India the 4th, overtaking Japan, France, Germany, Italy, and the UK.

The U.S. government spends $164 per capita which allows the U.S. to confirm its primacy in the metric. **The second largest result of $58 per capita is obtained by France**. The third place is taken by Japan which spends $34 per capita. Chinese and Indian budgets per capita are the lowest $7 and $1 respectively.

With respect to **PPP adjusted space budgets per capita**, the U.S. results remain unchanged, since, as mentioned before, the U.S. dollars are the reference point for the adjustments. Second and third come France and Russia with PPP adjusted space budget per capita of $67 and $62 respectively. The fourth largest result is obtained by Japan ($38) followed by Germany and Italy *ex aequo* ($33). China and India take again the last two positions with PPP adjusted space budgets per capita of $11 and $5 respectively.

The U.S. comes first in both metrics, the same as in the comparison of the total volumes. However, in the per capita approach the U.S. domination is reduced. For instance, the U.S. nominal budget is thirteen times larger than the French one, but in per capita approach it is only two and half times larger. An even smaller difference is observed when it comes to PPP adjusted space budgets per capita, which not only reduces the proportion between the U.S. and France to two, but also allows Russia to obtain a result equal with France. It means that Russian PPP adjusted space budget per capita nearly tripled in comparison to the nominal space budget per capita.

The most significant change occurs when it comes to the position taken by China. Although China has the second largest space national budget, per capita they come eighth, spending as much as $7 per capita in nominal values and $11 in the PPP adjusted.

By the same token India comes 7th in terms of nominal budget and last in both nominal space budget per capita ($1) and PPP adjusted space budget per capita ($5). It should be underlined that

China and India are also the two largest countries worldwide, which together represent around 1/3 of the world population.

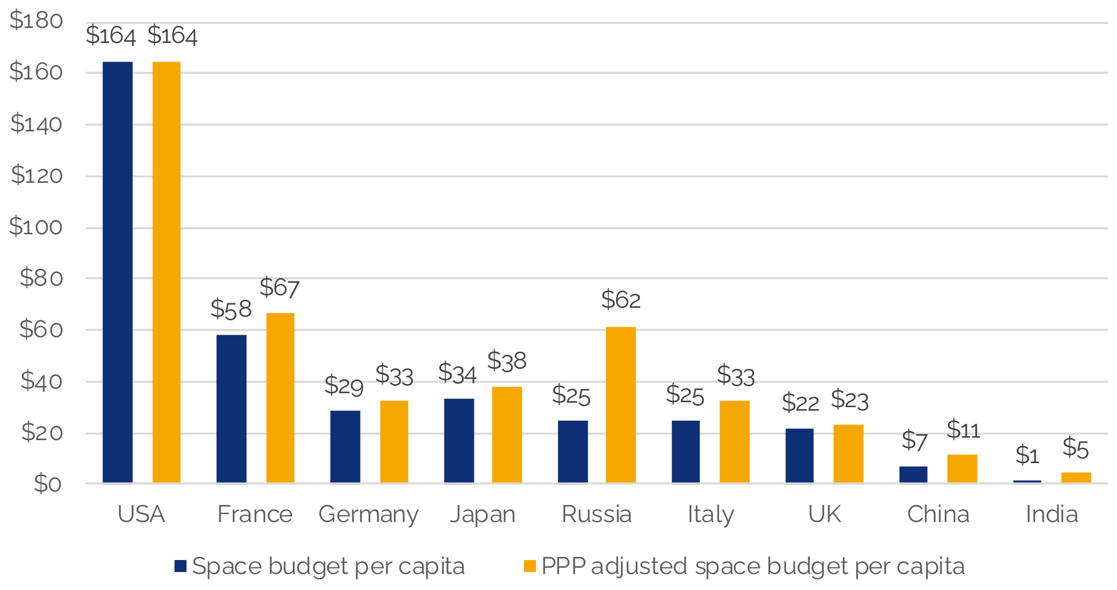


Figure 16: Space budget per capita in 2021 (Source: Euroconsult, World Bank, ESPI)

The differences between countries are not as clear as they might seem if only nominal budgets were taken into consideration. Although the U.S. occur to obtain 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 proportions turn out to be roughly the same for the U.S. and Russia. This can be interpreted that the space budget is equally important for both countries, they just differ in terms of their economic potential. Another important aspect is brought to light when the national space budgets are adjusted for purchasing power parity. 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.

3.3 European space budgets

3.3.1 Consolidated European space budget

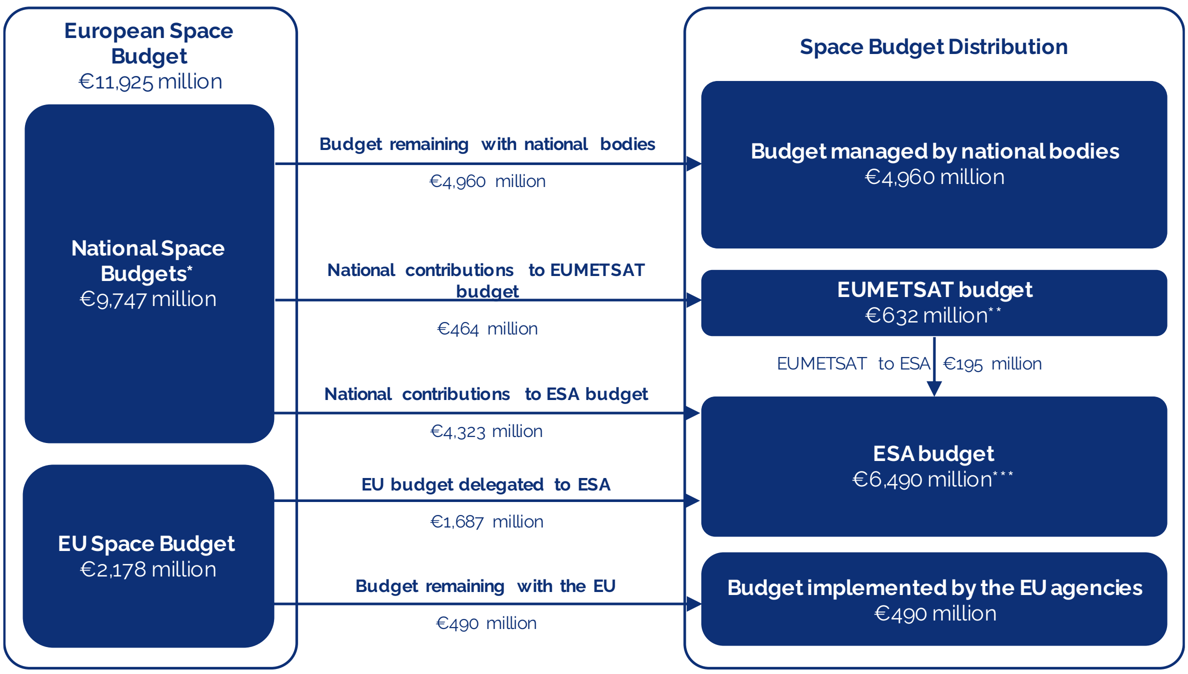
Space budgets in Europe are intertwined with a variety of budget transfers (delegations, contributions) between different national, intergovernmental and supranational actors. Overall, and after consolidation, ESPI estimates the consolidated European space budget was around €11,925 million in 2021 (Figure 17).

This includes two main sources of public funding:

- National space budgets are the primary source of public funding in Europe. In 2021, the total space budget of European countries (ESA and EU member states) was around €10,277 million.
- This budget includes:
  - Contributions to the ESA budget of €4,323 million
  - Contributions to the EUMETSAT budget of €464 million
  - Budget remaining with national bodies for the management of national space programmes and other space projects outside ESA and EUMETSAT
- 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 2021, the EU space budget represented an additional public investment of €2,178 million.

In 2021, the budget of the European Space Agency was €6,490 million, including income from EUMETSAT of around €195 million.

Consolidated European Space Budget 2021



*National Space Budgets include all budgets of EU and ESA member states excluding Canada

** EUMETSAT budget includes €144 million from other sources including the contribution from Turkey

*** ESA budget includes funding from other sources including the contribution from Canada

Figure 17: Consolidated European space budget 2021 (ESA, EUMETSAT, Euroconsult, 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 ESA Member States in 2021.

Country	National space budgets in 2021	ESA contribution	National activities
Austria	€ 73.6 M	€ 54.8 M	€ 18.8 M
Belgium	€ 280.0 M	€ 255.8 M	€ 24.2 M
Czech Republic	€ 62.6 M	€ 43 M	€ 19.6 M
Denmark	€ 44.8 M	€ 33 M	€ 11.8 M
Estonia	€ 6.2 M	€ 2.7 M	€ 3.5 M
Finland	€ 58.4 M	€ 27.5 M	€ 30.8 M
France	€ 3,343.4 M	€ 1,065.8 M	€ 2,277.6 M
Germany	€ 2,010.9 M	€ 968.6 M	€ 1,042.3 M
Greece	€ 28.8 M	€ 19.9 M	€ 8.9 M
Hungary	€ 24.5 M	€ 16.8 M	€ 7.7 M
Ireland	€ 25.4 M	€ 18.8 M	€ 6.6 M
Italy	€ 1,252.9 M	€ 589.9 M	€ 663 M
Luxembourg	€ 156.5 M	€ 46.9 M	€ 109.6 M
Netherlands	€ 141.3 M	€ 87.9 M	€ 53.4 M
Norway	€ 161.6 M	€ 83.2 M	€ 78.4 M
Poland	€ 61.8 M	€ 39 M	€ 22.8 M
Portugal	€ 49.9 M	€ 28 M	€ 21.9 M
Romania	€ 54.1 M	€ 43 M	€ 11.1 M
Slovenia	€ 11.0 M	€ 3.1 M	€ 7.9 M
Spain	€ 337.6 M	€ 223.6 M	€ 114 M
Sweden	€ 110.0 M	€ 80 M	€ 30 M
Switzerland	€ 213.2 M	€ 172.6 M	€ 40.6 M
United Kingdom	€ 1,238.5 M	€ 418.8 M	819,7 M

Table 3: National space budgets of European countries in 2021 (Source: Euroconsult, ESA, ESPI)

3.3.3 European Space Agency

The ESA budget saw an overall growth trajectory. In 2022, ESA budget reached €7,152 million which is a 10.2% increase compared to the 2021 budget of €6,490 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 reflect in the years to come**.

In terms of programmes, the Earth Observation budget remains the largest budget allocation at ESA accounting for €1.613 million which represents 22.5% of the total ESA budget, growing 12% as compared to the EO budget in 2021. The second biggest programme in terms of budget allocation is Navigation. The Navigation programme saw a 25.3% increase year over year, going from €1.224 million in 2021 to €1.534 million in 2022. It now upholds 21.4% of the total ESA budget. Both EO and Nav represented together in 2021 43.9% of the total ESA budget.

The space transportation programme was one of the few programmes with a budget decrease in 2022, going from €1.175 million or 16.4% of the total budget in 2020 to €1.006 million in 2021 or 14.1% of the total budget, representing a considerable decrease of 14.5%.

Following Space transportation, the biggest programmes in terms of budget allocation are Human Spaceflight at 13%, Scientific Programmes at 8.1% and finally Telecommunications and Integrated Applications at 7.2% .

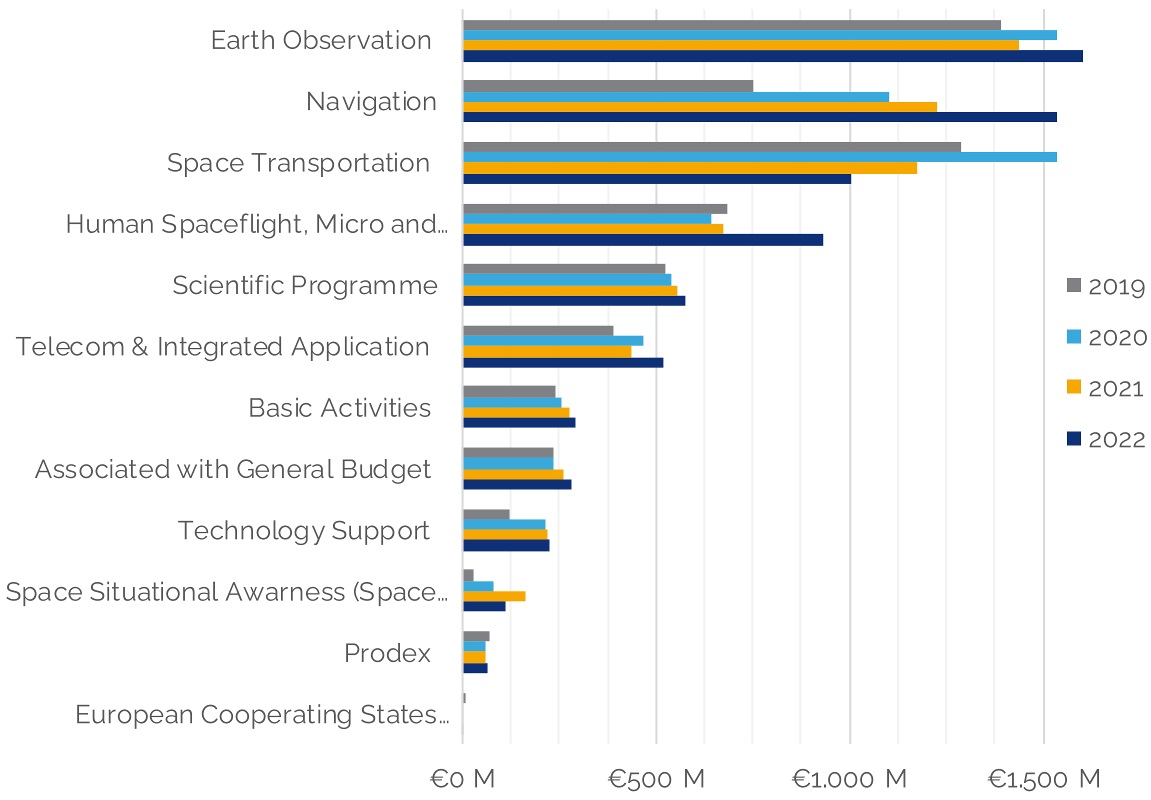


Figure 18: ESA programmatic budget allocations from 2018 to 2021 (Source: ESA)

The increase of the total budget was a result of the increased national contributions, which grew from €4348 million in 2021 to €4596 million in 2022, a change of 6% compared with 2021. The majority of member states increased their contributions to ESA, including the top four contributors France, Germany, Italy and the UK. The total increase of these 15 countries sums up to 305 million, while the top four represent 88.4% of the increase.

With the increase of 10.5%, France continues to be the largest contributor to ESA, accounting for €1,178 million or over 26% of the total member states contribution. Also, the German contribution grew year over year, however, much less significantly than the French. In 2021 Germany allocated €1018 million, representing 5% more than in the previous year. The German contribution represents approximately 22% of total member states contributions. The third largest contributor Italy (€680 million) and the fourth United Kingdom (€438 million) followed the trend and increased their contributions by 15.3% and 4.6% respectively. Conversely, Belgium (€238 million) substantially decreased its share of funding by nearly 7% year over year, but still maintaining its fifth position over Spain, which is was relegated to sixth position in 2021. The other countries which increased their contribution are Switzerland, the Netherlands, Luxembourg, Czechia, Poland, Denmark, Finland, Greece, Ireland, Hungary and Latvia. However, it should be underlined that France, the UK, Netherlands, Ireland and Greece had reduced their funding in 2021 so much, that the 2022 raise was not enough to reach their level of funding from 2020.

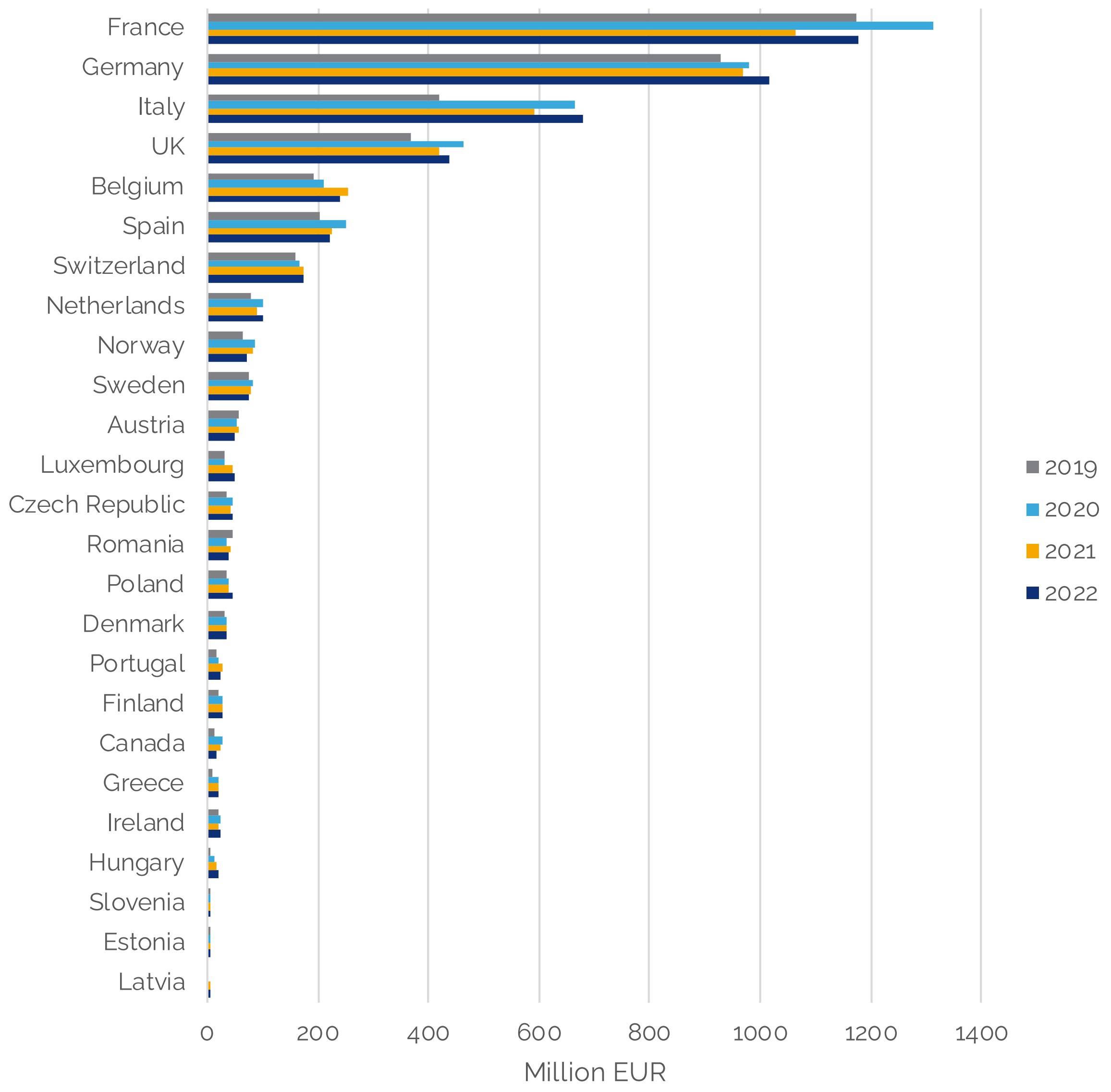


Figure 19: Member states contributions to ESA budget from 2018 to 2021 (Source: ESA)

The figure below illustrates the distribution between national budgets and the national contributions to the ESA budget. Only a few countries keep more than 50% of their national space budget under national management, however, interestingly, the two largest ESA contributors France and Germany are among those. Belgium contributes the largest proportion of its space budget to ESA (91%).

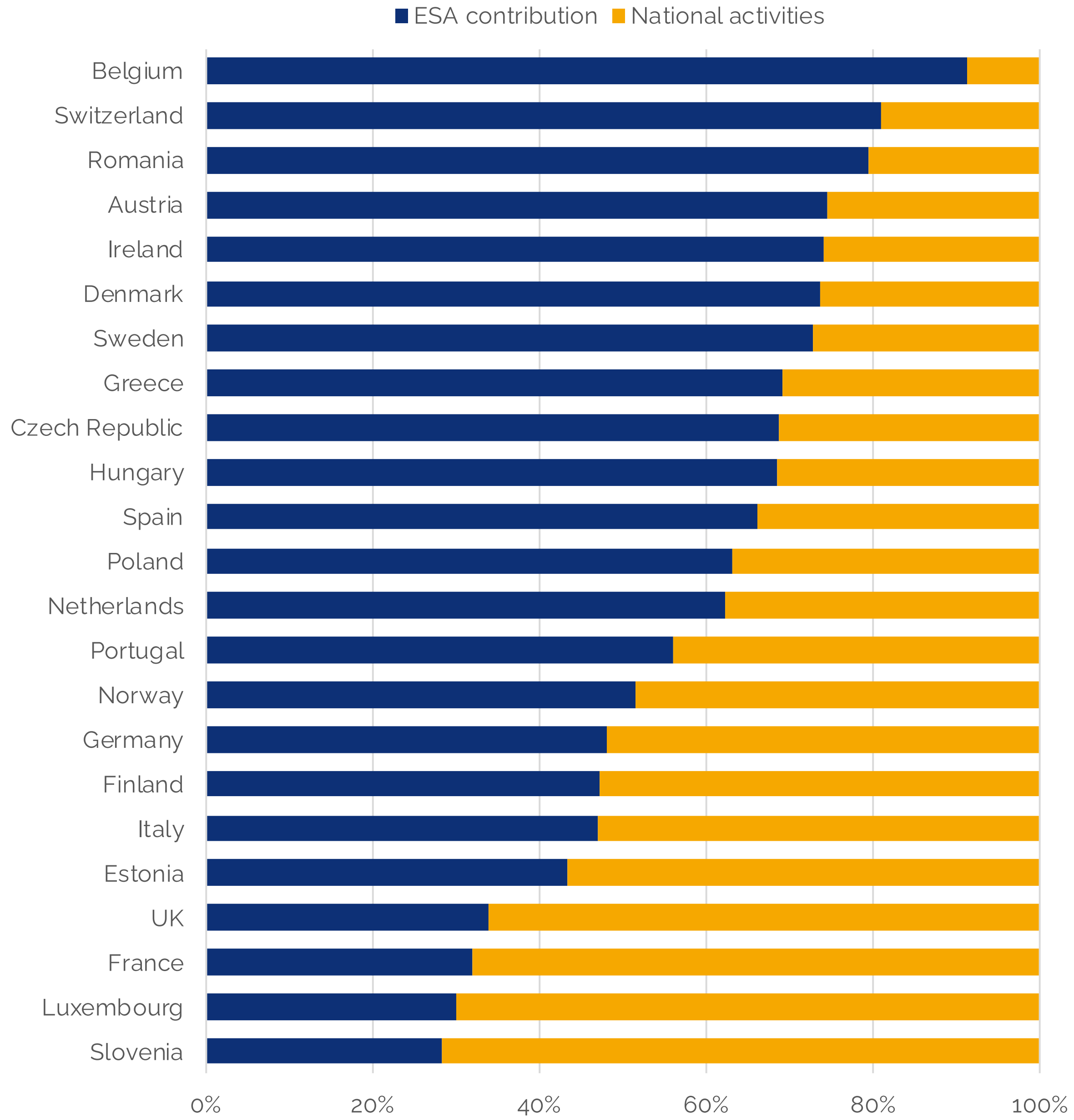


Figure 20: Member states budget allocation comparison in 2021 (Source: ESA, Euroconsult, ESPI)

3.3.4 European Union

The European Union conducts various space activities that are implemented and managed by different executive bodies and agencies including in particular the European Commission, the European Union Agency for the Space Programme (EUSPA) and the 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 2021, the European Union space budget stood at €2,076.5 million. €2,008.2 million are dedicated to the European 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**. Due to a series of challenges that the European Union has been facing, such as the war in Ukraine, the Covid-19 economic recovery and the twin transition, in June 2023 the EU Commission proposed a **mid-term review of the MFF budget** to increase the. The aforementioned programmes could see a budget increase. The Commission's objective reach an agreement until the end of 2023.

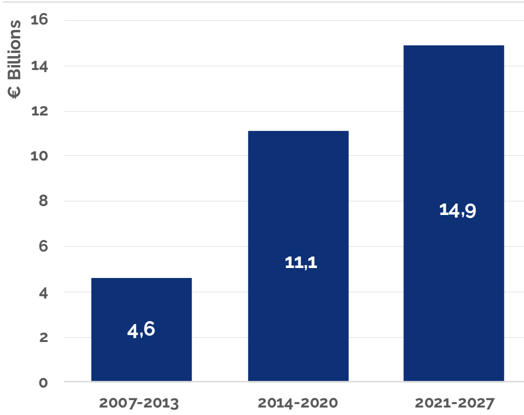


Figure 21: Evolution of Space budget in EU MFF (figures in € billion, current prices)

Galileo and EGNOS

In 2022, the European Union committed 1.15 billion to the Galileo/EGNOS programme, representing an approx. 7,6% decrease from 1.25 billion in the previous year. 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 2022, the European Union dedicated about €700 million to Copernicus, which represents a decrease of 1% compared to the €707.3 million committed in 2021. 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 EU has also provided for an increase in budget for the development of its Space Situational Awareness and GOVSATCOM initiative as part of the EU Space Programme. As part of the new MFF, the EU has committed €442 million to SSA and GOVSATCOM.

The committed appropriation for the GOVSATCOM and SSA saw an increase of 305,7%, from €37.1 million in 2021 to €150 million in 2022. 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.

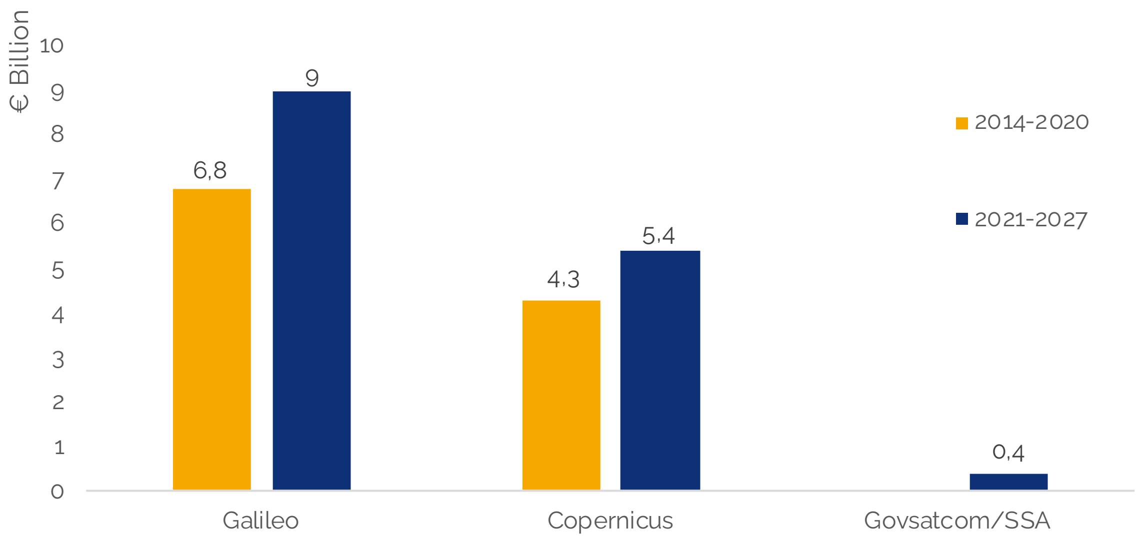


Figure 22: Evolution of budgets Galileo, Copernicus and Govsatcom/SSA between MFF 2014-2020 and MFF 2021-2027

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 overlining 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.

The EIC will support research and innovation on the continent through three main instruments, which include:

- The **EIC Accelerator**, with a budget of €1.16 billion in 2022, to support European companies to scale up and develop their disruptive, high risk and high impact technologies.
- The **EIC Pathfinder**, with a budget of €350 million in 2022, to support research in breakthrough and highly disruptive technologies.
- The **EIC Transition**, with a budget of €131 million in 2022, to support the transition between research and real innovation opportunities.

InvestEU Programme

The **InvestEU programme** and the **InvestEU Fund** are projected to have a key role in this regard. Within the 2021-2027 MFF, the EU provided the **InvestEU programme** with a total EU budget guarantee of €26.2 billion to attract over €372 billion in additional investment the budget period, aiming to provide support to European start-ups and SMEs, including in the space sector with the objective of "underpinning space entrepreneurship".

Accordingly, as a successor to the InnovFin Space Equity Pilot, the **CASSINI fund** was established in January 2022 and is managed by the Directorate-General for Defence Industry and Space. The space entrepreneurship initiative will run until 2027 and has three main vectors:

- Access to Finance, has approx. €1 billion budget to provide capital to Venture Capital Funds to be invested in European space companies.
- Prizes and Competitions, contains various initiatives to stimulate the development of innovative commercial solutions, get market validation and ideas based on European space data.
- Business Development and Networks, aiming to organise networking events and training for companies.

European Defence Fund

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 EDF 2021 Work Programme sets a budget of €924 million for the funding of projects undertaken in the scope of its annual call for proposals.

The calls for proposals are distributed among 16 thematic categories, and space is one of these categories, under which a call for projects was placed by the EDF in 2022 with a total budget of €150 million. €90 million were allocated to the development of in space-based missile early warning and €40 million for the and innovative space ISR capabilities, while €20 million were disbursed for the research of responsive space systems.

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 proposal would be funded through the existing 2021-2027 MFF, allocating a budget of €1600 million from 2023 to 2027. Considering that the MFF did not foresee this new programme, its budget would have to be sourced from reductions in other programmes, including €400 million from the EDF and €260 million from the Union Space Programme.

An additional envelope of €800 million would serve as a contribution to the Secure Connectivity System, to be implemented under the Horizon Europe (€430 million), the Union Space Programme (€220 million) and the Neighbourhood, Development, and International Cooperation Instrument

(€150 million). This brings the total contribution of the Union to the Secure Connectivity System up to €2400 million until 2027. On November 17th, 2022, the Council and the European Parliament reached a provisional agreement on the Regulation establishing the EU's space-based Secure Connectivity Programme for the period 2023-2027, aimed at deploying the Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS2).

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, which represented 77% of its total revenues in 2021, up from 75% in 2020, down from 84% in 2019, 85% in 2018 and 83% in 2017. More specifically, Member States contributions in 2021 were reduced by 1% compared to 2020. They went from €490 million in 2020 to €487 million in 2021.[644] Member States contributions are calculated on the basis of their Gross National Income (GNI).

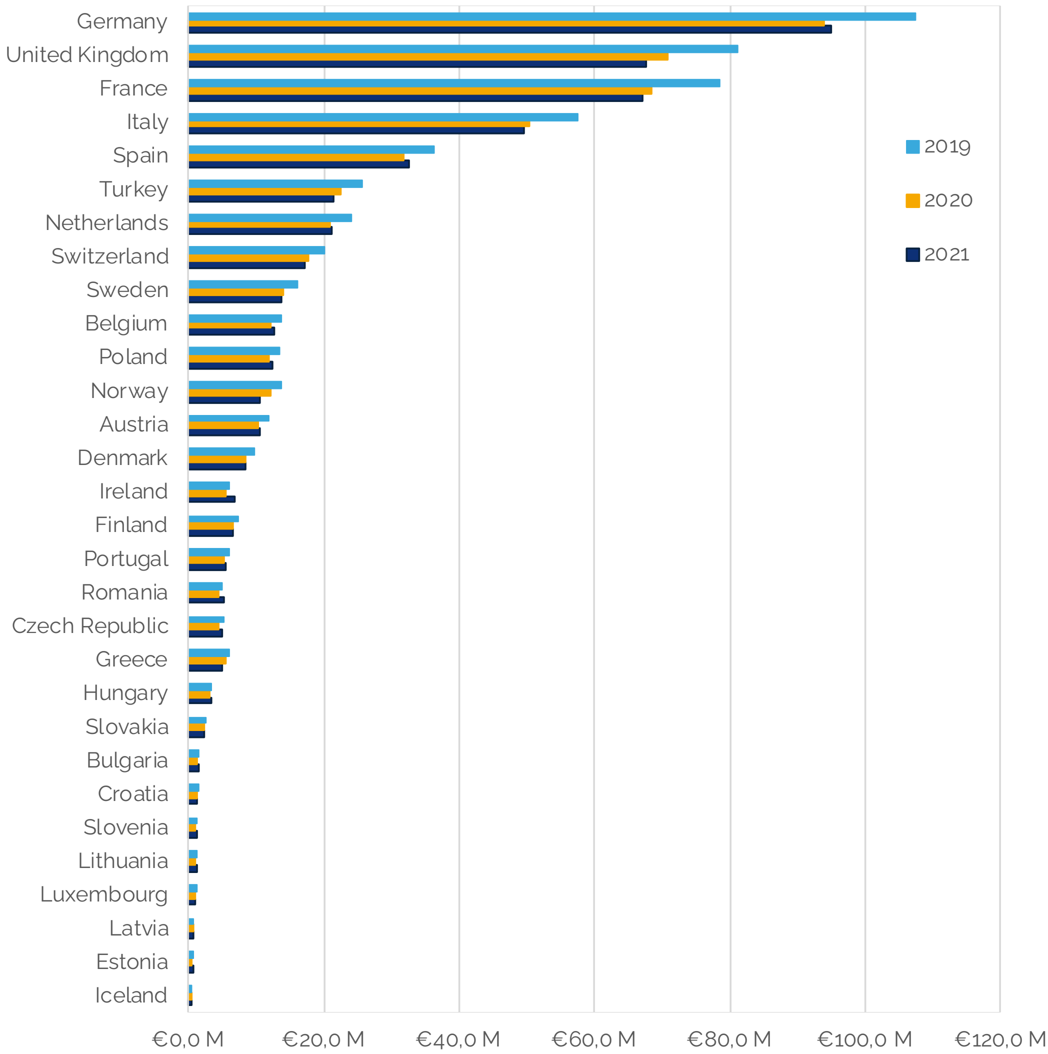


Figure 23: Member states contributions comparison for 2018/2019/2020 (Source: EUMETSAT, ESPI)

[644] Annual Report 2019, 2020 & 2021, EUMETSAT, 2021.

Germany remained the largest contributor to the EUMETSAT budget with €95 million, which is a 1% increase from the €93.8 million it funded in 2020. The United Kingdom remained the second biggest contributor in 2021, with its total contribution amounting to €67.5 million, a 5% decrease compared to is 2020 contribution. The third and fourth contributors to the EUMETSAT budget are Frances and Italy with an endowment of €67.1 million and €49.6 million respectively.

Beyond Member States contributions, other sources of revenues for EUMETSAT originated from products sales and other contributions and revenue totalling €144.3 million of its income or 22% of its total revenue. Following the contraction in Member States contributions in 2021 compared to 2020, EUMETSAT's overall revenue decreased by 3% going from €654.2 million to €631.9 million.

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.[645] This edition highlights the consequences of the war in Ukraine, with the disruption of economic activity in the European space industry.

Accordingly, the numerous dependencies that the European space industry had on Russian and Ukrainian space systems did not help the sector is striving to recover from the consequences of the Covid-19 crisis, which had already caused a €1 billion decline in industry sales during 2020, particularly in satellite applications systems sales. Nevertheless, the final sales of the European space manufacturing industry increased by 11,7% to around €8.620 million, representing a recovery to levels slightly below those observed in 2019. ASD-Eurospace underlined that the global economic disruption following the war, may lead to a potential reduction in profits as production costs, workforce expenses, and supply chain expenses are on the rise, creating a chain reaction of effects.

Space industry employment, on the other hand, grew to reach 52822 permanent staff (in Full-Time Equivalent - FTE), an increase of 5,0%. When including other personnel, not directly employed by space industry companies, the number of total staff increases by over 2000 to 55244.

Key figures employment (FTE) and sales (M€)	2019	2020	2021	Variation
Direct industry employment (FTE)	49018	50317	52822	5,0%
Other personnel working on site (FTE)	2356	2402	2422	0,8%
Total space industry employment (FTE)	51374	52720	55244	4,8%
Final sales (M€ current e.c.)	8803	7720	8620	11,7%

Table 4: 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 2021, public and private European customers accounted for 82% of industry sales, a marginal decrease of 1% in relation to the previous year. 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 64% of final sales in 2021.

[645] Facts & figures – The European space industry in 2020, ASD-Eurospace, July 2021.

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 2021. Accordingly, the pandemic induced downturn of this market segment between 2019 and 2020 seems to be an outlier, with sales resuming the path of long-term growth.

Similarly, following a contraction of 13.2% to €2.7 billion in commercial and export markets in 2020 due to Covid-19, the industry recovered to nearly the same levels of 2019, even though there are still constraints to its economic activity, such as the consequences of the war in Ukraine.

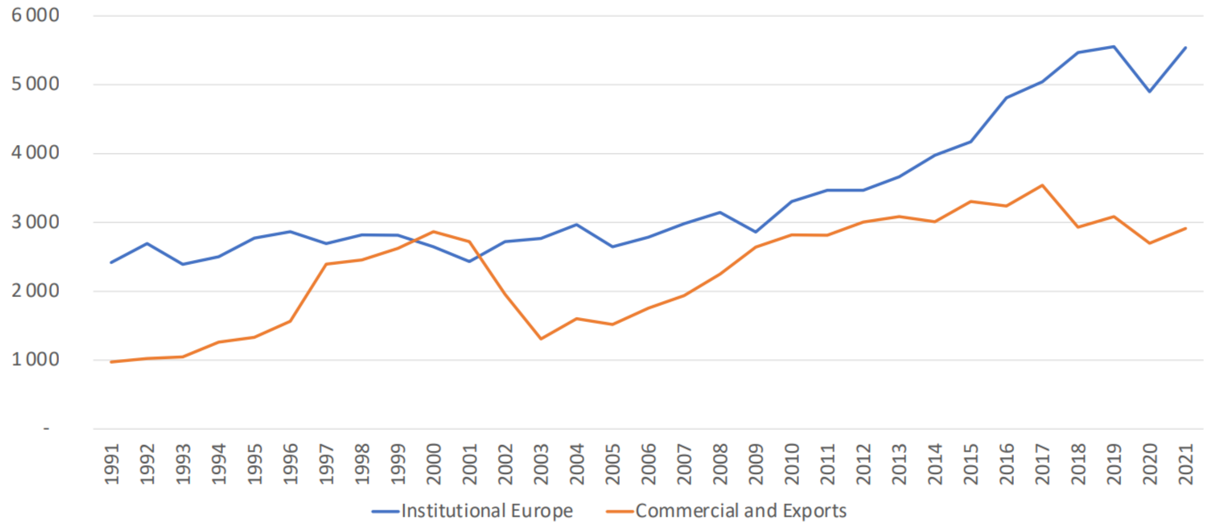


Figure 24: Sales by main market segment - type of system (M€)

Final sales by main customer segment (M€)	2019	2020	2021	Variation
European public customers	5554	4900	5539	13,0%
European private customers	1619	1297	1367	5,4%
Other European customers	115	99	117	17,4%
Public customers RoW	696	457	458	0,2%
Private customers RoW	768	941	1084	15,2%
Other customers RoW	50	25	54	114,3%

Table 5: 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, is the main market of the European space industry, representing 46% of sales. This segment grew steadily peaking in 2017 at €4.3 billion, to then fluctuate during the next two years until Covid-19 struck the sector between 2019 and 2020. After the dip, there have been signs of recovery to values closer to the lower end of the 2017-2019 fluctuation period reaching a € 3.959 million worth of sales in 2021.

Ground systems and services, including electric and mechanical ground segment equipment (EGSE & MGSE) as well as engineering and other specialised services, is the second source of revenue, representing 20,9% of the total sales by macro segment.

Scientific systems, including human spaceflight, exploration, Earth and space science programmes surpassed for the first time launcher systems, hitting an all-time high of revenues, accounting for 15,6% of the total sales. Traditionally the second product segment with most sales, launcher systems was downgraded to the segment with smallest share of revenues in 2021.

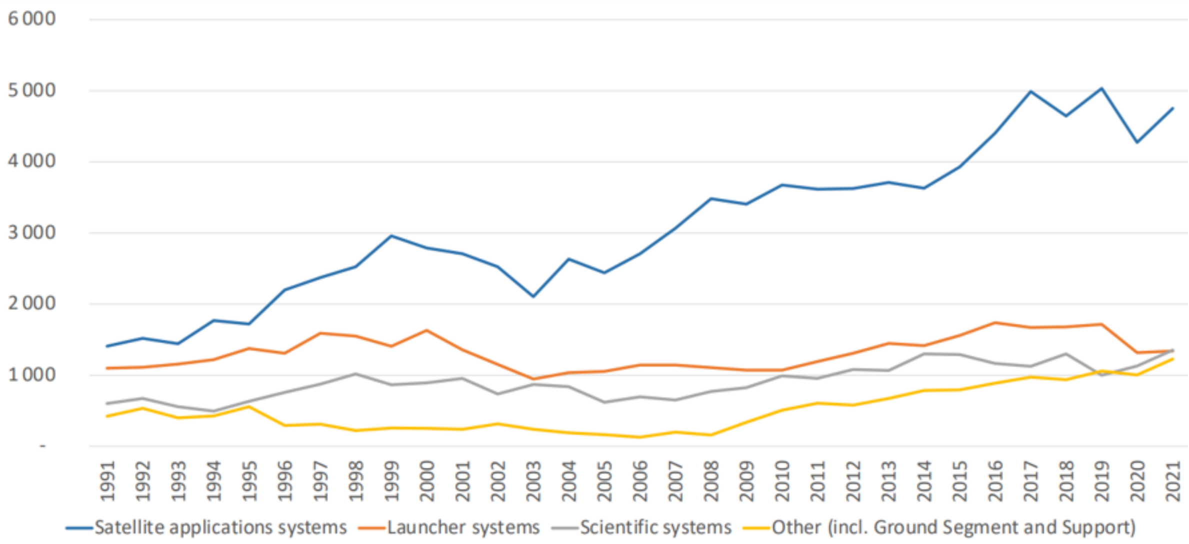


Figure 25: Sales by main market segment - type of system (M€)

Final sales by main product segment (M€)	2019	2020	2021	Variation
Launcher systems	1714	1316	1338	1,7%
Satellite applications systems	4225	3525	3959	12,3%
Scientific systems	998	1129	1341	18,7%
Ground systems and services	1705	1567	1806	15,3%
Other & Unknown	161	183	175	-4,5%

Table 6: Final sales by main product segment (M€)

Industry employment

Employment in the European space manufacturing industry has been steadily growing since 2005. A total of 2.524 jobs (FTE) were created in 2021 (+4.8%). The sector now employs a total of 55000+ workers (FTE). The space sector is a male-dominated industry where women count for only 2% of employment, a proportion that has not changed since 2019. The mean average age is 44 with a larger proportion of employees in the 49-58 age range. The industrial space workforce is also highly qualified with 67% of employees having attained a tertiary (university) level of education. The geographic distribution of industry employment within the European upstream manufacturing sector is highly concentrated and generally proportional to national space budgets, with some exceptions. Accordingly, 90% of the direct space industry employment is located in 6 countries: France, Germany, Italy, the United Kingdom, Spain and Belgium.

Industry employment (FTE)	2019	2020	2021	Confidence level
Austria	451	456	483	62%
Belgium	1606	1606	1606	51%
Bulgaria	76	102	117	0%
Cyprus	25	25	25	0%
Czech Republic	292	324	331	2%
Denmark	257	285	281	12%
Estonia	39	51	59	34%
Finland	227	280	501	60%
France	17938	17737	18309	78%
Germany	9577	10238	10246	62%
Greece	N/A	6	34	100%

Hungary	130	130	130	0%
Ireland	64	66	66	0%
Italy	5384	5411	5928	75%
Latvia	41	41	41	0%
Lithuania	99	99	109	0%
Luxembourg	36	41	66	64%
Netherlands	1240	1272	1380	8%
Norway	555	592	602	4%
Poland	397	495	509	70%
Portugal	239	254	287	55%
Romania	41	83	107	77%
Slovakia	31	31	72	29%
Spain	3815	4293	4563	75%
Sweden	996	985	1052	48%
Switzerland	917	911	1028	76%
United Kingdom	4545	4503	4890	71%

Table 71: European space industry employment by country,

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3.4.2 European GNSS and EO sector

The European Union Agency for the Space Programme (EUSPA) released the first issue of the EO & GNSS Market Report in 2022 (previously called GNSS Market report and published by the GSA). The report emphasises the growth of the EO and GNSS markets and how these industries contribute to innovations.

Earth Observation (EO)

According to the report, the EO global market turnover will grow from €2.8 billion in 2021 to €5.5 billion in 2031. The sales of this market mainly come from EO value-added services, amounting to €2.2 billion in 2021 and €4.7 billion in 2031.

Currently, 55% of the global revenues come from five market segments: Urban development and cultural heritage (€369 million), Agriculture (€337 million), Climate Services (€318 million), Energy and Raw Materials (€313 million), and Infrastructure (€209 million). Nevertheless, Insurance and Finance, which in comparison only amounts to €145 million in 2021, will grow substantially to achieve the largest revenue in the market at €994 million, representing 18.2% of the global revenues in 2031.

Distributing the revenues of the EO market according to the companies' headquarters, in 2019 most of it was concentrated in the U.S. and European industries, which hold over 83% of the global market, with 42% and 41%, respectively. On the other hand, China had 6%, Canada 4%, and Japan 3%.

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 its segments: the market share of the European industry is above 80% in Maritime and Inland Waterways, Fisheries and Aquaculture, and Aviation and Drones.

	2021		2031	
	EU27	Share of World	EU27	Share of World
Data revenues (€)	82 million	15.4%	117 million	14.6%
Value-added service revenues (€)	342 million	15.3%	664 million	14.2%

Table 82: EU27 EO market demand in 2021 and forecast in 2031 (Source: EUSPA)

Global Navigation Satellite Systems (GNSS)

According to the report, the global GNSS market was worth €199 billion in 2021, with an installed base of GNSS devices of 6.5 billion units worldwide. It is projected that this value will more than double over the next decade with annual revenues reaching €492 billion by 2031 for an installed base of 10.6 billion units.

The growing installed base is driven mainly by the Consumer Solutions, Tourism and Health segments, as between 2021 and 2031 approx. 92% 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 2021, its revenues reached €150.5 billion, representing 76% of the market, and are projected to increase to €405,2 billion in 2031, representing more than 82% 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. In 2021, these services accounted for €126 billion in revenues (63% of the global market sales) and are projected to reach just over €354 billion in 2031 (72% of the global sales).

From a geographical standpoint, the global market is concentrated mainly in companies with headquarters in the U.S. and Europe. In 2019, they represented 29% and 25% of the revenues, respectively. Still, the share of the European industry in the global market shrunk by 2%, from 27% in 2017 to 25% in 2019. On the other hand, the U.S. continues to lead the global GNSS market, having increased its share of the revenues from 28% in 2017 to 29% in 2019.

This reverses a trend highlighted in the previous 2019 GNSS market report, which stated that the European industry was "closing the gap" with its American counterpart. Moreover, Japanese, Chinese and South Korean companies accounted for 36% of the global market in 2019.

Regarding market segments, the ones where the European industry holds a larger share are Space (65%), Road and Automotive (53%) and Maritime (47%). In contrast, the European industry had a smaller market share in Rail (14%), Drones (10%) and Consumer Solutions (7%).

	2021		2031	
	EU27	Share of World	EU27	Share of World
Devices revenues (€)	12.1 billion	25.0%	21.6 billion	24.8%
Services Revenues (€)	27.4 billion	18.2%	53.7 billion	13.3%

Table 9: EU27 GNSS market demand in 2021 and forecast in 2031 (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".

3.5.1 Global investment dynamics

Global investment in space ventures in 2022 totalled **€8.8 billion**, which represents a **28% decline from the previous year's peak of €12.2 billion**. 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 2021 can be almost entirely attributed to the lack of SPACs**. Despite the year-on-year downturn, the industry has maintained a healthy growth rate of 14% CAGR since 2019. Furthermore, the number of deals increased from 272 in 2021 to 293 in 2022, indicating that the interest and the amount of capital raised for New Space companies worldwide remained strong in 2022.

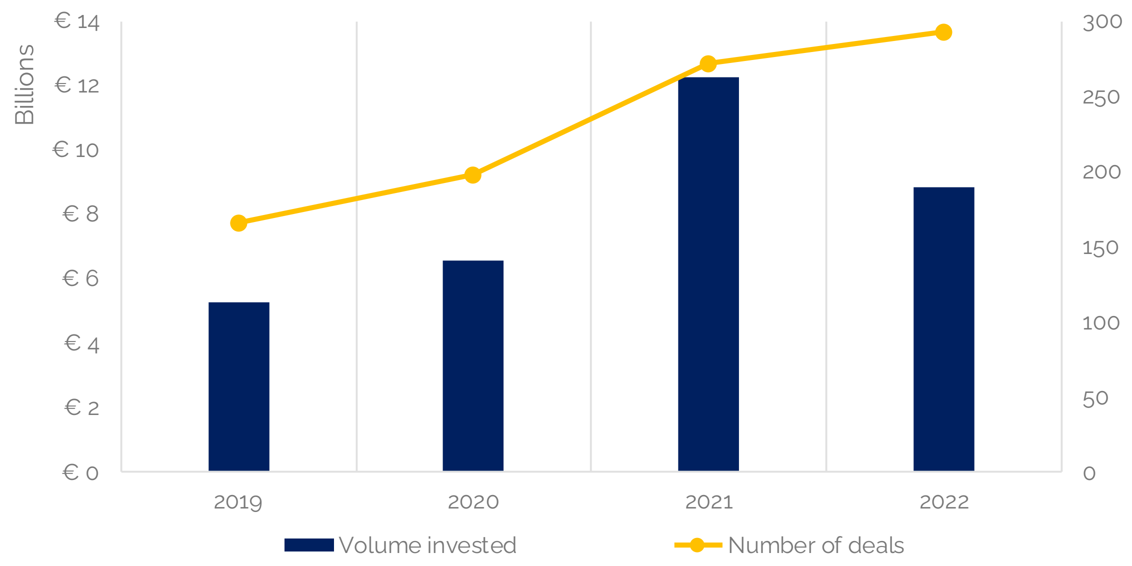


Figure 26: Global Investment & Deals

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%. In 2021 and 2022 the share remained at just above 55%. The most notable difference between 2021 and 2022 is the absence of SPACs. This investment type accounted for €3 billion over ten SPACs in 2021, which decreased to €400 million over two deals in 2022. Another notable trend is the increase in acquisitions total value, which reached €1.8 billion, up from the previous record of €955 million in 2020.

ESPI also accounts the self-capitalization into Blue Origin from Jeff Bezos which is approximately $1 billion per year and is included as an "Angel" investment.

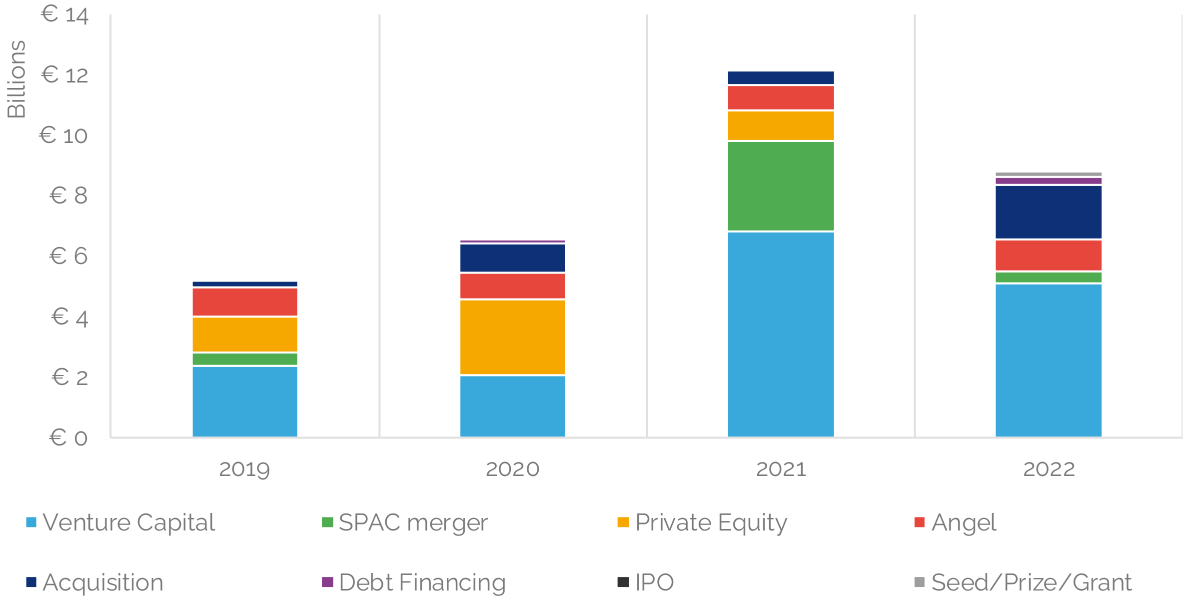


Figure 27: Investment type for global New Space ventures

Another interesting index to analyse is the share of the top five deals with regard to total investment. What can be seen is that while the **U.S. has raised considerably more capital than Europe, the top five deals regularly represent more than 75% of the total raised** in the country. In Europe, this average is considerably lower, with the **top five deals only representing on average about 45% of the total In 2019**,

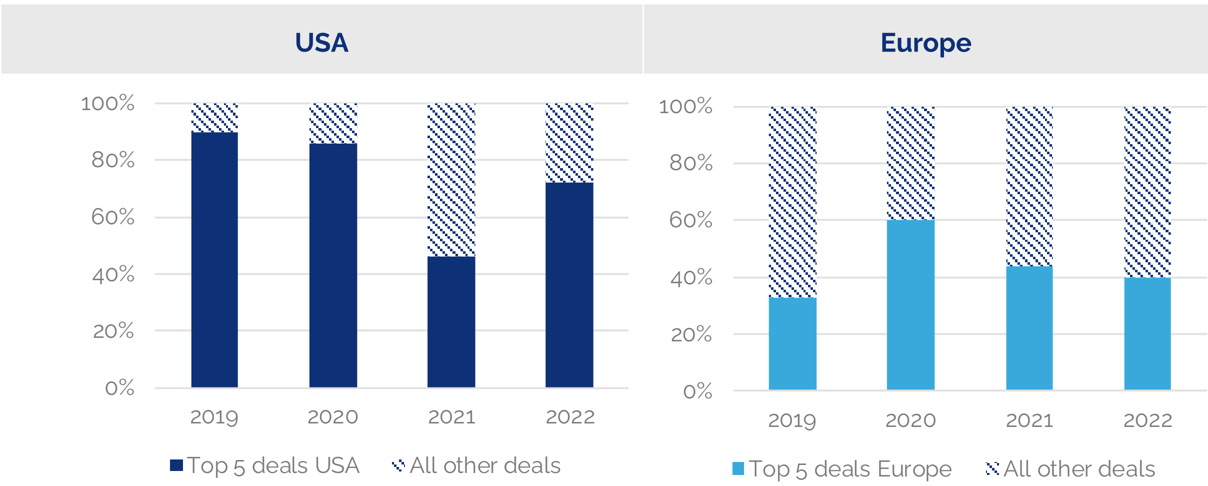


Figure 28: Weighting of top 5 deals – U.S. vs Europe (One Web is excluded from Europe in this graphic)

3.5.2 Global distribution of investment

The U.S. has historically been the most active country for New Space investment and ventures. The U.S. has also seen significant growth over the past three years, going from €3.2 billion in 2019 to €9 billion in 2021 and then decreasing to €6 billion in 2022. This represents a **17% CAGR**.

Europe remains the second region attracting the most investment into New Space ventures. China has seen steady growth, with an increase of 90% between 2019 and 2022.

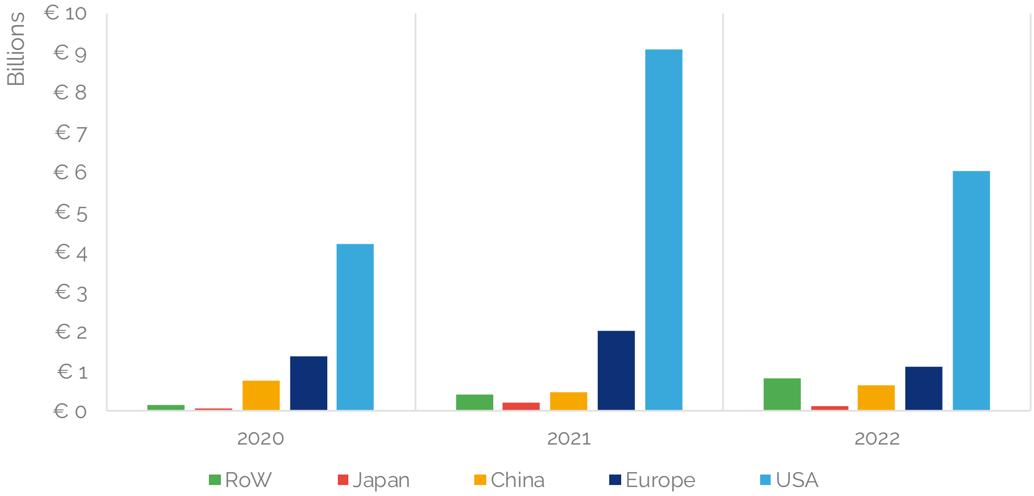


Figure 29: Investment volume per region

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 from **€24 million in 2019 to €837 million in 2022** (majority originating from Canada, India, Israel and Australia). This represents an incredible **3379%** growth over three years.

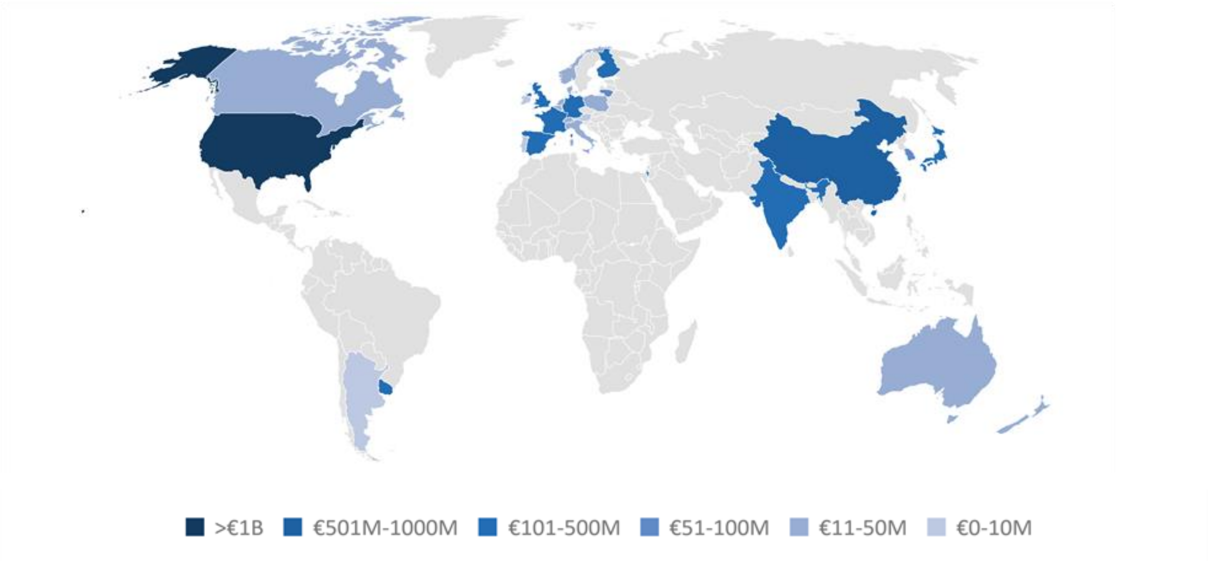


Figure 30: 2022 investment map

Europe has averaged 89 deals over the past 3 years compared to 106 for the U.S. As such, **while there is only a 17% difference in deal number between the EU and the U.S., there is a 124% difference in investment volume** between both regions (Europe has averaged €1.5 billion over 3 years as compared to €6.5B for the U.S.).

The U.S. saw 111 deals in 2022 for a total of €6 billion. This makes an average deal size of €55 million. In comparison, Europe saw a total of 114 deals totalling approx. €1.1 billion, which makes an average deal size of €10 million. The size of certain US deals can affect this average significantly.

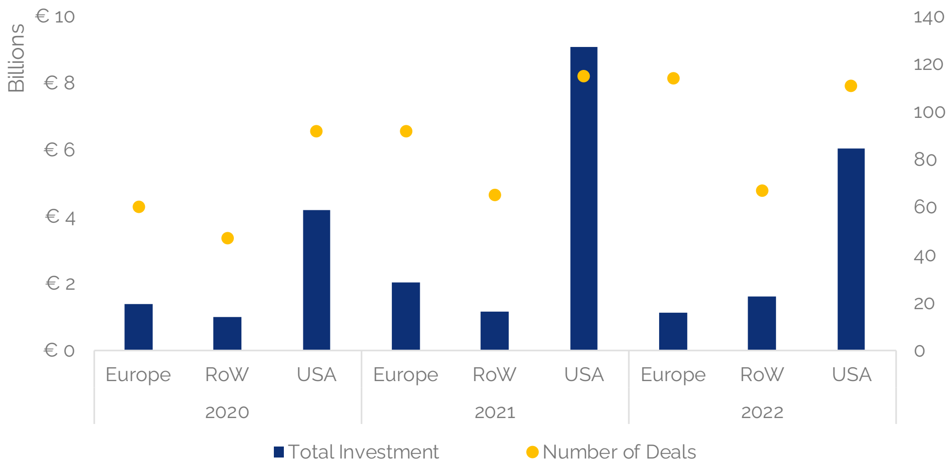


Figure 31: Volume and deals per region

Another interesting factor when considering the role of private investments globally is the ratio between public space budgets and private investment. While **public budgets and private investments are inherently different in nature and in purpose**, it is important to understand that the ratio tends to be relatively consistent across continents. Over the past 3 years, the average was 14% in U.S. and 13% in Europe. It confirms that public sector support remains a key enabler to stimulate private investments. With increased private investment the level of public support is also required to step, including to ensure policy direction for investments in space.

The ratio of public space budgets to private space investments had been continuously growing until 2021. In 2022, this ratio decreased in both Europe and the U.S.

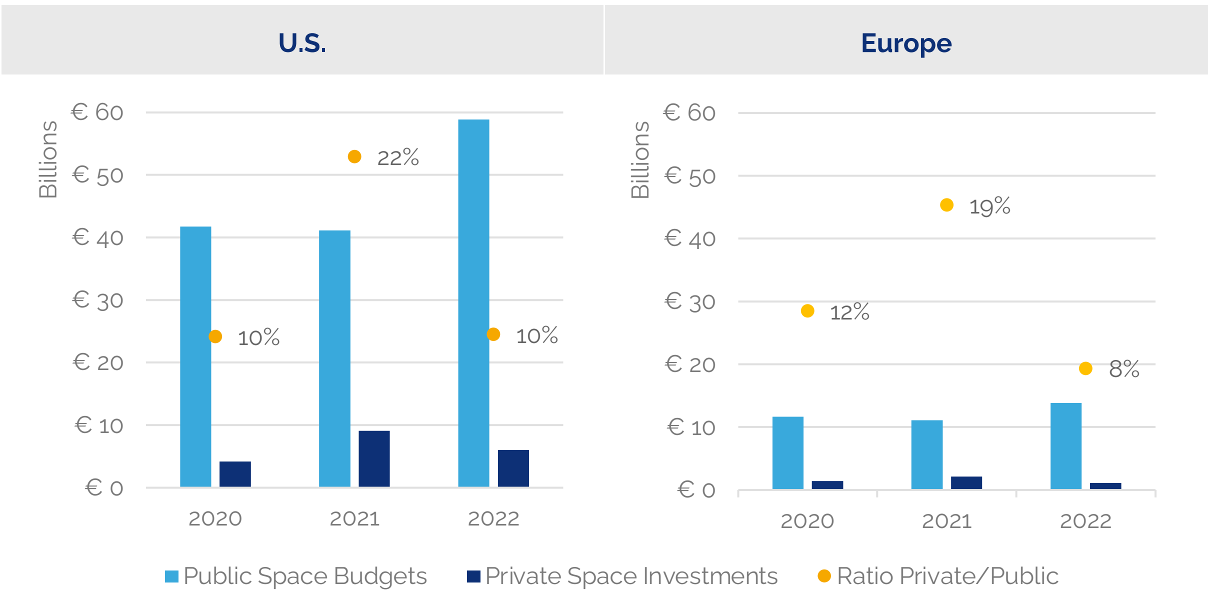


Figure 32: Ratio public space budgets to private investments

4 Launches & Satellites

4.1 Global space activity evolution 2000-2022

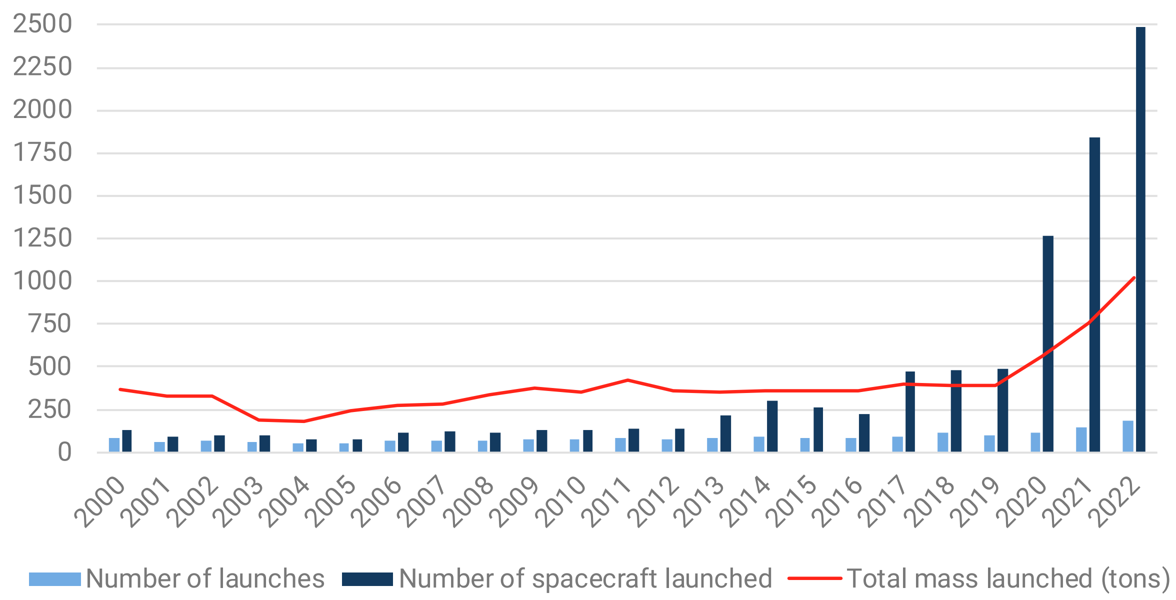


Figure 33: Evolution of launch activity over time (2000-2022)

Once again, the global space activity broke all records in 2022 reaching new heights in terms of total mass, number of launches and number of spacecraft launched. With **185 launches being carried out** in the world, 2022 is a new landmark, **28%** higher than the previous one set in 2021 with 144 launches. Confirming the trend started in 2020, a new record high of **2491 satellites were launched** in a single year (**35% more** than in 2021), exceeding for the first time the threshold of 2000 spacecraft launched in a year. This number is largely due to the launch of large constellations including Starlink, OneWeb, and Planet spacecraft. As a result, the total mass launched also increased drastically, thus reaching for the first time an amount of more than 1000 tons (1021 tons, i.e. 35% more than in 2021, similar to the increase in terms of spacecraft numbers).

As mentioned above, the **highest change concerns the number of spacecrafts launched** to orbit. While the period 2017-2019 already marked a major step compared to previous years, the period 2020-2022 brought the observed landscape to an entirely new level: in these three years, more satellites were launched than in the timeframe 2000-2019. This increase is in large part due to the 3548 Starlink satellites (51% of them being launched in 2020-2021 and 49% in 2022 alone) and, to a lesser extent, to the 498 satellites deployed for OneWeb, representing together 72% of all satellites launched worldwide in 2020-2022.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of launches	81	92	87	86	91	114	103	114	144	185
Spacecraft launched	213	298	266	223	471	477	490	1266	1843	2491
Mass launched (tons)	348	363	360	359	401	389	385	564	756	1021

Table 3: Key space activity statistics (2012-2022)

4.1.1 Launch activity evolution by country

The evolution of activities in top space launch countries (United States, Russia, Europe, China) shows very different profiles. Furthermore, despite a strong domestic space sector, other countries such as India and Japan still have comparatively limited launch activity.

Figure 34: Evolution of the number of launches (left) and total mass launched (in tons, right) per country (2000-2022), with trendline

- **United States:** after a decrease related to the retirement of the space shuttle and other factors in the early 2000s, the U.S. activity is now experiencing steep growth, with a particular peak in 2022 (78 launches). This trend is largely driven by a single launch service provider, SpaceX, and by the recovery of the capacity to service the ISS, for both cargo and crew missions. **The role of SpaceX in the striking increase of 2020-2022 is predominant (73% of the U.S. launches and one quarter 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 57% of SpaceX launches in the period.
- **China:** the Chinese launch activity has skyrocketed since 2000 and China has now become a serious contender in terms of number of launches, ahead of the United States between 2018 and 2021. However, the country is not yet a leader in terms of mass launched. The strong growth in institutional demand from Chinese authorities remains the main driver, as almost all payloads launched by China are domestic and **more than 80% of the mass is launched for governmental actors** (civil and military).
- **Russia:** along the rest of its space sector, the launch activity of the historical (co)leader has experienced a sharp decrease over time, both in number of launches and mass launched. This decreasing trend **accelerated in 2020 with only 15 launches but bounced back in 2021 and 2022 to the level of 2019** (with respectively 24 and 21 launches, compared to 22 in 2019). In terms of mass, the country has been on a decreasing trend 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 line with the trend making ISS-related activities a significant share of the Russian launch activity in terms of number of launches (one quarter of Russian launches in 2022) and of mass launched (55% of the total mass put in orbit in 2022). In 2022, the total mass launched decreased to 68 tons, i.e. half the mass launched in the previous year.
- **Europe**: the launch activity has decreased in the period 2019-2022 compared to 2015-2018, with **less than 10 launches** and an average of 36 tons put in orbit per year. While the introduction of the new launchers Vega and Soyuz at the beginning of the 2010s contributed to diversifying and expanding European launch capabilities, the recent drop of the last years can be partly explained by the Guiana Space Centre's closure because of the COVID-19 pandemic, the decreasing availability of Ariane 5 vehicles, delays in the rollout of Ariane 6, , as well as by failures that delayed some launches.

4.1.2 Spacecraft orbit and mass

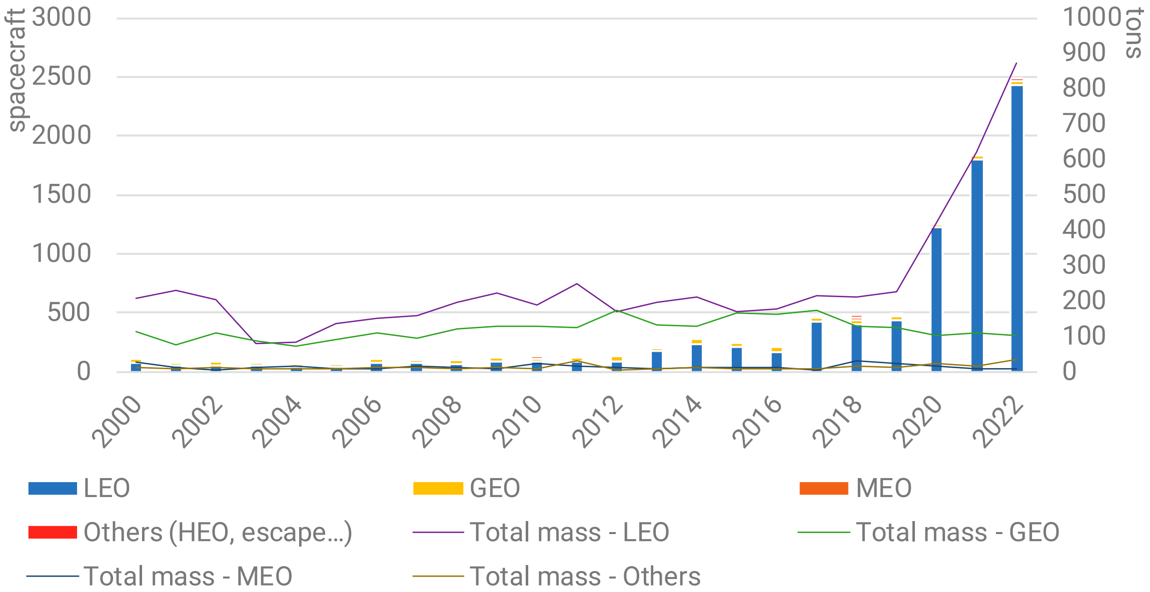


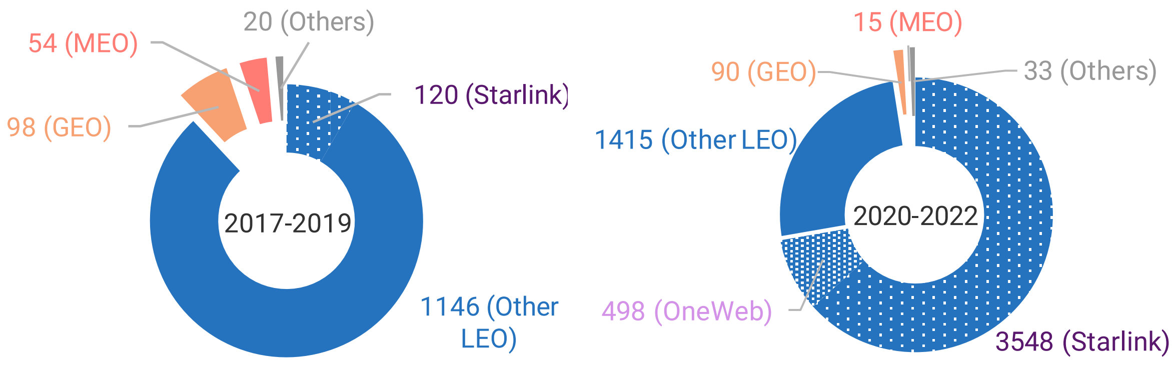
Figure 35: Evolution of the number and mass of spacecraft launched per orbit (2000-2022)

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, **34 satellites were launched to geostationary orbit in 2022**. By contrast, an overwhelming majority of satellites is deployed in LEO, mainly due to the launch of small spacecraft and CubeSats in the context of large constellations (for Earth observation or telecommunications). During the period 2017-2019, LEO was the destination of 88% of all satellites launched but, in 2020-2022, this rate reached 97.5%. This remarkable increase is mostly due to the launch of Starlink and OneWeb satellites; yet, even when excluding them, still 91% of all spacecraft launched in 2020-2022 were for LEO.

The number of launches to MEO also increased over time but to a much lesser extent (5 in 2009, 16 in 2019, with a peak at 31 in 2018), due to the deployment of several GNSS systems (China's Beidou, Europe's Galileo), as well as the development of satcom systems in MEO (e.g. the O3b constellation and its 20 satellites that were launched between 2013 and 2019). Therefore, the completion of GNSS constellations (e.g. Galileo, Beidou) and the development of LEO satcom constellations may explain the low number of satellites that were launched to MEO in 2020 (5), 2021 (4) and 2022 (6), although the launch of the first O3b mPower satellites in 2022 may indicate another increase in the future, as the rest of the constellation will be deployed.

Interestingly, from 2020 onwards, most of the mass was launched to LEO even when excluding human spaceflight activities (which are traditionally accrue more mass and could bias the calculations). This is new, as 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 97.5% of all spacecraft in 2020-2022, they represented 76.6% 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 17.4% of the total mass (when excluding human spaceflight activities). This latter share is nonetheless decreasing as well, due to the quick growth of LEO activities.

Number of satellites launched



Total mass launched (in tons), excluding human spaceflight activities

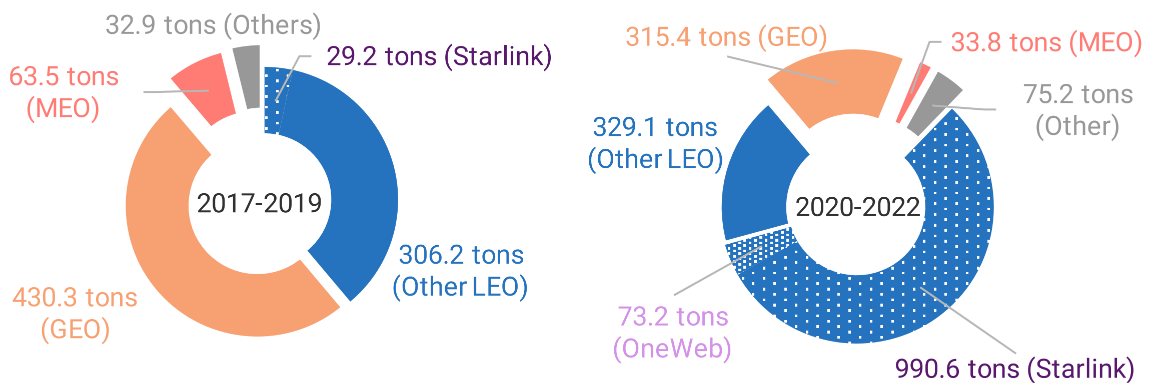


Figure 36: Comparison of the number of satellites and total mass launched by orbit between the period 2017-2019 (left) and the period 2020-2022 (right)

The total mass launched to GEO has increased over time (+34% between 2009 and 2017), but this trend has reversed in the past years. Since 2017, the mass has gradually decreased (around 125 tons launched per year in 2018-2019, and around 105 tons in 2020-2022) due to difficulties in the satcom market (governmental satellites being included, 15 and 16 GEO satcoms were launched in 2018 and 2019 and 21 in 2022, as compared to 30 in 2017) but also due to the reduction of size of GEO satellites. Indeed, while the average mass of GEO satcoms was around 5 tons in 2019, it decreased to around 3 tons in 2022 (reaching the level of the 2000s). The total mass launched to LEO (including human spaceflight) was around 200 tons per year in 2017-2019, comparable to the years 2000s when the ISS was under construction. However, in the period 2020-2022, **this amount reached around 638.9 tons in average** (422 tons in 2020, 619.7 tons in 2021 and a record high of 874.7 tons in 2022). The increasing launch rate of mega-constellations for telecommunication purposes (in particular Starlink) as well as the increased number of human spaceflight activities by U.S. and Chinese agencies are the main drivers of this stark increase (e.g. the launch by China of two modules to complete the space station Tiangong in 2022 explains partly the record observed that year).

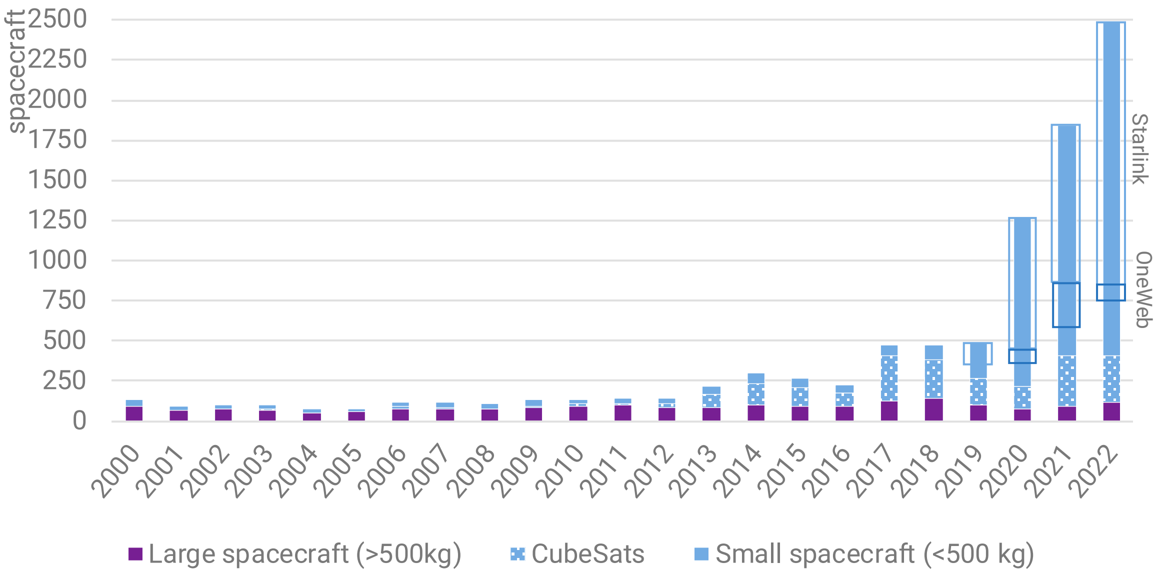


Figure 37: Evolution of the number of spacecraft launched per mass category (2000-2022)

CubeSats became the dominant category of payloads launched to orbit in 2013, but this pre-eminence decreased with time, in particular since 2019 (when other types of small spacecraft below 500 kg became the overwhelming category). Over the past years, the number of small spacecraft launched (including CubeSats) reached an all-time high and this exponential increase happened in a very short timeframe: while, in 2019, small spacecraft were already four times more numerous than large spacecraft (80% of all spacecraft launched), in 2022, they represented 20 times the number of large spacecraft sent to orbit. Here again, this very high number is mostly linked to the **1726 Starlink and 110 OneWeb satellites launched in 2022** only. In a broader perspective, and even excluding these constellations, the number of small spacecraft launched in 2020-2022 represented more than four times the quantity of large spacecraft launched in that period, thus demonstrating a trend towards a greater spectrum of uses for small satellites, serving a wide variety of missions.

Thus, most of the spacecraft launched are small spacecraft, and this latter category now accounts for the majority of the mass put in orbit as well. This decrease has been gradual. **While large spacecraft accounted for 94% of the total mass launched in the period 2017-2019, they represented only 59% of it in 2020-2021.** From 2012 onwards, the total mass of large spacecraft had stabilised around 360 tons per year but had been following a slightly decreasing trend since the peak reached in 2017 (389 tons). Therefore, 2021 and 2022 are exceptional years as they reverse this trend, in part due to the launch of multiple heavy military satellites and to the multiplication of human spaceflight missions after the entry into operations of the Chinese space station. However, **although the mass of large spacecraft and satellites sent to orbit reached a record in 2022** (468 tons), for the first time, **these spacecrafts represented less than 50% of the mass launched (46%) that year**. This is largely due to the exceptional dynamics of small spacecraft launches, driven by the very high number of Starlink satellites deployed in 2022.

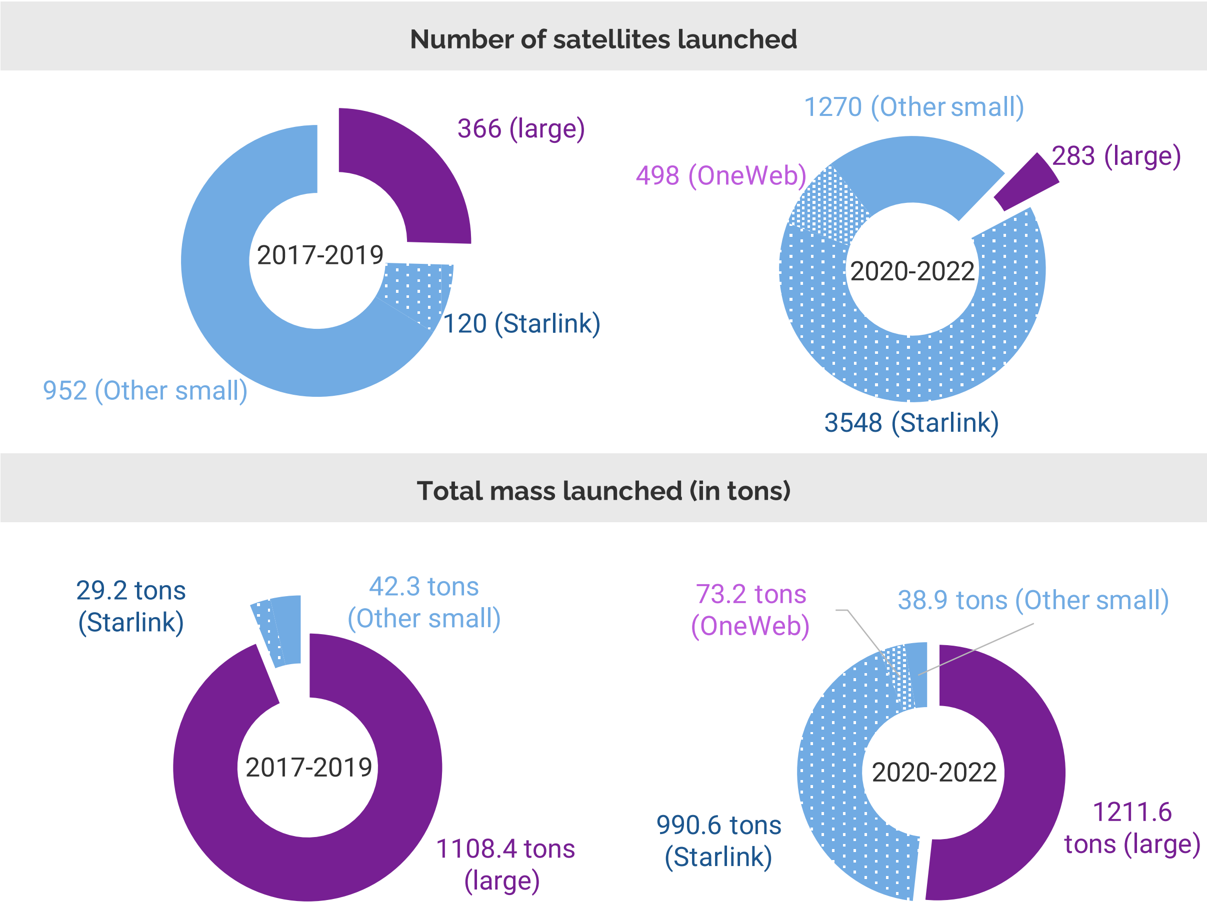


Figure 38: Comparison of the number of satellites and total mass launched per mass category between the period 2017-2019 (left) and the period 2020-2022 (right)

4.1.3 Space missions and markets

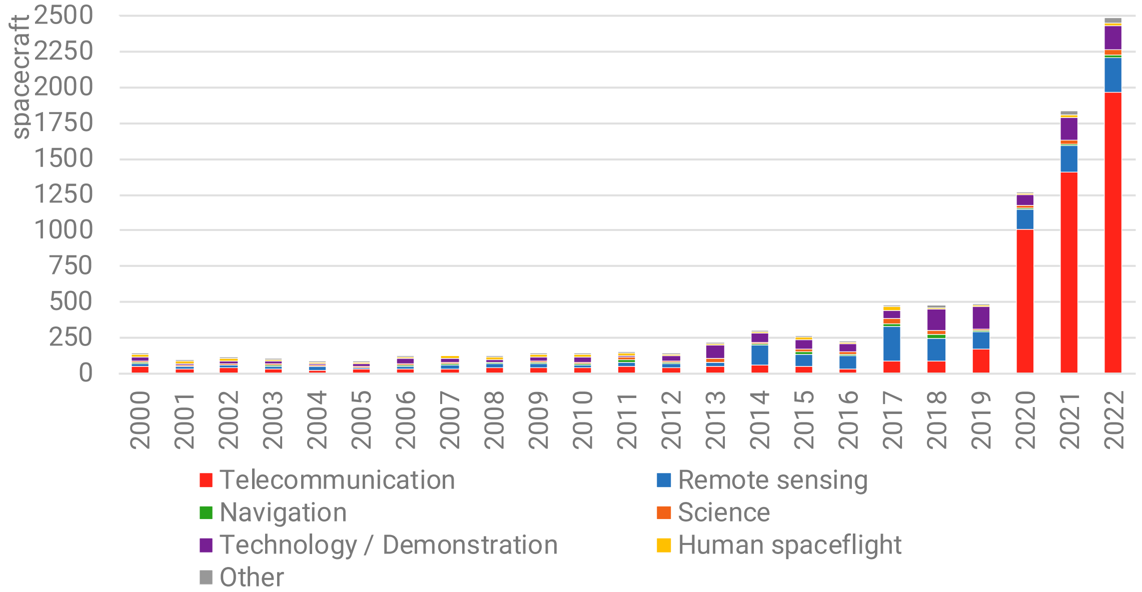


Figure 39: Evolution of the number of spacecraft launched, per mission (2000-2022)

In the past three years, a majority of spacecraft has been launched for telecommunication missions. Small satellites represent 86% of the mass launched for telecommunication missions in 2022, a significant change compared to the previous paradigm in which heavy GEO satcom accounted for the bulk of this mass. Despite their limited individual size, **telecommunication spacecraft account for 60.6% of the total mass launched in 2022** (while this share was of 49.6% in 2021), compared to 19.1% for human spaceflight and 11.3% for remote sensing. The share of technology/demonstration spacecraft represents 7.1% of the total mass launched in 2022 (an improvement compared to 2021, when it accounted only for 4.5%).

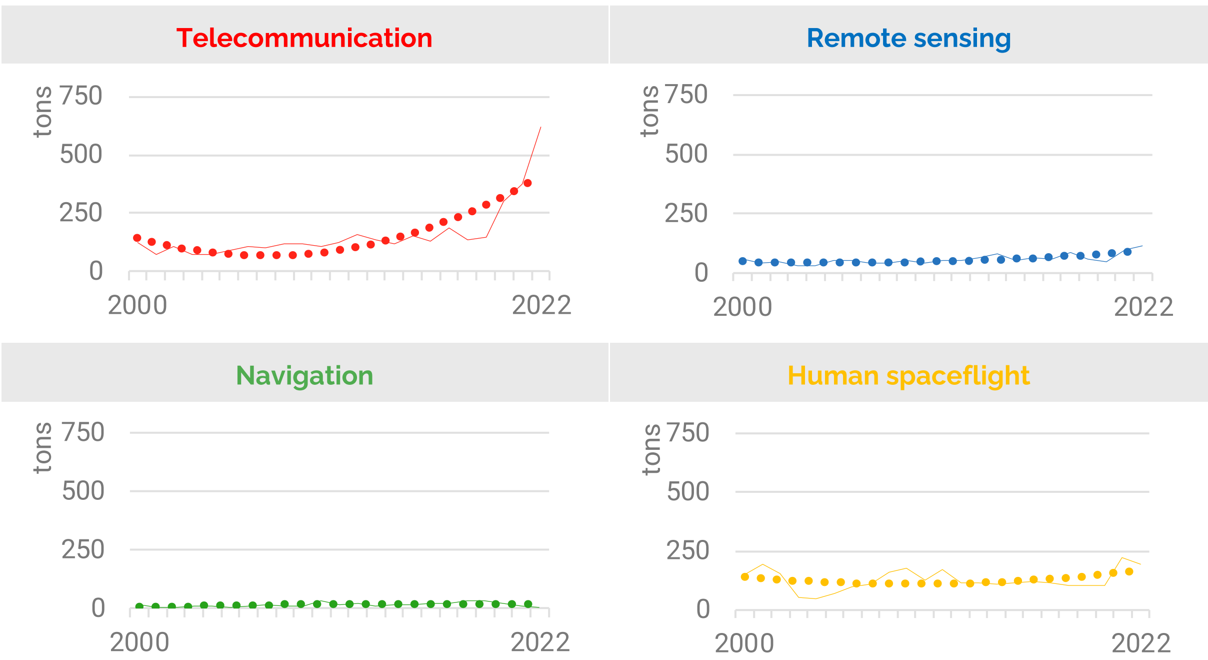


Figure 40: Evolution of the total mass launched (in tons) per mission (2000-2022) with trendline

The high number of telecommunication satellites launched in the recent years is mostly due to the launch of constellations, in particular Starlink and OneWeb. While the number of technology/demonstration satellites increased substantially in 2018 and 2019 to reach a third of all spacecraft (mostly CubeSats), it decreased in 2020, but came back to its previous level in 2021-2022. However, the share that they represent dropped in the past two years: in average, they represented 7.5% of all spacecraft launched in the period (27% without Starlink and OneWeb). Their average mass has quickly increased over the year, from 67 kg in 2018 to 437 kg in 2022, with a peak at 950 kg in 2020. The major increase in 2020 can be explained by a few heavy Chinese and American satellites aimed at testing/demonstrating technologies for these countries' military and civil space programmes. Finally, the number of human spaceflight missions, mostly comprising the servicing of the ISS, remained rather steady with 12 to 20 missions per year (with the exception of the period following the Columbia disaster in 2003). However, the past years have seen a slight increase for this category, with 23 and 20 missions being conducted in 2021 and 2022 respectively.

Telecommunication and human spaceflight spacecraft are the two main types of missions contributing to the total mass launched. Even though the mass related to human spaceflight missions has decreased slightly between 2010 and 2019, more than 100 tons were still launched every year to service the ISS. However, in line with the higher number of human spaceflight missions in 2021 and 2022, the mass launched over these two years has also increased substantially. 2021 marks a record year, as more than 200 tons were launched for human spaceflight activities and, although less important, the 195 tons launched in 2022 are far above the pre-2021 period.

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 and 375 tons were achieved in 2020 and 2021 respectively, 2022 outweighs them by far with more than 620 tons launched for telecommunications that year only. Finally, the mass launched for remote sensing missions has also increased significantly in 2021-2022 in comparison to the previous years, for the first time exceeding 100 tons in 2022 (115 tons).

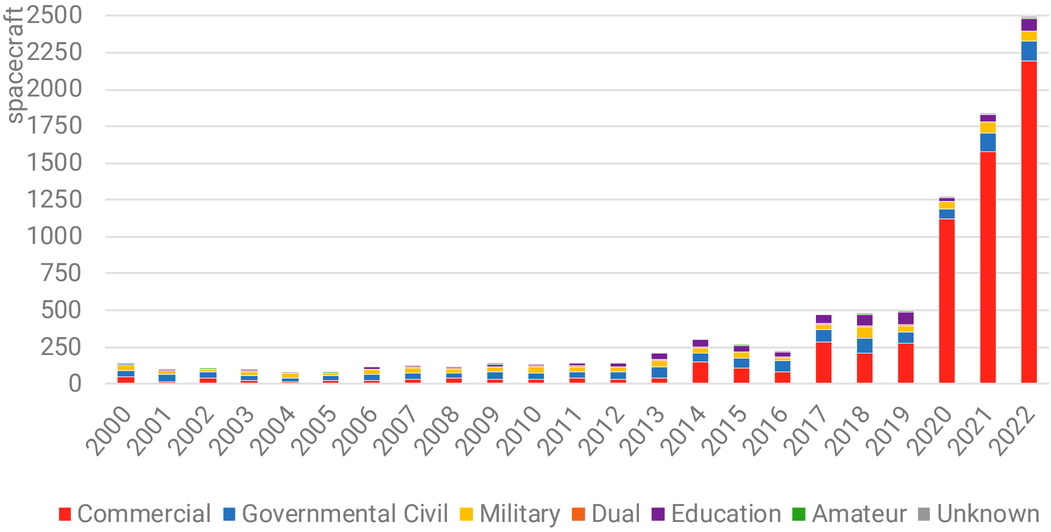


Figure 41: Evolution of the number of spacecraft launched per market (2000-2022)

Data show a steep increase of the number of commercial satellites over the period 2017-2019, but the year 2020 marks a change of scale, continued in 2021 and 2022. 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 alone and 1576 in 2021 (that is, in average over the two years, 86.7% of all spacecraft). **In 2022, 2196 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 54% of the spacecraft launched in 2020-2021, with a similar figure for 2022. The total mass of commercial satellites also grew over time, this mass being multiplied by 5 between 2019 and 2022, and undergoing an increase of 67% between 2021 and 2022 only. These figures illustrate the growing momentum in commercial space activities and the emergence of new entrants, services, and markets.

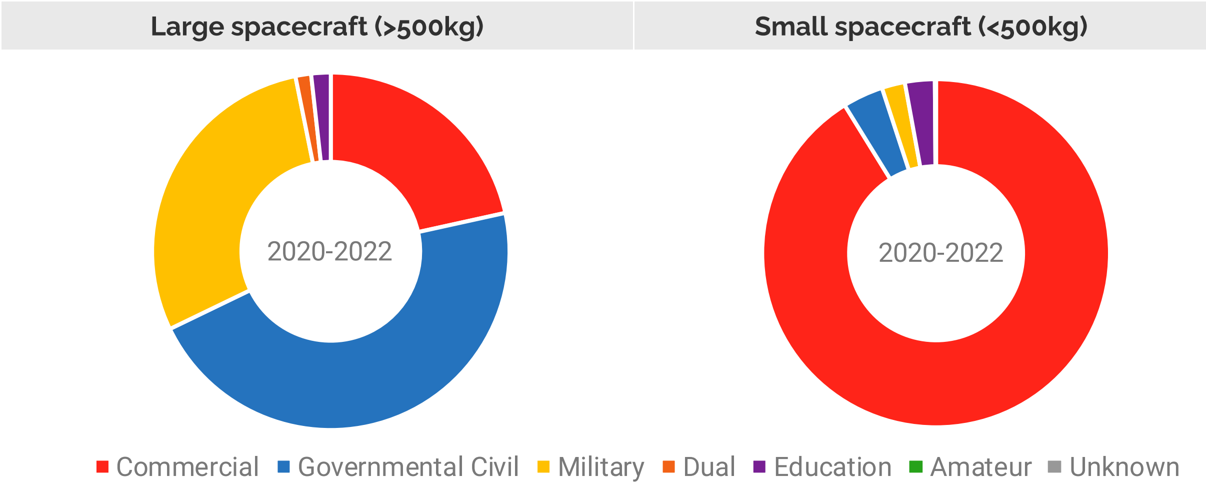


Figure 42: Number of spacecraft launched per market and mass category (2020-2022)

While being less numerous than commercial satellites, spacecraft used for institutional purposes (governmental civil, military and dual) have continued to make up a great share of the total mass launched over the past years, representing between two thirds and three quarters of the total mass between 2015 and 2019. While this share significantly decreased in 2020-2021, institutional spacecraft still account for 48.3% of the total mass launched over the two years. However, **2022 marks a record low as only 37% of the mass launched served the institutional market.** With regard to the **military market, the number and mass of these satellites have grown, slightly but steadily, since 2000**. Since 2018, several dozens of military satellites have been launched per year, for an average mass of 89 tons. Over the past two years (2021 and 2022), the number of military satellites launched has exceeded 70 for each year. Various factors contribute to this growth, which concerns a variety of missions, both operational and experimental. It is also noteworthy that, while governmental civil missions have represented the largest share in terms of mass launched since 2000, primarily due to human spaceflight, this position is eroding in 2020 and 2021 in front of the commercial activity. In average, commercial missions indeed account for slightly more than half of the total mass launched these two years. In 2022, this trend was clearly confirmed, as **commercial satellites represented more than 60% of the total mass launched,** again to a large part due to the rollout of the Starlink.

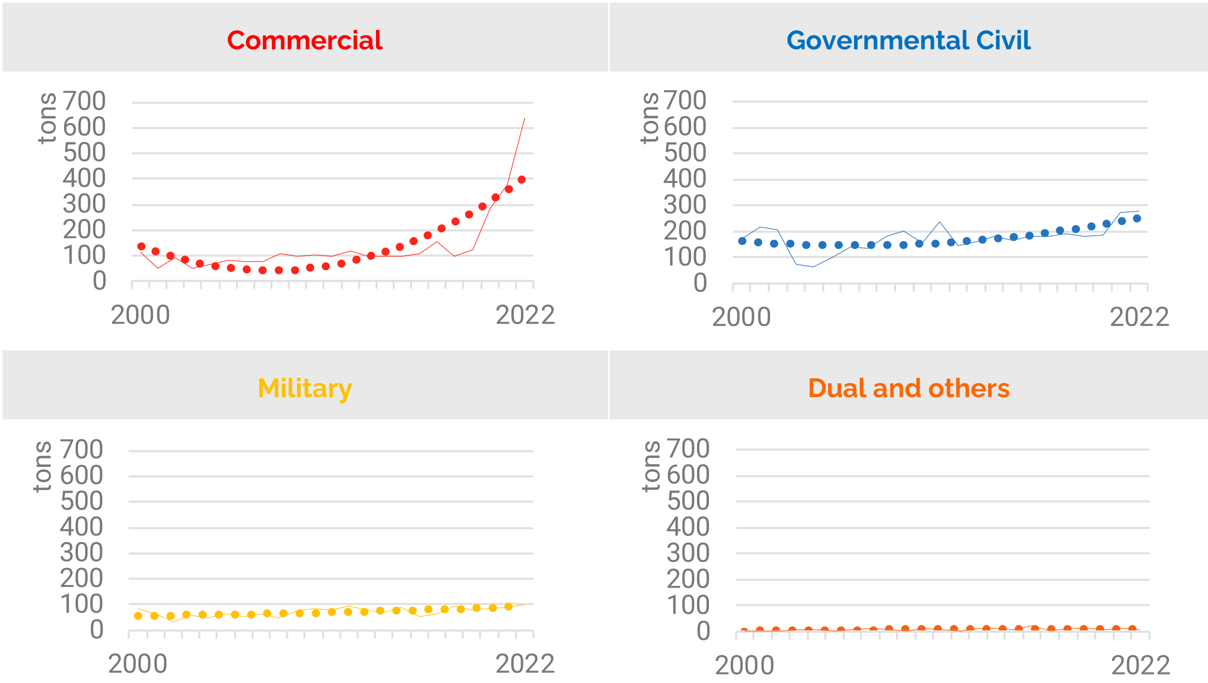


Figure 43:: Evolution of total mass launched (in tons) per market (2000-2022) with trendline

4.1.4 Spacecraft manufacturing and procurement by country

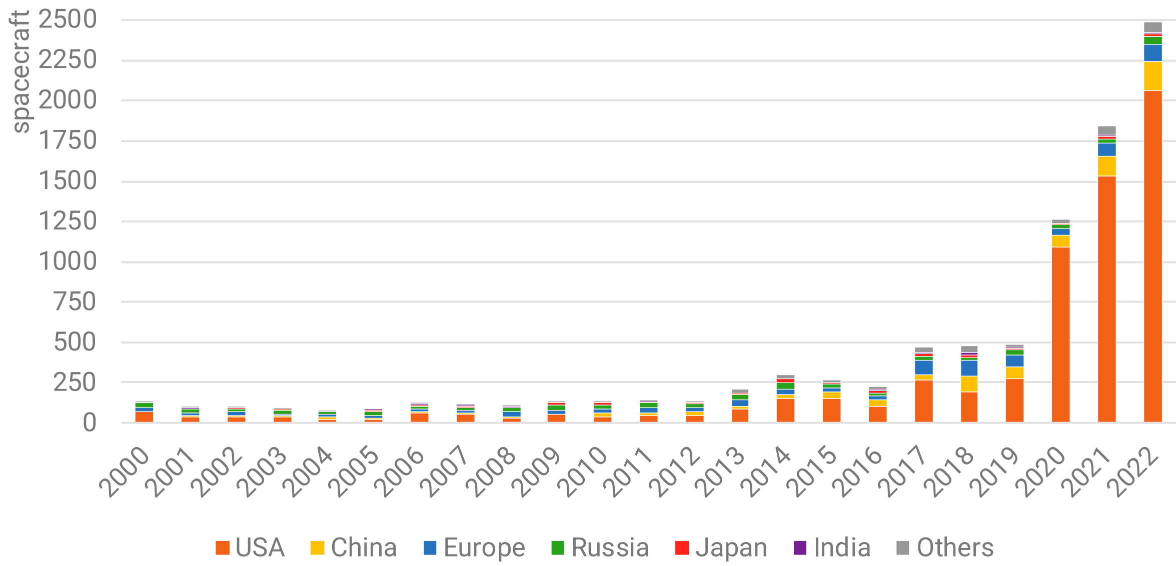


Figure 44: Evolution of the number of spacecraft per manufacturing country (2000-2022)

The manufacturing activity of 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 2020-2022, these shares respectively reached 83.8% and 65.2%,** again largely boosted by Starlink (and OneWeb).[646] Spacecraft manufacturing in China also experienced

[646] OneWeb spacecraft are produced by OneWeb Satellites, a joint venture between OneWeb and Airbus. Although these two companies are European, the main production line is located in Florida, hence ESPI considers the satellites as a U.S. output. It is expected that the production is repatriated to the United Kingdom by 2024-2025.

a massive growth, in parallel with the increase of the country's launch activity. Between 2017 and 2019, China produced 15% of the spacecraft that were launched (17% of the total mass) in this period.

While the strong increase of the U.S. activity decreased China's share of the number of spacecrafts launched in 2020-2022 (only 6.7%), the share of Chinese-made spacecraft in the total mass launched increased to 19.1% over the period, confirming that the U.S. spike is mostly due to smaller satellites.

The activity of Russia remained stable for many years with a vast majority of its output concerning human spaceflight vehicles (Soyuz, Progress) and satellites for various domestic public programmes. Yet, a surge in the number of spacecrafts launched appeared in 2022, due to a high number of CubeSats manufactured and launched by Russian universities.

The output of Europe has been irregular and does not allow to draw a clear trend, although it has been somewhat declining in the recent years. In the period 2017-2019, Europe manufactured 18% of all spacecraft put in orbit for about 17% of the mass launched. In 2020-2022, these figures dropped to 4% of satellites and of the total mass launched. However, in absolute numbers, the number and mass of satellites manufactured by European entities has increased in this period.

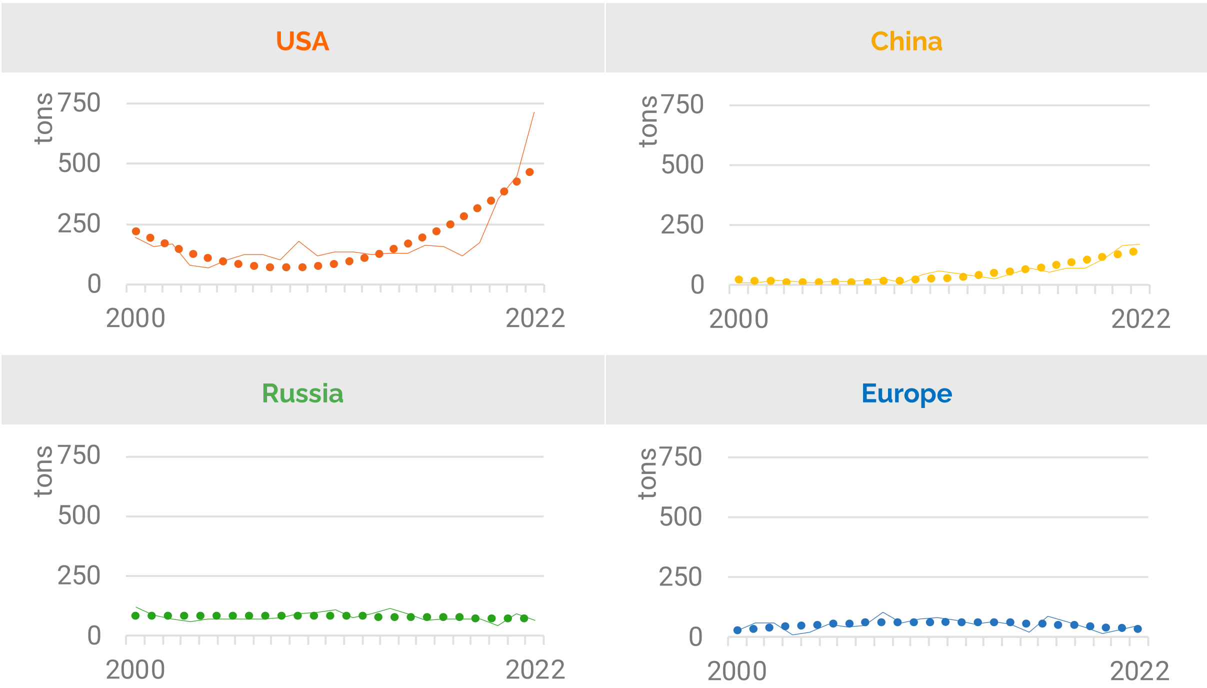


Figure 45: Evolution of spacecraft mass (in tons) per manufacturing country (2000-2022) with trendline

With the popularisation of the CubeSat standard, a growing number of countries and organisations have already developed a spacecraft, even though very basic. Since 2018, more than 420 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 a few organisations. Over the last 5 years, the top 10 manufacturers produced 81% of the total mass put in orbit.**

This concentration is even more visible in the commercial market (mostly 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 97.6% in 2020-2022.** U.S. companies, including Boeing, Northrop Grumman, Maxar Technologies and, above all, SpaceX, are the main actors on the market but Chinese companies (especially CAST) are now rivalling.

Interestingly, Lockheed Martin, a major space company, was demoted from the top 10 after the year 2022. SpaceX put into orbit 120 operational Starlink satellites in 2019, 1822 more in 2020-2021, and almost the same number (1726) in 2022 alone, 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.

This also allowed SpaceX to become the primary manufacturer worldwide, responsible for most of the mass launched on the commercial market (while it does not sell its manufacturing services to almost anyone else). In parallel, the deployment of OneWeb's constellation allowed this company to quickly become one of the leading actors in terms of mass launched, despite a reduction of the number of satellites launched in 2022.

Position	Top 10 (2015-2019)	Share of the total commercial mass	Top 10 (2020-2022)	Share of the total commercial mass
1	SSL/Maxar	26.1%	**SpaceX**	**77.9%**
2	TAS	19.9%	OneWeb Satellites	5.6%
3	Boeing	15.1%	CAST	3.3%
4	Airbus	12.8%	Maxar	2.9%
5	CASC	6.8%	Airbus	2.7%
6	**SpaceX**	**5.5%**	TAS	2.3%
7	Orbital ATK/NG	3.4%	Northrop Grumman	1%
8	Lockheed Martin	2.7%	ISS Reshetnev	0.8%
9	Mitsubishi Electric	1.8%	Chang Guang	0.6%
10	NEC	0.9%	Boeing	0.5%
	Total	95%	Total	97.6%

Table 11: Share of the mass launched (in tons) for the commercial market by the top 10 manufacturers

The leading position of European companies Airbus and Thales Alenia Space, which used to be prominent, starts to be increasingly challenged, in particular due to difficulties on the GEO satcom market. **In the period 2017-2019, the two European companies delivered 150 tons of commercial satellites, corresponding to 40% of the total mass launched these years. However, in 2020-2022, they delivered only 65 tons (excluding the satellites produced by OneWeb Satellites), accounting for 4.3% of the mass launched.** It is to be noted that the total mass launched by the two companies in 2020-2021 was 29 tons only, therefore 2022 was marked by a positive trend.

The commercial activity of the China Aerospace Science and Technology Corporation (including through its subsidiaries), remains rather limited because of difficulties to enter large segments of the market, for example due to export control restrictions.

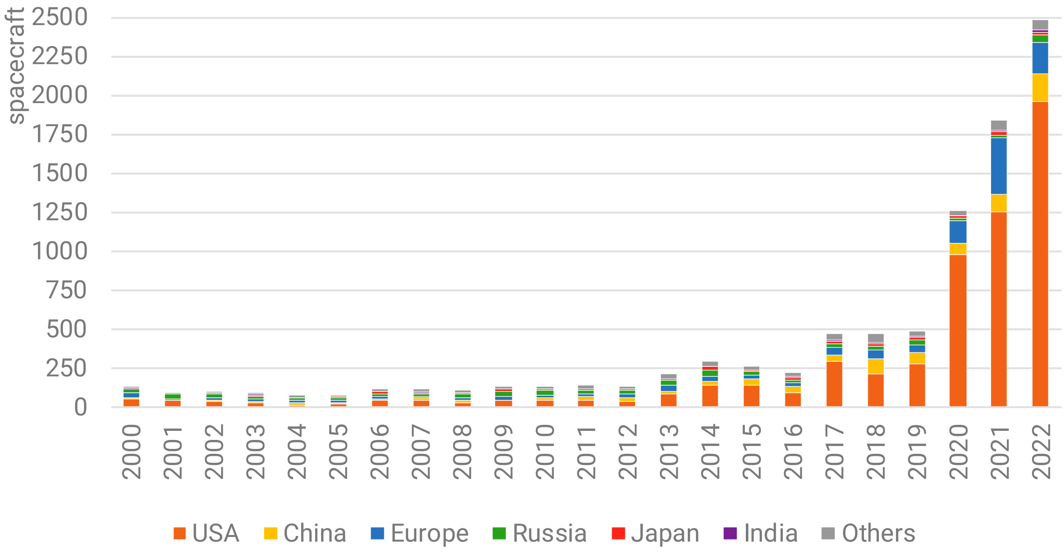


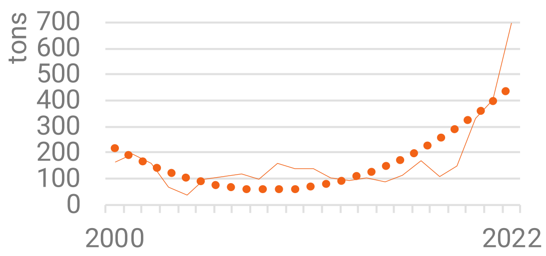
Figure 46: Evolution of the number of spacecraft per procuring country (2000-2022)

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.

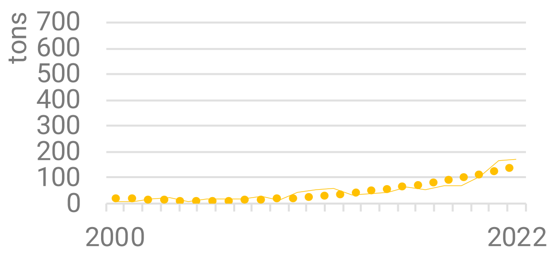
During the period 2017-2019, 55% of spacecraft launched worldwide were for U.S. customers, corresponding to 36% of the total mass. **This share reached 75% of spacecraft and 61% of the total mass launched in 2020-2022**.

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, for the first time exceeding 100 tons in 2020; the increase accelerated in 2021, with an augmentation of 57% (164 tons) compared to the year before. This number stabilised around 170 tons in 2022.

USA



China



Russia

Europe

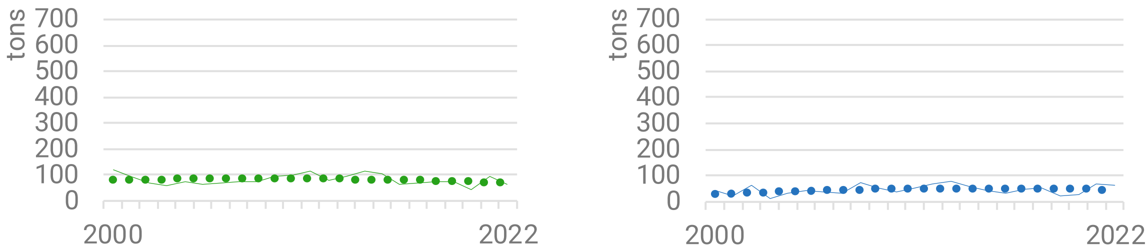


Figure 47: Evolution of total mass launched (in tons) per customer country (2000-2022) with trendline

Interestingly, the "European way" has been changing recently. 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 2022, the number of spacecraft launched for European customers was only half of the number of satellites launched that were built by European manufacturers (100 vs 205)**. 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 are currently produced in the United States. Procurement statistics in Russia are somewhat biased by the human spaceflight activity, as Progress and Soyuz capsules are attributed to Russia although they may be paid for, at least partially, by other countries.

On the commercial market, leading satellite operators and customers are more diverse and include European, American, Russian, 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 2020-2022, the top 10 operators represented 92.5% of this mass. This remarkable increase is strongly driven by SpaceX and its Starlink constellation, which accounts for more than three quarters of the total mass launched for the commercial market during these three 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. Intelsat's ELERA constellation). Over these three years, the geographical distribution was also more restricted, as American, European and Chinese operators clearly dominated the sector.

Position	Top 10 (2015-2019)	Share of the total commercial mass	Top 10 (2020-2022)	Share of the total commercial mass
1	Iridium	11.7%	**SpaceX**	**76%**
2	Intelsat	10.2%	OneWeb	5.6%
3	SES	5.8%	Eutelsat	2.1%
4	Eutelsat	5.5%	China Satcom	2%
5	**SpaceX**	**5.5%**	Intelsat	1.8%
6	Inmarsat	4.9%	SES	1.3%
7	SKY Perfect JSAT	4.4%	SiriusXM	1%
8	Telesat	3.4%	Axiom Space	0.9%
9	Arabsat	3.3%	Private individuals	0.9%
10	DirecTV	2.7%	RSCC	0.7%
	Total	**57.4%**	**Total**	**92.4%**

Table 12:: Share of the mass launched (in tons) for the top 10 operators on the commercial market

Finally, several of these companies contributed to the bounce of the market of GEO telecommunications satellites in 2020 (21 commercial satellites ordered compared to 10 in 2019 and 12 in 2018). But this exceptional situation was the result of the replacement of satellites stemming from the C-band spectrum reallocation taking place in the United States. In 2021, only 9 GEO telecommunications satellites were ordered for commercial customers, even lower than previous numbers, but the number of contracts bounced back to 11 in 2022 (all of them being for commercial customers). 60% of these spacecrafts will be provided by European manufacturers, however the customers are mostly non-European.

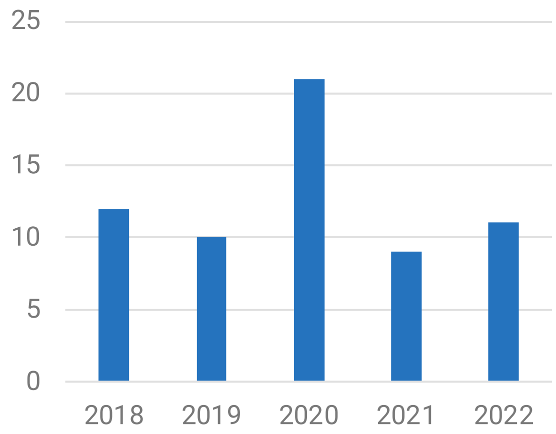


Figure 48: Evolution of the number of commercial GEO telecommunications satellites' orders (2018-2022)

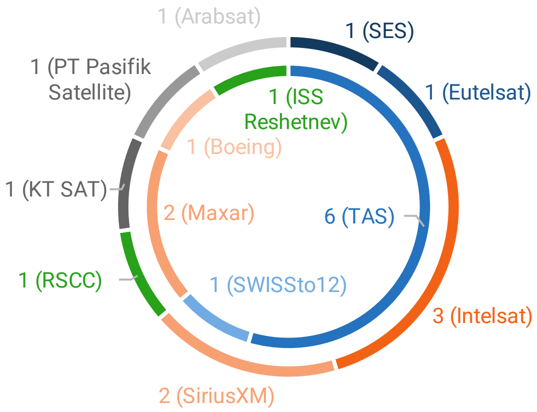


Figure 49: Number and share of commercial GEO telecommunications satellites' orders by manufacturer (inner circle) and operator (outer circle) in 2022

4.2 Global space activity in 2022

4.2.1 Overview

185 launches
+ 28% compared to 2021

7 failures
3.8% of all launches
21 spacecraft

Top 3 launch countries
(number of launches)

2491 satellites
launched
+ 35% compared to 2021

1020.9 tons
launched
+ 35% compared to 2021

LEO	MEO	GEO	Others
2432	6	34	19
874.7 tons	6.9 tons	103.7 tons	35.6 tons

Top Application

Telecommunications
79% of all satellites launched
61% of the mass launched

Main markets

Commercial

Governmental civil

Military

4.2.2 Launch activity in 2022

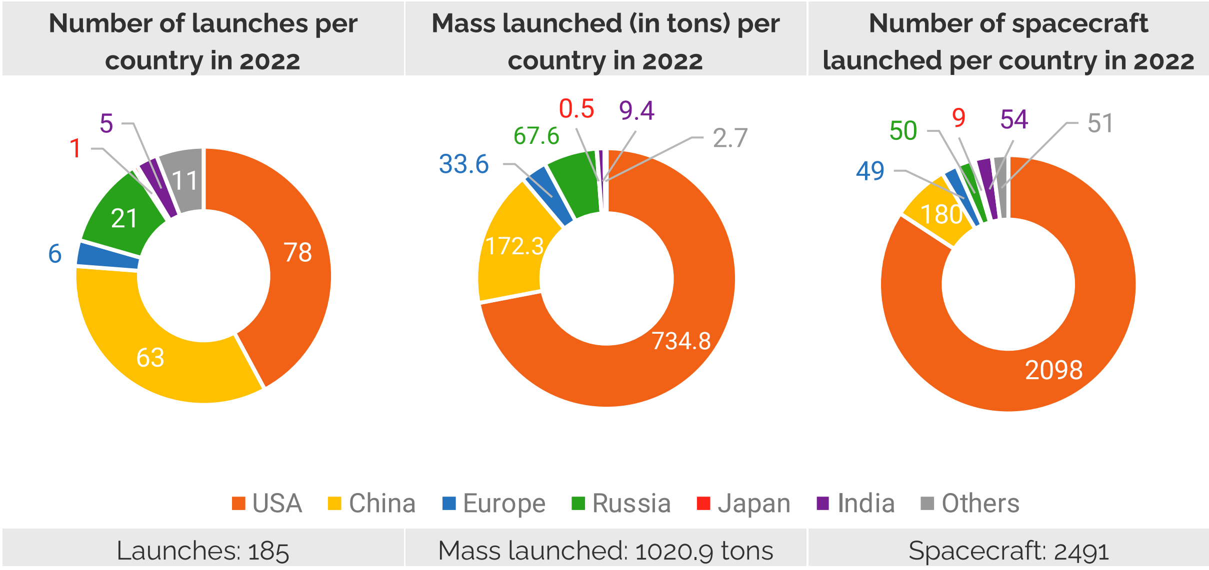


Figure 2: Number of launches, spacecraft and mass launched in 2022 per launch country

In 2022, nine countries (United States, China, France (for Europe), Russia, Japan, India, New Zealand, South Korea and Iran) launched 2491 spacecraft belonging to 48 nations. Among these nations, Moldova, Nepal, Uganda and Zimbabwe had their first satellite launched, joining the more than 90 countries involved in outer space activities. These figures and the numbers given below also include failed launch attempts, which represent 3.8% of all launches carried out this year **(7 failures for 185 launches).** Contrary to the four previous years, China was now second to the United States with 63 launches representing 34% of all launches. The United States itself launched 78 times, an increase of 73% compared to its previous record of 2021. The third traditional main launch country, Russia, lags behind with only 21 launches (11.4% of the total), a smaller number than what was performed in 2021 (24). 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.

In terms of mass launched, the United States holds the first place, primarily due to the launch of Starlink satellites (69.4% of the total mass launched by the United States) and its human spaceflight activities. The total mass launched by China is 2.5 times the one of Russia, despite the role of the latter in bringing crew and cargo to the ISS (accounting for 53% of the total mass launched by Russia, comparable to previous years). This breakthrough is caused by the launch of numerous remote sensing satellites and heavy demonstration spacecraft, as well as by the deployment of the new Chinese space station and related human spaceflight activities. With 6 launches (including one failure), European activity reached its lowest number since 2010. Only 33.6 tons were launched from Kourou, 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 regains its position as the most active spaceport of the planet, after having relinquished it to the Jiuquan Satellite Launch Center in 2021. 40 launches were conducted from there, followed by Jiuquan (19 launches) and the Kennedy Space Centre (17 launches). In terms of mass launched, Cape Canaveral is also the major spaceport, with 336 tons, that is, 43% more than the second (Kennedy Space Center, with 234 tons) and more than four times the mass launched from the first non-U.S. spaceport (Wenchang, 4th position with 76 tons).

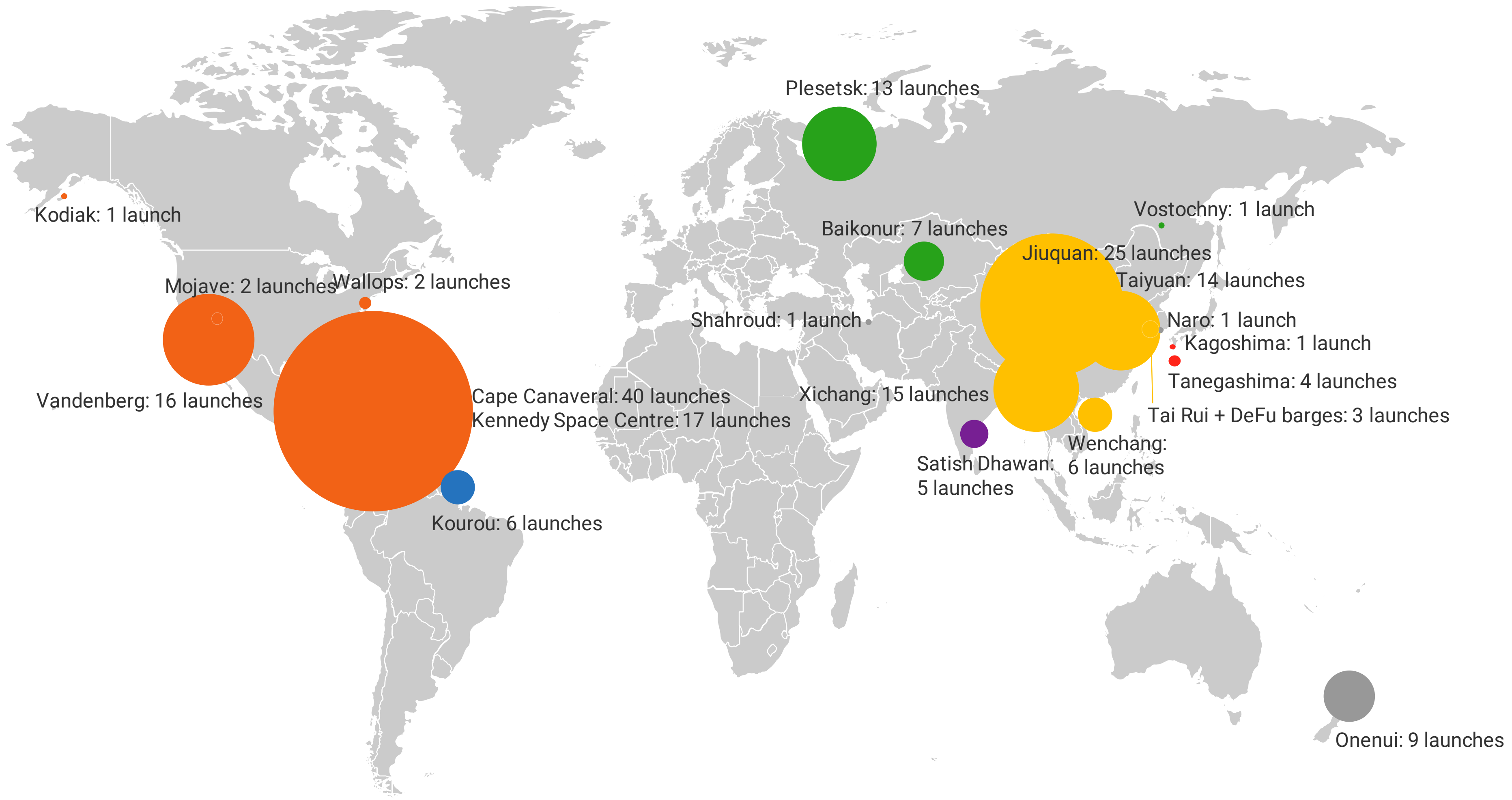


Figure 3: Number of launches per spaceport in 2022

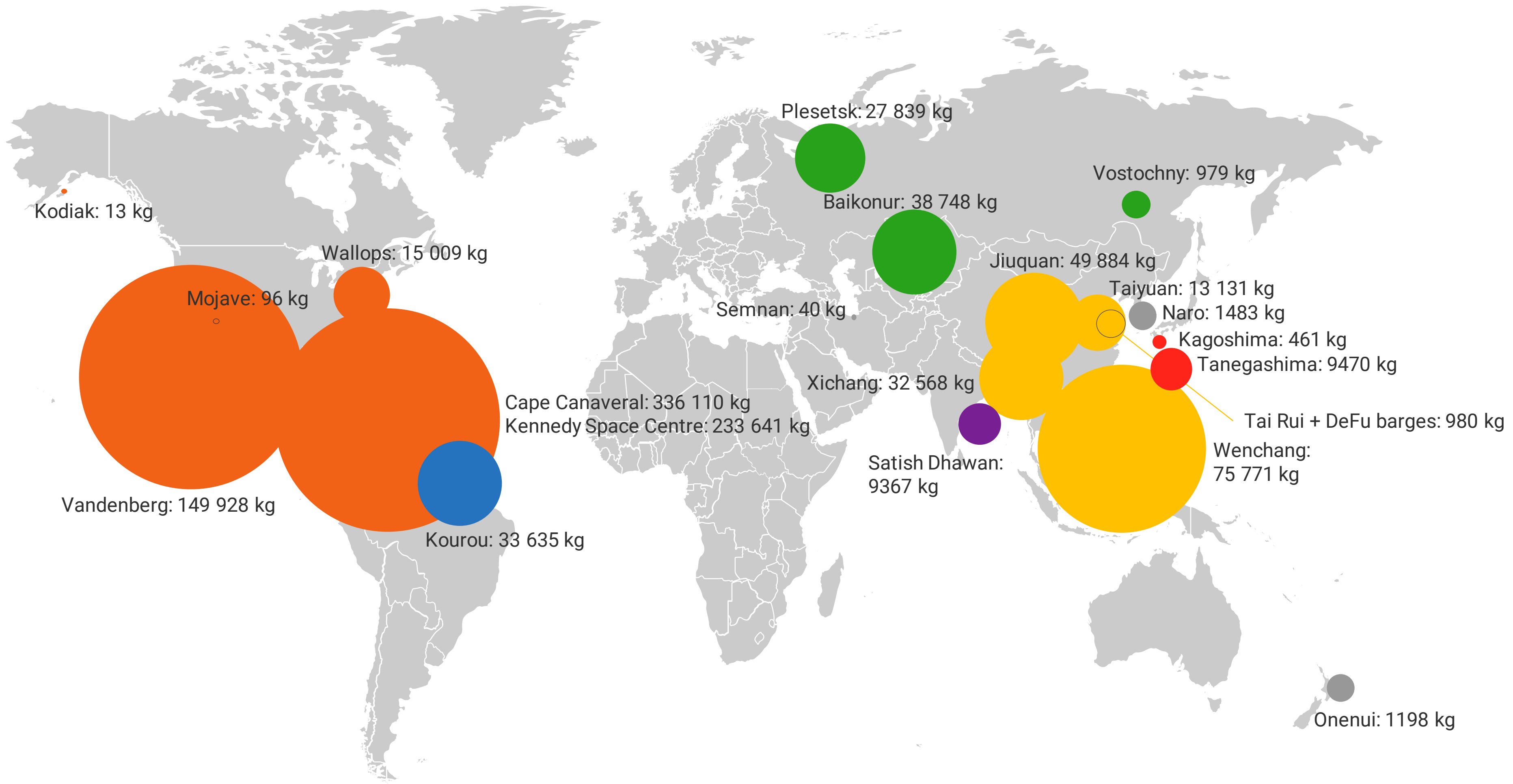


Figure 4: Total mass launched per spaceport in 2022

4.2.3 Spacecraft launched in 2022: customers and manufacturers

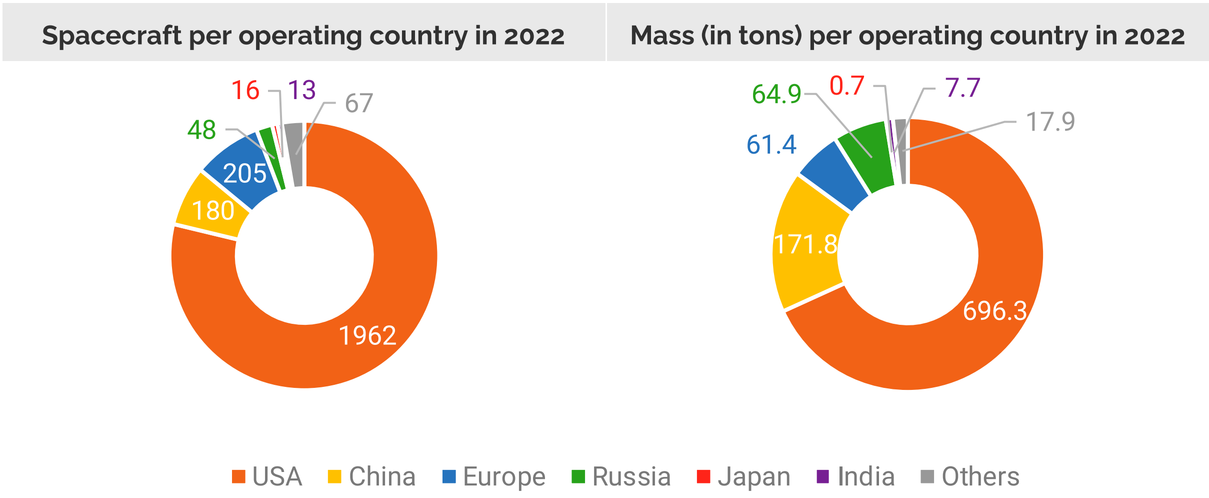


Figure 5: Number and mass of spacecraft per operating country in 2022

The United States was the top customer country in 2022 with 1962 satellites launched for U.S. operators, accounting for almost 700 tons. 78.8% of the spacecraft launched in 2022 were American. In terms of mass, satellites operated by U.S. organisations account for 68.2% of the mass launched, and those for China for 16.8%, while the number of satellites operated by Chinese organisations is 11 times lower than the American one.

The average weight of spacecraft launched for Chinese organisations is thus much higher than it is for their American counterparts (955 kg vs. 355 kg). 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.

From a manufacturing perspective, the United States has an even more prominent position, in particular in terms of number of spacecraft produced (83%) and, to a lesser extent, in terms of satellite mass (70.1%). It shows that, even though most of the spacecraft built by U.S. companies are for U.S. customers, several satellites launched in 2022 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, the company played a pivotal role in 2022 launch activity, as it alone represented 79.5% and 55.7% 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 2021, but the mass of European-built satellites launched in orbit that year represents "only" 83% of the mass launched for European operators, meaning that some European customers make use of spacecraft built in other regions of the world. This is for instance the case of OneWeb which, although being a UK company, is launching satellites manufactured by a joint-venture established in the United States.

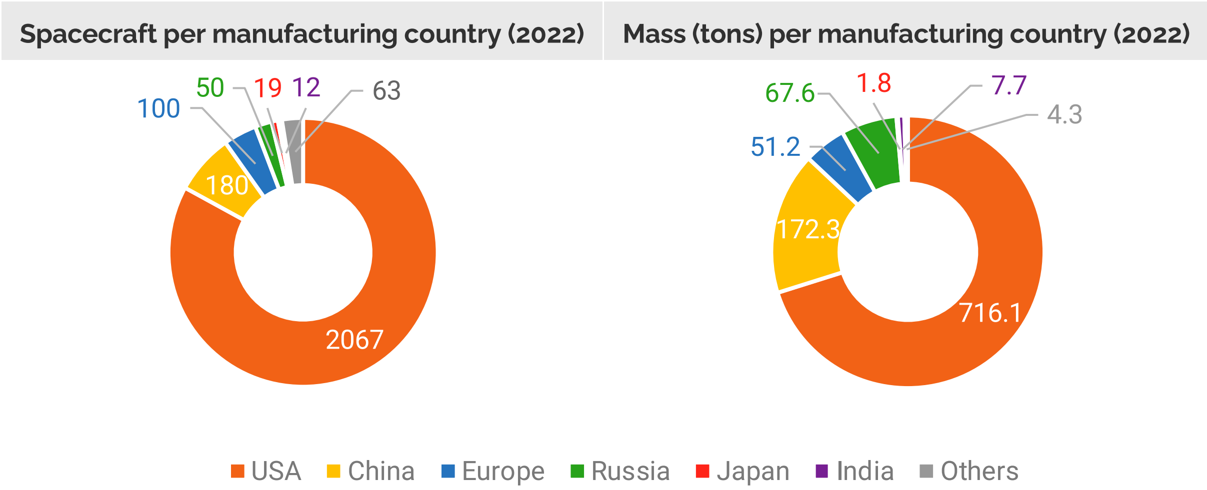


Figure 6: Number and mass of spacecraft per manufacturing country in 2022

4.2.4 Spacecraft launched in 2022: missions and markets

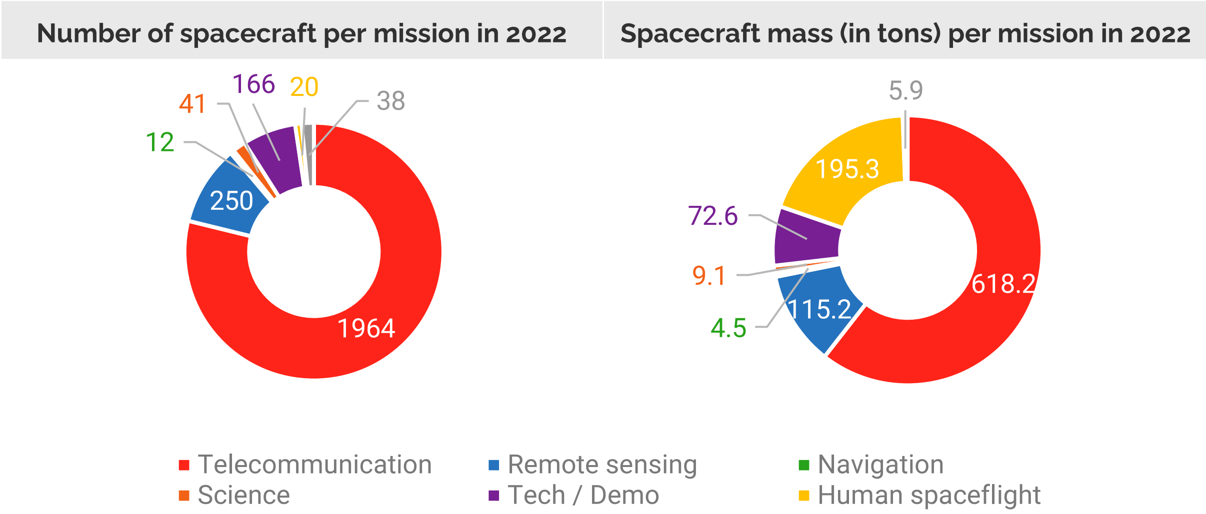


Figure 7: Number and mass of spacecraft per mission in 2022

Mainly as a result of the Starlink and OneWeb constellations, **an overwhelming majority (78.8%) of the satellites launched in 2022 serve telecommunication purposes**, followed to a much lesser extent by remote sensing (10%) and technology/demonstration spacecraft (6.7%). **Telecommunication satellites represent slightly more than 60% of the total mass launched,** followed by human spaceflight systems, which remain the second main category of mission in terms of mass launched (29.6%) after a noticeable increase in 2022. The mass launched for remote sensing missions represents twice the one for technology/demonstration spacecraft, while only 50% more satellites were launched for the former compared to the latter.

Commercial satellites account for 88.2% of the satellites launched in 2022, and this is the third consecutive year that the majority of the mass launched is dedicated to the commercial market (62.7%). Slightly less than one third of the mass (27%) was launched for governmental civil purposes (66% of which for human spaceflight and 17% for technology/demonstration), a decrease of ten percentage points compared to 2021. 10% 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.

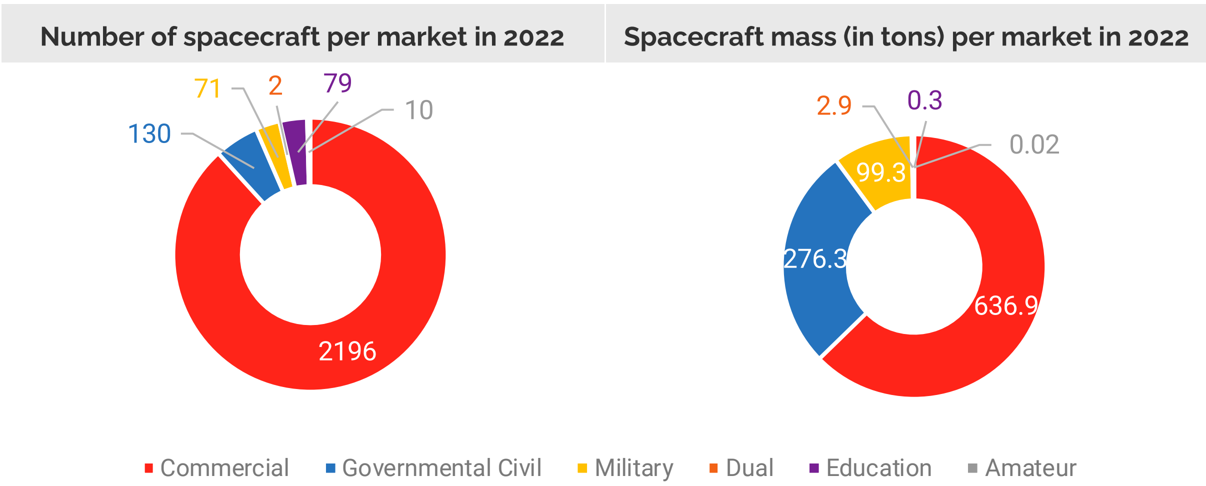


Figure 8: Number and mass of spacecraft per market in 2022 (excluding Other and Unknown missions)

4.3 Launch log and activity highlights

4.3.1 ESPI launch log 2022

Launch date	Launch country	Launcher	Outcome	Spacecraft name	Customer country	Manufacturer country	Mass at launch (kg)	Orbit	Mission	Market
06/01/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (49 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
13/01/2022	USA	Falcon-9 v1.2 (Block 5)	Success	BRO 5	France	Denmark	6	LEO	Signal Intelligence	Commercial
				Capella 7 & 8	USA	USA	112 (each)	LEO	Earth Observation	Commercial
				Challenger	USA	USA	0,9	LEO	Tech / Demo	Commercial
				Delfi-PQ 1	Netherlands	Netherlands	0,6	LEO	Tech / Demo	Education
				DEWA-Sat 1	UAE	Lithuania	3	LEO	Telecommunication	Commercial
				Dodona	USA	USA	4	LEO	Tech / Demo	Education
				EASAT 2	Spain	Spain	0,2	LEO	Radio Amateur	Amateur
				ETV A1	UK	Lithuania	20	LEO	Earth Observation	Commercial
				Flock-4x (44 satellites)	USA	USA	5 (each)	LEO	Earth Observation	Commercial
				FossaSat 2E (1 & 2)	Switzerland	Spain	0,5 (each)	LEO	Telecommunication	Commercial
				FossaSat 2E (4 satellites)	Spain	Spain	0,5 (each)	LEO	Telecommunication	Commercial
				Gossamer Piccolomini / Gossamer 1	USA	USA	1	LEO	Tech / Demo	Commercial
				Grizu-263a	Turkey	Turkey	0,25	LEO	Radio Amateur	Education
				HADES	Spain	Spain	0,2	LEO	Radio Amateur	Amateur
				HYPSO 1	Norway	Lithuania	6	LEO	Earth Science	Gov. Civil
				ICEYE (X14 & X16)	Finland	Finland	85 (each)	LEO	Earth Observation	Commercial
				ION-SCV 4	Italy	Italy	100	LEO	Other	Commercial
				IRIS-A	Taiwan	Taiwan	2	LEO	Tech / Demo	Gov. Civil
				Kepler (4 satellites)	Canada	Canada	16 (each)	LEO	Telecommunication	Commercial
				LabSat	Poland	Poland	3	LEO	Biology	Gov. Civil
				Lemur-2 (4 satellites)	USA	USA	4 (each)	LEO	Earth Observation	Commercial
				MDASat 1 (a, b & c)	South Africa	South Africa	2 (each)	LEO	AIS	Education

				MDQube-SAT 1	Argentina	Argentina	0,5	LEO	Tech / Demo	Commercial
				NuX 1	Singapore	Singapore	3	LEO	Tech / Demo	Commercial
				OroraTech 1	Germany	USA	10	LEO	Earth Observation	Commercial
				PION-BR 1	Brazil	Brazil	0,25	LEO	Radio Amateur	Education
				SanoSat-1 / Nepal-PQ 1	Nepal	Nepal	0,25	LEO	Radio Amateur	Education
				SATTLA 2 (A & B)	Israel	Israel	0,25 (each)	LEO	Tech / Demo	Education
				Sich 2-1	Ukraine	Ukraine	170	LEO	Earth Observation	Gov. Civil
				STORK (1 & 2)	Poland	Poland	3 (each)	LEO	Earth Observation	Commercial
				SW1FT	Poland	Poland	2	LEO	Tech / Demo	Commercial
				Tatan-Artibeus 1	USA	UK	0,25	LEO	Tech / Demo	Education
				Tevel (8 satellites)	Israel	Israel	1 (each)	LEO	Radio Amateur	Education
				Umbra 02	USA	USA	65	LEO	Earth Observation	Commercial
				Unicorn 1	UK	UK	0,25	LEO	Tech / Demo	Commercial
				Unicorn 2 (A, D & E)	UK	UK	0,5 (each)	LEO	Tech / Demo	Commercial
				VZLUsat 2	Czech Republic	Czech Republic	3	LEO	Tech / Demo	Gov. Civil
13/01/2022	USA	LauncherOne	Success	ADLER 1	Austria	USA	6	LEO	Tech / Demo	Amateur
				GEARRS 3	USA	USA	3	LEO	Tech / Demo	Military
				PAN (A & B)	USA	USA	4,6 (each)	LEO	Tech / Demo	Education
				STORK 3	Poland	Poland	3	LEO	Earth Observation	Commercial
				StreamSat 2	UK	Poland	4	LEO	Tech / Demo	Commercial
				TechEdSat 13	USA	USA	3	LEO	Tech / Demo	Education
17/01/2022	China	CZ-2D(2)	Success	Shiyan 13	China	China	1200	LEO	Tech / Demo	Unknown
19/01/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
21/01/2022	USA	Atlas-5(511)	Success	GSSAP (5 & 6)	USA	USA	700 (each)	GEO	SSA	Military
26/01/2022	China	CZ-4C	Success	Ludi Tance 1-01A	China	China	3200	LEO	Earth Observation	Gov. Civil
31/01/2022	USA	Falcon-9 v1.2 (Block 5)	Success	CSG 2	Italy	France	2205	LEO	Earth Observation	Dual
02/02/2022	USA	Falcon-9 v1.2 (Block 5)	Success	USA 326	USA	USA	2000	LEO	Earth Observation	Military
03/02/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (49 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
05/02/2022	Russia	Soyuz-2-1a Fregat	Success	Kosmos 2553 / Neitron 1	Russia	Russia	1000	LEO	Tech / Demo	Military

10/02/2022	*USA*	*Astra Rocket-3*	*Failure*	*BAMA 1*	*USA*	*USA*	*3*	*LEO*	*Tech / Demo*	*Education*
				INCA	*USA*	*USA*	*3,8*	*LEO*	*Earth Science*	*Education*
				QubeSat	*USA*	*USA*	*3*	*LEO*	*Tech / Demo*	*Education*
				R5-S1	*USA*	*USA*	*3*	*LEO*	*Tech / Demo*	*Gov. Civil*
10/02/2022	France	Soyuz-ST-B Fregat-M	Success	OneWeb (34 satellites)	UK	USA	147 (each)	LEO	Telecommunication	Commercial
14/02/2022	India	PSLV-XL	Success	INS 2TD	India	India	18	LEO	Tech / Demo	Gov. Civil
				INSPIREsat 1	India	India	8	LEO	Earth Science	Gov. Civil
				RISAT 1A / EOS 04	India	India	1858	LEO	Earth Observation	Gov. Civil
15/02/2022	Russia	Soyuz-2-1a	Success	Progress-MS 19	Russia	Russia	7280	LEO	Cargo Transfer	Gov. Civil
				YuZGU-55 (5 satellites)	Russia	Russia	4,8 (each)	LEO	Tech / Demo	Gov. Civil
19/02/2022	USA	Antares-230+	Success	Cygnus CRS-17	USA	USA	7492	LEO	Cargo Transfer	Gov. Civil
				KITSUNE	Japan	Japan	14	LEO	Telecommunication	Gov. Civil
				NACHOS	USA	USA	6,25	LEO	Tech / Demo	Gov. Civil
21/02/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (46 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
25/02/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (50 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
26/02/2022	China	CZ-4C	Success	Ludi Tance 1-01B	China	China	3200	LEO	Earth Observation	Gov. Civil
27/02/2022	China	CZ-8(2)	Success	Chaohu-1	China	China	325	LEO	Earth Observation	Commercial
				Chuangxing Leishen / Thor Smart Satellite	China	China	14	LEO	Tech / Demo	Commercial
				Hainan-1 (01 & 02)	China	China	60 (each)	LEO	Earth Observation	Commercial
				Jilin-1 Gaofen-03D (9 satellites)	China	China	42 (each)	LEO	Earth Observation	Commercial
				Jilin-1 Mofang-02A	China	China	32	LEO	Earth Observation	Commercial
				Qimingxing 1 / Phospherus 1	China	China	19	LEO	Earth Observation	Education
				Taijing-3 01	China	China	240	LEO	Earth Observation	Commercial
				Taijing-4 01	China	China	250	LEO	Earth Observation	Commercial
				Tianqi 19	China	China	50	LEO	Telecommunication	Commercial
				Wenchang-1 (01 & 02)	China	China	62,5 (each)	LEO	Earth Observation	Gov. Civil
				Xidian-1	China	China	50	LEO	Tech / Demo	Gov. Civil

				Xingshidai 17 / Star Era 17	China	China	20	LEO	Earth Observation	Commercial
28/02/2022	New Zealand	Electron KS	Success	Strix-β	Japan	Japan	150	LEO	Earth Observation	Commercial
01/03/2022	USA	Atlas-5(541)	Success	GOES 18 / GOES T	USA	USA	5192	GEO	Meteorology	Gov. Civil
03/03/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (47 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
05/03/2022	China	CZ-2C(3)	Success	Xingyuan 2	China	China	8	LEO	Earth Observation	Commercial
				Yinhe 2 (6 satellites)	China	China	190 (each)	LEO	Telecommunication	Commercial
08/03/2022	Iran	Qased	Success	Noor 2	Iran	Iran	40	LEO	Earth Observation	Military
09/03/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (48 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
14/03/2022	USA	Astra Rocket-3	Success	OreSat 0	USA	USA	1	LEO	Tech / Demo	Education
				S4 Crossover	USA	USA	5	LEO	Tech / Demo	Commercial
				SpaceBEE (16 satellites)	USA	USA	0,4 (each)	LEO	Telecommunication	Commercial
				SpaceBEENZ 11	USA	USA	0,4	LEO	Telecommunication	Commercial
17/03/2022	China	CZ-4C	Success	Yaogan 34-02	China	China	2300	LEO	Earth Observation	Military
18/03/2022	Russia	Soyuz-2-1a	Success	Soyuz-MS 21	Russia	Russia	7080	LEO	Crew Transfer	Gov. Civil
19/03/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	306 (each)	LEO	Telecommunication	Commercial
22/03/2022	Russia	Soyuz-2-1a Fregat	Success	Meridian-M 10	Russia	Russia	2100	HEO	Telecommunication	Military
29/03/2022	China	CZ-6A	Success	Pujiang 2	China	China	200	LEO	Earth Observation	Gov. Civil
				Tiankun 2	China	China	85	LEO	Tech / Demo	Gov. Civil
30/03/2022	China	CZ-11	Success	Tianping 2 (A, B & C)	China	China	50 (each)	LEO	Tech / Demo	Gov. Civil
01/04/2022	USA	Falcon-9 v1.2 (Block 5)	Success	AlfaCrux	Brazil	Spain	1	LEO	Tech / Demo	Education
				ARCSAT	Norway	Denmark	10	LEO	Tech / Demo	Military
				BD-Sat	Czech Republic	Czech Republic	1	LEO	Tech / Demo	Gov. Civil
				BRO 7	France	Denmark	6	LEO	Signal Intelligence	Commercial
				EnMAP	Germany	Germany	936	LEO	Earth Observation	Gov. Civil
				GNOMES 3	USA	USA	30	LEO	Meteorology	Commercial
				Hawk 4 (A, B & C)	USA	Canada	25 (each)	LEO	Signal Intelligence	Commercial
				ION-SCV 5	Italy	Italy	100	LEO	Other	Commercial
				KSF 2 (4 satellites)	Luxembourg	Netherlands	8 (each)	LEO	Signal Intelligence	Commercial

				Lynk 05 / Lynk Tower 1	USA	USA	60	LEO	Telecommunication	Commercial
				MP42	Lithuania	Lithuania	40	LEO	Tech / Demo	Commercial
				ÑuSat (5 satellites)	Uruguay	Uruguay	41 (each)	LEO	Earth Observation	Commercial
				Pixxel-TD 2 / Shakuntala	India	Lithuania	15	LEO	Tech / Demo	Commercial
				PlantSat	Chile	Denmark	4	LEO	Biology	Education
				SpaceBEE (12 satellites)	USA	USA	0,4 (each)	LEO	Telecommunication	Commercial
				Spark 1	USA	Lithuania	10	LEO	Tech / Demo	Commercial
				SUCHAI (2 & 3)	Chile	Chile	4 (each)	LEO	Space Science	Education
				UP-Box	Italy	Italy	2	LEO	Other	Commercial
02/04/2022	New Zealand	Electron KS	Success	BlackSky (16 & 17)	USA	USA	56 (each)	LEO	Earth Observation	Commercial
06/04/2022	China	CZ-4C	Success	Gaofen 3-03	China	China	2950	LEO	Earth Observation	Gov. Civil
07/04/2022	Russia	Soyuz-2-1b	Success	Lotos-S1 5	Russia	Russia	6000	LEO	Signal Intelligence	Military
08/04/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Crew Dragon Ax-1	USA	USA	12055	LEO	Space Tourism	Commercial
15/04/2022	China	CZ-4C	Success	Daqi 1	China	China	2600	LEO	Earth Science	Gov. Civil
15/04/2022	China	CZ-3B/G3	Success	ChinaSat 6D	China	China	5100	GEO	Telecommunication	Commercial
17/04/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Intruder 13 (A & B)	USA	USA	3250 (each)	LEO	Signal Intelligence	Military
21/04/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
27/04/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Crew Dragon USCV-4	USA	USA	12055	LEO	Crew Transfer	Gov. Civil
29/04/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
29/04/2022	China	CZ-2C(3)	Success	Siwei Gaojing 1 (-01 & -02)	China	China	540 (each)	LEO	Earth Observation	Commercial
29/04/2022	Russia	Angara-1.2	Success	Kosmos 2555 / MKA-R 1	Russia	Russia	150	LEO	Earth Observation	Military
30/04/2022	China	CZ-11H	Success	Jilin-1 Gaofen-03D (4 satellites)	China	China	42 (each)	LEO	Earth Observation	Commercial
			Success	Jilin-1 Gaofen-04A	China	China	95	LEO	Earth Observation	Commercial
02/05/2022	New Zealand	Electron KS (R)	Success	AuroraSat-1	Finland	Poland	2	LEO	Tech / Demo	Commercial
			Success	BRO 6	France	Denmark	6	LEO	Signal Intelligence	Commercial
			Success	Copia	New Zealand	New Zealand	20	LEO	Tech / Demo	Commercial
			Success	E-Space Demo (1, 2 & 3)	USA	USA	50 (each)	LEO	Tech / Demo	Commercial

			Success	MyRadar 1	USA	USA	0,2	LEO	Tech / Demo	Commercial
			Success	SpaceBEE (16 satellites)	USA	USA	0,4 (each)	LEO	Telecommunication	Commercial
			Success	SpaceBEENZ (8 satellites)	USA	USA	0,4 (each)	LEO	Telecommunication	Commercial
			Success	TRSI (2 & 3)	USA	USA	0,2 (each)	LEO	Tech / Demo	Commercial
			Success	Unicorn 2	UK	UK	0,5	LEO	Tech / Demo	Commercial
05/05/2022	China	CZ-2D(2)	Success	Jilin-1 Gaofen-03D (7 satellites)	China	China	42 (each)	LEO	Earth Observation	Commercial
			Success	Jilin-1 Kuanfu-01C	China	China	1250	LEO	Earth Observation	Commercial
06/05/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
09/05/2022	China	CZ-7	Success	Tianzhou 4	China	China	12910	LEO	Cargo Transfer	Gov. Civil
13/05/2022	*China*	*Hyperbola-1*	*Failure*	*Jilin-1 Mofang-01A(R)*	*China*	*China*	*18*	*LEO*	*Earth Observation*	*Commercial*
13/05/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
14/05/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
18/05/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
19/05/2022	USA	Atlas-5(N22)	Success	Starliner OFT-2	USA	USA	13000	LEO	Tech / Demo	Gov. Civil
19/05/2022	Russia	Soyuz-2-1a	Success	Bars-M 03	Russia	Russia	4000	LEO	Earth Observation	Military
20/05/2022	China	CZ-2C(3)/YZ-1S	Success	Unknown (3 satellites)	China	China	50 (each)	LEO	Tech / Demo	Commercial
25/05/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Agile Micro Sat	USA	USA	16	LEO	Tech / Demo	Gov. Civil
				BroncoSat 1	USA	USA	2	LEO	Tech / Demo	Education
				Centauri 5	Australia	USA	8	LEO	Telecommunication	Commercial
				CICERO-2 (1 & 2)	USA	USA	10 (each)	LEO	Earth Observation	Commercial
				CNCE Block 2 (-1 & -2)	USA	USA	6 (each)	LEO	Tech / Demo	Military
				Connecta T1.1	Turkey	Turkey	4	LEO	Tech / Demo	Commercial
				CPOD (A & B)	USA	USA	4 (each)	LEO	Tech / Demo	Commercial
				Foresail 1	Finland	Finland	3	LEO	Space Science	Gov. Civil
				FossaSat 2E (7 satellites)	Spain	Spain	0,5 (each)	LEO	Telecommunication	Commercial
				GHGSat (C3, C4 & C5)	Canada	Canada	15 (each)	LEO	Earth Observation	Commercial
				Guardian	Spain	UK	6	LEO	Tech / Demo	Commercial
				Hawk 5 (A, B & C)	USA	Canada	25 (each)	LEO	Signal Intelligence	Commercial
				ICEYE (5 satellites)	Finland	Finland	85 (each)	LEO	Earth Observation	Commercial

				ION-SCV 6	Italy	Italy	100	LEO	Other	Commercial
				Lemur-2 (5 satellites)	USA	USA	4 (each)	LEO	Earth Observation	Commercial
				ÑuSat (4 satellites)	Uruguay	Uruguay	41 (each)	LEO	Earth Observation	Commercial
				Outpost Mars Demo-1 / OMD-1	USA	USA	111	LEO	Tech / Demo	Commercial
				Planetum 1	Czech Republic	Czech Republic	1	LEO	Other	Education
				Platform 1	Bulgaria	Bulgaria	6	LEO	Other	Commercial
				PTD 3	USA	USA	12	LEO	Tech / Demo	Gov. Civil
				SBUDNIC	USA	USA	3	LEO	Tech / Demo	Education
				SelfieSat-1	Norway	Norway	1,8	LEO	Other	Education
				Sherpa-AC 1	USA	USA	150	LEO	Other	Commercial
				Spark 2	USA	Lithuania	10	LEO	Tech / Demo	Commercial
				SPiN 1	Germany	Germany	1	LEO	Tech / Demo	Commercial
				Umbra 03	USA	USA	65	LEO	Earth Observation	Commercial
				Urdaneta-Armsat 1	Spain	Spain	20	LEO	Earth Observation	Commercial
				VariSat 1C	USA	USA	11	LEO	Tech / Demo	Commercial
				Veery FS-1	USA	USA	0,25	LEO	Tech / Demo	Commercial
				Vigoride 3 / Vigoride Demo-1	USA	USA	215	LEO	Other	Commercial
02/06/2022	China	CZ-2C(3)	Success	GeeSAT-1 (9 satellites)	China	China	130 (each)	LEO	Navigation	Commercial
03/06/2022	Russia	Soyuz-2-1a	Success	Progress-MS 20	Russia	Russia	7280	LEO	Cargo Transfer	Gov. Civil
				Tsiolkovsky-Ryazan (1 & 2)	Russia	Russia	4,8 (each)	LEO	Tech / Demo	Education
				YuZGU-55 (11 & 12)	Russia	Russia	4,8 (each)	LEO	Tech / Demo	Education
05/06/2022	China	CZ-2F/G	Success	Shenzhou 14	China	China	8082	LEO	Crew Transfer	Gov. Civil
08/06/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Nilesat 301	Egypt	France	3938	GEO	Telecommunication	Commercial
12/06/2022	*USA*	*Astra Rocket-3*	*Failure*	*TROPICS (02 & 03)*	*USA*	*USA*	*5,3 (each)*	*LEO*	*Earth Science*	*Gov. Civil*
17/06/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
18/06/2022	USA	Falcon-9 v1.2 (Block 5)	Success	SARah 1	Germany	France	4000	LEO	Earth Observation	Military
19/06/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Globalstar M087	USA	France	700	LEO	Telecommunication	Commercial
				USA (328, 329, 330 & 331)	USA	USA	295 (each)	LEO	Tech / Demo	Military

21/06/2022	South Korea	Nuri	Success	MIMAN	South Korea	South Korea	3,7	LEO	Earth Science	Gov. Civil
				Nuri Test Payload 2	South Korea	South Korea	1300	LEO	Tech / Demo	Gov. Civil
				PVSAT	South Korea	South Korea	162,5	LEO	Tech / Demo	Gov. Civil
				RANDEV	South Korea	South Korea	3,2	LEO	Earth Observation	Gov. Civil
				SNUGLITE 2	South Korea	South Korea	3,8	LEO	Radio Amateur	Education
				STEP Cube Lab 2	South Korea	South Korea	9,6	LEO	Earth Observation	Gov. Civil
22/06/2022	France	Ariane-5ECA+	Success	Gsat 24 / CMS 02	India	India	4181	GEO	Telecommunication	Commercial
				MEASAT 3D	Malaysia	France	5648	GEO	Telecommunication	Commercial
22/06/2022	China	Kuaizhou-1A	Success	Tianxing 1	China	China	100	LEO	Tech / Demo	Gov. Civil
23/06/2022	China	CZ-2D(2)	Success	Yaogan 35-02 (A. B & C)	China	China	750 (each)	LEO	Earth Observation	Military
27/06/2022	China	CZ-4C	Success	Gaofen 12-03	China	China	2400	LEO	Earth Observation	Gov. Civil
28/06/2022	New Zealand	Electron Photon-IP	Success	CAPSTONE	USA	USA	27	Escape	Tech / Demo	Gov. Civil
				Lunar Photon	New Zealand	New Zealand	300	Escape	Tech / Demo	Commercial
29/06/2022	USA	Falcon-9 v1.2 (Block 5)	Success	SES 22	Luxembourg	France	3500	GEO	Telecommunication	Commercial
30/06/2022	India	PSLV-CA	Success	DS-EO	Singapore	South Korea	365	LEO	Earth Observation	Gov. Civil
				NeuSAR	Singapore	South Korea	155	LEO	Earth Observation	Commercial
				POEM	India	India	350	LEO	Tech / Demo	Gov. Civil
				SCOOB 1	Singapore	Singapore	2,8	LEO	Space Science	Education
01/07/2022	USA	Atlas-5(541)	Success	USSF-12 Ring	USA	USA	500	GEO	Tech / Demo	Military
				WFOV-T / USA 332	USA	USA	3200	GEO	Tech / Demo	Military
02/07/2022	USA	LauncherOne	Success	CTIM-FD	USA	USA	6	LEO	Tech / Demo	Gov. Civil
				GPX-2	USA	USA	3,4	LEO	Tech / Demo	Gov. Civil
				Gunsmoke-L (1 & 2)	USA	USA	6 (each)	LEO	Tech / Demo	Military
				MISR B	USA	USA	6	LEO	Tech / Demo	Military
				NACHOS 2	USA	USA	6,25	LEO	Tech / Demo	Military
				Recurve	USA	USA	15	LEO	Tech / Demo	Military
				Slingshot 1	USA	USA	19	LEO	Tech / Demo	Military
07/07/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
07/07/2022	Russia	Soyuz-2-1b Fregat	Success	Kosmos 2557 / Glonass-K 16L	Russia	Russia	962	MEO	Navigation	Military

11/07/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (46 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
12/07/2022	China	CZ-3B/G3	Success	TianLian 2C	China	China	4000	GEO	Satellite Data Relay	Gov. Civil
13/07/2022	France	Vega-C	Success	ALPHA	Italy	Italy	1	LEO	Tech / Demo	Commercial
				AstroBio Cubesat	Italy	Italy	5	LEO	Biology	Gov. Civil
				Celesta / Robusta 1D	Europe	France	1	LEO	Tech / Demo	Education
				Greencube	Italy	Italy	4	LEO	Biology	Gov. Civil
				LARES 2	Italy	Italy	295	LEO	Space Science	Gov. Civil
				MTCube-2 / Robusta 1F	France	France	1	LEO	Tech / Demo	Education
				Trisat-R	Slovenia	Slovenia	5	LEO	Space Science	Gov. Civil
13/07/2022	New Zealand	Electron KS	Success	USA 334	USA	USA	80	LEO	Earth Observation	Military
15/07/2022	USA	Falcon-9 v1.2 (Block 5)	Success	BeaverCube	USA	USA	3	LEO	Earth Science	Education
				CapSat 1	USA	USA	1	LEO	Tech / Demo	Education
				CLICK A	USA	USA	3	LEO	Tech / Demo	Gov. Civil
				D3	USA	USA	2	LEO	Tech / Demo	Education
				Dragon CRS-25	USA	USA	11000	LEO	Cargo Transfer	Gov. Civil
				EMIT	USA	USA	500	LEO	Earth Science	Gov. Civil
				JagSat-1	USA	USA	2	LEO	Tech / Demo	Education
				TUMnanoSAT	Moldova	Moldova	1	LEO	Tech / Demo	Education
15/07/2022	China	CZ-2C(3)	Success	Siwei Gaojing 2 (-01 & -02)	China	China	540 (each)	LEO	Earth Observation	Commercial
17/07/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
22/07/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (46 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
24/07/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
24/07/2022	China	CZ-5B	Success	Wentian	China	China	23000	LEO	Space Station Infrastructure	Gov. Civil
27/07/2022	China	Zhongke-1A	Success	Dianci zuzhuang Shiyan (1 & 2)	China	China	50 (each)	LEO	Tech / Demo	Gov. Civil
				Diguidao Liangzi Mishifenfa Shiyan / Jinan-1	China	China	100	LEO	Telecommunication	Gov. Civil

				Guidao Daqimidu Tance Shiyan	China	China	75	LEO	Earth Science	Gov. Civil
				Huawan-Nanyue Kexue	China	China	20	LEO	Earth Science	Education
				SATech 01	China	China	120	LEO	Space Science	Gov. Civil
01/08/2022	Russia	Soyuz-2-1v Volga	Success	Kosmos 2558	Russia	Russia	1200	LEO	Other	Military
04/08/2022	USA	Falcon-9 v1.2 (Block 5)	Success	KPLO / Danuri	South Korea	South Korea	678	Escape	Planetary Science	Gov. Civil
04/08/2022	USA	Atlas-5(421)	Success	SBIRS-GEO 6	USA	USA	4500	GEO	Early Warning	Military
04/08/2022	China	CZ-2F/T	Success	Chongfu Shiyong Shiyan Hangtian Qi 2 / CSSHQ 2	China	China	8500	LEO	Tech / Demo	Military
04/08/2022	New Zealand	Electron KS	Success	USA 335	USA	USA	80	LEO	Earth Observation	Military
04/08/2022	China	CZ-4B	Success	HEAD 2G	China	China	45	LEO	AIS	Commercial
				Minhang Shaonian	China	China	50	LEO	Unknown	Education
				TECIS / Guomang	China	China	500	LEO	Earth Science	Gov. Civil
07/08/2022	*India*	*SSLV*	*Failure*	*AzaadiSAT*	*India*	*India*	*8*	*LEO*	*Tech / Demo*	*Education*
				Microsat 2A / EOS 02	*India*	*India*	*142*	*LEO*	*Earth Observation*	*Gov. Civil*
09/08/2022	Russia	Soyuz-2-1b Fregat	Success	CubeSX-HSE 2	Russia	Russia	3,4	LEO	AIS	Education
				CYCLOPS	Russia	Russia	3	LEO	Tech / Demo	Education
				Geoscan-Edelveis	Russia	Russia	2,9	LEO	Tech / Demo	Education
				ISOI	Russia	Russia	3,5	LEO	Earth Observation	Education
				KAI 1	Russia	Russia	3,6	LEO	Earth Observation	Education
				Khayyam 1	Iran	Russia	650	LEO	Earth Observation	Dual
				Kuzbass-300	Russia	Russia	3	LEO	Earth Observation	Education
				MIET-AIS	Russia	Russia	3,4	LEO	AIS	Education
				Monitor 1	Russia	Russia	2,8	LEO	Space Science	Education
				Polytech Universe (1 & 2)	Russia	Russia	4,5 (each)	LEO	Earth Science	Education
				ReshUCube	Russia	Russia	3,4	LEO	Tech / Demo	Education
				Siren / LILAC	Russia	Russia	3,2	LEO	Biology	Education
				Skoltech B (1 & 2)	Russia	Russia	4,2 (each)	LEO	Tech / Demo	Education
				UTMN	Russia	Russia	3	LEO	Earth Observation	Education
				Vizard SS1	Russia	Russia	2,3	LEO	Telecommunication	Education

09/08/2022	China	Ceres-1	Success	Donghai 1	China	China	25	LEO	Tech / Demo	Commercial
				Taijing-1 (01 & 02)	China	China	70 (each)	LEO	Earth Observation	Commercial
10/08/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (52 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
10/08/2022	China	CZ-6	Success	Jilin-1 Gaofen-03D (10 satellites)	China	China	42 (each)	LEO	Earth Observation	Commercial
				Jilin-1 Hongwai-A (6 satellites)	China	China	42 (each)	LEO	Earth Observation	Commercial
12/08/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (46 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
19/08/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
19/08/2022	China	CZ-2D(2)	Success	Yaogan 35-04 (A, B & C)	China	China	750 (each)	LEO	Earth Observation	Military
23/08/2022	China	Kuaizhou-1A	Success	CX 16 (A & B)	China	China	50 (each)	LEO	Tech / Demo	Gov. Civil
24/08/2022	China	CZ-2D(2)	Success	Beijing 3B / Nanning 1	Singapore	China	1500	LEO	Earth Observation	Commercial
28/08/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (54 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
31/08/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (46 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
02/09/2022	China	CZ-4C	Success	Yaogan 33-02	China	China	1040	LEO	Earth Observation	Military
05/09/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Sherpa-LTC 2	USA	USA	180	LEO	Other	Commercial
				Starlink (51 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
06/09/2022	China	Kuaizhou-1A	Success	CentiSpace-1 (S3 & S4)	China	China	97 (each)	LEO	Tech / Demo	Commercial
06/09/2022	China	CZ-2D(2)	Success	Yaogan 35-05 (A, B & C)	China	China	750 (each)	LEO	Earth Observation	Military
07/09/2022	France	Ariane-5ECA+	Success	Eutelsat Konnect VHTS	France	France	6396	GEO	Telecommunication	Commercial
11/09/2022	USA	Falcon-9 v1.2 (Block 5)	Success	BlueWalker 3	USA	USA	1500	LEO	Tech / Demo	Commercial
				Starlink (34 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
13/09/2022	China	CZ-7A	Success	ZhongXing 01E / FengHuo 02E	China	China	5320	GEO	Telecommunication	Military
15/09/2022	New Zealand	Electron KS	Success	StriX 1	Japan	Japan	100	LEO	Earth Observation	Commercial
19/09/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (54 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
20/09/2022	China	CZ-2D(2)	Success	Yunhai-1 03	China	China	750	LEO	Earth Observation	Gov. Civil
21/09/2022	Russia	Soyuz-2-1a	Success	Soyuz-MS 22	Russia	Russia	7080	LEO	Crew Transfer	Gov. Civil
24/09/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (52 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
24/09/2022	China	Kuaizhou-1A	Success	Shiyan (14 & 15)	China	China	100 (each)	LEO	Tech / Demo	Gov. Civil

24/09/2022	USA	Delta-4H (upg.)	Success	KH-11 19	USA	USA	15000	LEO	Earth Observation	Military
26/09/2022	China	CZ-6	Success	Shiyan 16 (A & B)	China	China	350 (each)	LEO	Tech / Demo	Gov. Civil
				Shiyan 17	China	China	350	LEO	Tech / Demo	Gov. Civil
26/09/2022	China	CZ-2D(2)	Success	Yaogan 36-01 (A, B & C)	China	China	400 (each)	LEO	Earth Observation	Military
01/10/2022	USA	Firefly Alpha	Success	Firefly Capsule 2	USA	USA	25	LEO	Tech / Demo	Gov. Civil
				FossaSat 1b (2)	Spain	Spain	0,25	LEO	Tech / Demo	Commercial
				Genesis (-G & -J)	Spain	Spain	0,4 (each)	LEO	Radio Amateur	Amateur
				Qubik (3 & 4)	Greece	Greece	0,2 (each)	LEO	Tech / Demo	Amateur
				Serenity 2	USA	USA	4	LEO	Radio Amateur	Education
				TechEdSat 15	USA	USA	4	LEO	Tech / Demo	Education
04/10/2022	USA	Atlas-5(531)	Success	SES 20	Luxembourg	USA	1500	GEO	Telecommunication	Commercial
				SES 21	Luxembourg	USA	1700	GEO	Telecommunication	Commercial
05/10/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Crew Dragon USCV-5	USA	USA	12055	LEO	Crew Transfer	Gov. Civil
05/10/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (52 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
07/10/2022	China	CZ-11H	Success	CentiSpace-1 (S5 & S6)	China	China	97 (each)	LEO	Tech / Demo	Commercial
07/10/2022	New Zealand	Electron KS	Success	Gazelle / Argos-4	USA	USA	110	LEO	Telecommunication	Commercial
08/10/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Galaxy 33	USA	USA	3654	GEO	Telecommunication	Commercial
				Galaxy 34	USA	USA	3695	GEO	Telecommunication	Commercial
08/10/2022	China	CZ-2D(2)	Success	ASO-S / Kuafu	China	China	888	LEO	Astronomy	Gov. Civil
10/10/2022	Russia	Soyuz-2-1b Fregat	Success	Kosmos 2559 / Glonass-K 17L	Russia	Russia	962	MEO	Navigation	Military
12/10/2022	Russia	Proton-M Blok-DM-3	Success	AngoSat 2	Angola	Russia	2000	GEO	Telecommunication	Commercial
12/10/2022	*Japan*	*Epsilon-2 CLPS*	*Failure*	*FSI-SAT*	*Japan*	*Japan*	*1*	*LEO*	*Tech / Demo*	*Education*
				KOSEN 2	*Japan*	*Japan*	*2,7*	*LEO*	*Tech / Demo*	*Education*
				MAGNARO A / Tigris	*Japan*	*Japan*	*3*	*LEO*	*Tech / Demo*	*Gov. Civil*
				MAGNARO B / Piscis	*Japan*	*Japan*	*1,4*	*LEO*	*Tech / Demo*	*Gov. Civil*
				MITSUBA	*Japan*	*Japan*	*1,7*	*LEO*	*Other*	*Gov. Civil*
				QPS-SAR (3 & 4)	*Japan*	*Japan*	*170 (each)*	*LEO*	*Earth Observation*	*Commercial*
				RAISE 3	*Japan*	*Japan*	*110*	*LEO*	*Tech / Demo*	*Gov. Civil*
				Waseda-SAT 0	*Japan*	*Japan*	*1,2*	*LEO*	*Tech / Demo*	*Gov. Civil*

13/10/2022	China	CZ-2C(3)	Success	HJ 2E	China	China	500	LEO	Earth Observation	Gov. Civil
14/10/2022	China	CZ-2D(2)	Success	Yaogan 36-02 (A, B & C)	China	China	400 (each)	LEO	Earth Observation	Military
15/10/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Hotbird 13F	France	France	4500	GEO	Telecommunication	Commercial
15/10/2022	Russia	Angara-1.2	Success	Kosmos 2560 / EO-MKA 3	Russia	Russia	150	LEO	Earth Observation	Military
20/10/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (54 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
21/10/2022	Russia	Soyuz-2-1v Volga	Success	Kosmos (2561 & 2562)	Russia	Russia	1200 (each)	LEO	Unknown	Military
22/10/2022	India	GSLV Mk.3(2)	Success	OneWeb (36 satellites)	UK	USA	147 (each)	LEO	Telecommunication	Commercial
22/10/2022	Russia	Soyuz-2-1b Fregat	Success	Gonets-M (23, 24 & 25)	Russia	Russia	280 (each)	LEO	Telecommunication	Gov. Civil
				Skif-D	Russia	Russia	139	MEO	Telecommunication	Gov. Civil
26/10/2022	Russia	Soyuz-2-1a	Success	Progress-MS 21	Russia	Russia	7280	LEO	Cargo Transfer	Gov. Civil
28/10/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (53 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
29/10/2022	China	CZ-2D(2)	Success	Shiyan 20C	China	China	1200	LEO	Tech / Demo	Gov. Civil
31/10/2022	China	CZ-5B	Success	Mengtian	China	China	20000	LEO	Space Station Infrastructure	Gov. Civil
01/11/2022	USA	Falcon Heavy	Success	LDPE-2	USA	USA	850	GEO	Tech / Demo	Military
				LINUSS (1 & 2)	USA	USA	21,5 (each)	GEO	Tech / Demo	Commercial
				Shepherd Demonstration	USA	USA	1000	GEO	Tech / Demo	Military
				Tetra 1	USA	USA	20	GEO	Tech / Demo	Military
				USUVL	USA	USA	20	GEO	Tech / Demo	Military
02/11/2022	Russia	Soyuz-2-1b Fregat	Success	Kosmos 2563	Russia	Russia	1500	HEO	Early Warning	Military
03/11/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Hotbird 13G	France	France	4500	GEO	Telecommunication	Commercial
04/11/2022	New Zealand	Electron KS (R)	Success	MATS	Sweden	Germany	50	LEO	Earth Science	Gov. Civil
05/11/2022	China	CZ-3B/G2(2)	Success	ZhongXing 19 / ChinaSat 19	China	China	5000	GEO	Telecommunication	Commercial
07/11/2022	USA	Antares-230+	Success	Cygnus CRS-18	USA	USA	7492	LEO	Cargo Transfer	Gov. Civil
				PearlAfricaSat 1	Uganda	Japan	1	LEO	Earth Observation	Education
				SpaceTuna 1	Japan	Japan	1	LEO	Tech / Demo	Education
				Taka	Japan	Japan	2	LEO	Tech / Demo	Education
				ZimSat 1	Zimbabwe	Japan	1	LEO	Earth Observation	Education

09/11/2022	USA	Atlas-5(401)	Success	JPSS-2 / NOAA 21	USA	USA	2930	LEO	Meteorology	Gov. Civil
				LOFTID	USA	USA	1224	LEO	Tech / Demo	Gov. Civil
11/11/2022	China	CZ-6A	Success	Yunhai-3 01	China	China	100	LEO	Meteorology	Gov. Civil
12/11/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Galaxy 31 & 32	USA	USA	3300 (each)	GEO	Telecommunication	Commercial
12/11/2022	China	CZ-7	Success	Tianzhou 5	China	China	12910	LEO	Cargo Transfer	Gov. Civil
				XW 4 / CAS 10	China	China	8	LEO	Radio Amateur	Amateur
15/11/2022	China	CZ-4C	Success	Yaogan 34-03	China	China	2300	LEO	Earth Observation	Military
16/11/2022	USA	SLS (Block 1) iCPS	Success	ArgoMoon	Italy	Italy	14	Escape	Tech / Demo	Gov. Civil
				BioSentinel	USA	USA	14	Escape	Biology	Gov. Civil
				CuSP	USA	USA	10,2	Escape	Astronomy	Gov. Civil
				EQUULEUS	Japan	Japan	11,5	Escape	Earth Science	Gov. Civil
				LunaH-Map	USA	USA	14	Escape	Planetary Science	Gov. Civil
				Lunar-IceCube	USA	USA	14	Escape	Planetary Science	Gov. Civil
				LunIR	USA	USA	14	Escape	Tech / Demo	Commercial
				Miles	USA	USA	14	Escape	Tech / Demo	Commercial
				NEA-Scout	USA	USA	12	Escape	Planetary Science	Gov. Civil
				OMOTENASHI	Japan	Japan	14,6	Escape	Tech / Demo	Gov. Civil
				Orion CM-002 / Artemis 1	USA	USA	25848	Escape	Tech / Demo	Gov. Civil
16/11/2022	China	Ceres-1 (2)	Success	Jilin-1 Gaofen-03D (5 satellites)	China	China	42 (each)	LEO	Earth Observation	Commercial
23/11/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Eutelsat 10B	France	France	5500	GEO	Telecommunication	Commercial
26/11/2022	USA	Falcon-9 v1.2 (Block 5)	Success	DanteSat	Italy	Italy	3	LEO	Other	Education
				Dragon CRS-26	USA	USA	11000	LEO	Cargo Transfer	Gov. Civil
				iROSA (1A & 3B)	USA	USA	600 (each)	LEO	Space Station Infrastructure	Gov. Civil
				MARIO	USA	USA	5	LEO	Tech / Demo	Gov. Civil
				NUTSat	Taiwan	Taiwan	2	LEO	Telecommunication	Amateur
				PetitSat	USA	USA	8	LEO	Earth Science	Gov. Civil
				SPORT	USA	Brazil	8	LEO	Earth Science	Gov. Civil
				Surya Satellite 1 / SS 1	Indonesia	Indonesia	1	LEO	Telecommunication	Amateur

				TJREVERB	USA	USA	2	LEO	Tech / Demo	Education
26/11/2022	India	PSLV-XL	Success	Astrocast (4 satellites)	Switzerland	Switzerland	4 (each)	LEO	Telecommunication	Commercial
				INS 2B / BhutanSat	India	India	18	LEO	Tech / Demo	Gov. Civil
				Oceansat 3 / EOS 6	India	India	1117	LEO	Earth Observation	Gov. Civil
				Pixxel-TD 1 / Anand	India	India	16,5	LEO	Earth Observation	Commercial
				Thybolt (1 & 2)	India	India	0,5 (each)	LEO	Tech / Demo	Commercial
27/11/2022	China	CZ-2D(2)	Success	Yaogan 36-03 (A, B & C)	China	China	400 (each)	LEO	Earth Observation	Military
28/11/2022	Russia	Soyuz-2-1b Fregat	Success	Kosmos 2564 / Glonass-M 761	Russia	Russia	1415	MEO	Navigation	Military
29/11/2022	China	CZ-2F/G	Success	Shenzhou 15	China	China	8082	LEO	Crew Transfer	Gov. Civil
30/11/2022	Russia	Soyuz-2-1b Fregat	Success	Kosmos 2565 / Lotos S1 6	Russia	Russia	6000	LEO	Signal Intelligence	Military
07/12/2022	China	Kuaizhou-11	Success	Xingyun Jiaotong VDES Shiyan	China	China	100	LEO	AIS	Commercial
08/12/2022	USA	Falcon-9 v1.2 (Block 5)	Success	OneWeb (40 satellites)	UK	USA	147 (each)	LEO	Telecommunication	Commercial
08/12/2022	China	CZ-2D(2)	Success	Gaofen 5-01A	China	China	1000	LEO	Earth Observation	Gov. Civil
09/12/2022	China	Jielong-3	Success	CAS 5A / Fengtai Shaonian 2	China	China	6	LEO	Radio Amateur	Education
				CAS 5B	China	China	0,5	LEO	Radio Amateur	Education
				HEAD 2H	China	China	45	LEO	AIS	Commercial
				Huoju 1	China	China	12,8	LEO	Tech / Demo	Commercial
				Jilin-1 Gaofen-03D (7 satellites)	China	China	42 (each)	LEO	Earth Observation	Commercial
				Jilin-1 Pingtai-01A-01	China	China	15	LEO	Tech / Demo	Commercial
				Golden Bauhinia 1 (-05 & -06)	China	China	50	LEO	Earth Observation	Commercial
				Tianqi 7	China	China	50	LEO	Telecommunication	Commercial
11/12/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Hakuto-R M1	China	Japan	1000	Escape	Planetary Science	Commercial
				Lunar Flashlight	USA	USA	14	Escape	Planetary Science	Gov. Civil
12/12/2022	China	CZ-4C	Success	Shiyan 20 (A & B)	China	China	1200 (each)	LEO	Tech / Demo	Gov. Civil
13/12/2022	France	Ariane-5ECA+	Success	Galaxy 35 & 36	USA	USA	3250 (each)	GEO	Telecommunication	Commercial
				MTG-I 1	Europe	France	3760	GEO	Meteorology	Gov. Civil

14/12/2022	*China*	*ZhuQue-2*	*Failure*	*Zhixing 1B*	*China*	*China*	*10*	*LEO*	*Earth Observation*	*Unknown*
14/12/2022	China	CZ-2D(2)	Success	Yaogan 36-04 (A, B & C)	China	China	400 (each)	LEO	Earth Observation	Military
16/12/2022	USA	Falcon-9 v1.2 (Block 5)	Success	O3b mPower (1 & 2)	Luxembourg	USA	1700 (each)	MEO	Telecommunication	Commercial
16/12/2022	USA	Falcon-9 v1.2 (Block 5)	Success	SWOT	USA	France	2200	LEO	Earth Science	Gov. Civil
16/12/2022	China	CZ-11	Success	Shiyan 21	China	China	500	LEO	Tech / Demo	Gov. Civil
17/12/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (54 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
21/12/2022	*France*	*Vega-C*	*Failure*	*Pléiades Neo (5 & 6)*	*France*	*France*	*920 (each)*	*LEO*	*Earth Observation*	*Commercial*
27/12/2022	China	CZ-4B	Success	Gaofen 11-04	China	China	805	LEO	Earth Observation	Gov. Civil
28/12/2022	USA	Falcon-9 v1.2 (Block 5)	Success	Starlink (54 satellites)	USA	USA	295 (each)	LEO	Telecommunication	Commercial
29/12/2022	China	CZ-3B/G2(2)	Success	Shiyan 10-02	China	China	4000	HEO	Tech / Demo	Unknown
30/12/2022	USA	Falcon-9 v1.2 (Block 5)	Success	EROS C3-1	Israel	Israel	400	LEO	Earth Observation	Commercial

4.3.2 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 and of 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
- Other
  - In-Orbit Servicing: provision of services to another spacecraft
  - 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 a commercial market and to make profit.
- 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.

4.4 Space activity highlights in 2022

4.4.1 Noticeable missions and payloads

China completes its Tiangong space station

Credit: SAST

On July 24th, China launched its most powerful rocket, the Long March-5B, to send in orbit one of the main segments of its Tiangong space station.[647] The module, called Wentian, has a mass of 23 tons and is intended to be a laboratory allowing to conduct in-orbit experiments. It will also be used as a backup life support and propulsion for the core module of the station, Tianhe, and will provide more living space for taikonauts onboard the station. Wentian also carries a robotic arm that is more precise than the one installed on Tianhe.

The last module of Tiangong, Mengtian, was launched on October 31st. After a flight of 13 hours, the module docked to the station, and reached its final position early November. Mengtian brings 32 more cubic meters for use by the astronauts and will provide a payload airlock allowing the robotic arm of Tiangong to grab payloads and install them outside of the station.[648]

As with previous launches of Tiangong's modules, the two flights created safety concerns, as the first stages of the Long March-5B, weighing more than 20 tons, were never actively deorbited, resulting in uncontrolled re-entries.[649]

Artemis 1: the first step for a return to the Moon

Credit: NASA

On November 16th, NASA performed the launch of the Artemis 1 mission, a first in a series that aims at bringing humans back to the Moon. The mission was the first launch of the long-delayed Space Launch System (SLS), a rocket whose original maiden flight was planned for 2016 and that has suffered several postponements. The rocket was carrying the Orion capsule, a spacecraft built by both U.S. and European (for the service module) partners, as well as ten CubeSats that were released in cislunar space. Orion reached the farthest distance from the Earth for a human-rated spacecraft (435.000 kilometres) and performed some tests around the Moon before flying back to Earth in December.[650]

The third generation of Meteosat takes off

Credit: ESA

On December 13th, the last Ariane 5 launch of 2022 sent to orbit two Galaxy satellites for Intelsat and one spacecraft for EUMETSAT, the Meteosat Third Generation-Imager1 (MTG-I1). The calibration and validation steps for the satellite's data will take approximately one year and operational data will start being disseminated after this period. Overall, six of the Meteosat third-generation spacecraft will be deployed, all of which will feature radically improved instruments as well as completely new ones for Europe (Lightning Imager) and worldwide (Infrared Sounder).[651]

[647] Second module docks at China's space station, large rocket stage tracked in orbit, SpaceNews, July 2022
[648] Final module docks at China's Tiangong space station, SpaceNews, October 2022
[649] Huge Chinese rocket booster falling from space after launching space station module, Space.com, July 2022
[650] Artemis I, NASA, November 2022
[651] EUMETSAT Announces Successful Launch of MTG-I1, Spacewatch Global, December 2022

Eutelsat Konnect VHTS is launched by Ariane 5

Credit: Thales Group

On September 7th, Arianespace launched the Eutelsat Konnect VHTS satellite, built by Thales Alenia Space with the support of CNES and ESA, to geostationary orbit. The satellite has a capacity of 500 Gbps, which makes it the most performant GEO communications satellite ever built in Europe. It relies on a fully electric propulsion and carries a powerful digital processor allowing it to be more flexible. With this spacecraft, Eutelsat will provide high-speed Internet to remote areas in Europe and address the needs for fixed and mobile telecommunications networks, including to governments and public administrations, with Telespazio serving as the exclusive provider for defence and security. A first Eutelsat Konnect satellite was launched in January 2020, but VHTS has a capacity seven times higher. This was only the third time that a single satellite was launched to GEO on an Ariane 5, as the rocket usually conducts dual launches.[652]

Germany starts the deployment of its new military constellation

On June 18th, the German military satellite SARah-1 built by Airbus was launched aboard SpaceX's Falcon 9 from the U.S. Space Force base in Vandenberg, following a launch contract that the German government awarded to SpaceX in 2013.[653] SARah-1 is the first of a constellation of three satellites that will replace the previous SAR-Lupe constellation and will provide Synthetic Aperture Radar images to the German armed forces for intelligence, surveillance and reconnaissance purposes. The Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw) contracted OHB System for the development and integration of the satellite in March 2018, while Airbus was appointed as the main subcontractor.[654]

The first private Japanese lunar lander launches on a 4-month voyage to the Moon

On December 11th, a SpaceX's Falcon 9 launched two spacecraft towards the Moon. The first is a commercial lunar lander, Hakuto-R, developed by the Japanese company ispace. The lander is carrying several commercial and governmental payloads, including the first rover of the UAE. If successful, this will become the first privately-developed spacecraft to accomplish a soft landing on Earth's satellite. The launch also carried Lunar Flashlight, a lunar orbiter aiming at mapping ice around the lunar south pole.[655]

Uganda and Zimbabwe launch their first satellites

Credit: BIRDS-5

On November 7th, Northrop Grumman launched a Cygnus spacecraft to resupply the International Space Station with cargo. Several CubeSats were also onboard the flight, including the first satellites of Uganda and Zimbabwe. The satellites were built in partnership with Japan, in the framework of the Joint Global Multi-Nations BIRDS Satellite project led by JAXA and the Kyushu Institute of Technology. ZimSat-1, the Zimbabwean satellite, will provide imagery to monitor the status of natural resources and get information on natural disasters. On its end, the PearlAfricaSat-1 satellite launched for Uganda will support the development of the agricultural sector and the oil and gas business in the country.[656]

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[652] Eutelsat KONNECT VHTS communications satellite successfully launched, Thales Group, Thales Alenia Space, September 2022
[653] SpaceX awarded first European government contract via SARah missions, NASA Spaceflight, August 2013
[654] German Bundeswehr's first SARah satellite to launch this week, Airforce Technology, June 2022
[655] Japanese moon lander, NASA hitchhiker payload launched by SpaceX, Spaceflight Now, December 2022
[656] Zimbabwe and Uganda Launched their First Satellites Today, Africa News Space, Space in Africa, November 2022

Iran develops its use of space for military purposes

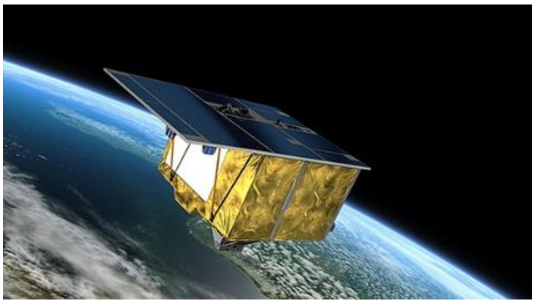
Credit: IRIB

On March 8th, Iranian media announced that the country's second military satellite (Noor 2) was launched by the Iranian Revolutionary Guard Corps, a claim that was confirmed by the U.S. Space Command after a few hours. Noor 2 is a 6U CubeSat carrying imagery equipment. The launch was the first to succeed since the first military satellite, Noor 1, was deployed in April 2020.[657]

In addition, on August 9th, Russia launched a Soyuz rocket carrying several satellites from Russian universities as well as one satellite built for Iran, Khayyam. Some U.S. observers noted that the satellite could be used to provide intelligence capabilities to Russia for its war in Ukraine, but Iran denied these claims, asserting that it gained full control of the satellite from day one. The country said that Khayyam is designed for scientific research including radiation and environmental monitoring for agricultural purposes, although Western security services emphasised its military capabilities. Iran plans to order three more Khayyam-like satellites from Russia.[658]

SpaceX's Transporter-4 and Transporter-5 missions

On April 1st, SpaceX launched the fourth of its Transporter missions, which provide rideshare opportunities for a multitude of small satellites; however, contrary to the previous missions, which each launched more than 100 satellites, Transporter-4 only carried around 40 spacecraft to space. Several payloads of the mission are remarkable: first, the EnMAP satellite, operated by DLR, will provide hyperspectral imagery to monitor the evolution of the environment, a kind of data that is currently not common. Another hyperspectral satellite for the Indian start-up Pixxel was also onboard the ride. Second, the company Lynk, which aims at directly connecting unmodified smartphones to satellites, launched its first operational cell tower in space that can be used to provide a commercial service. Finally, three companies, from the United States, Luxembourg and France, launched 8 satellites (20% of the payloads) that will serve the growing market of signal intelligence.[659]



Credit: DLR

On May 25th, Falcon 9 launched SpaceX's Transporter-5 mission from Space Launch Complex 40 at Cape Canaveral Space Force Station in Florida. After the stage separation, the Falcon 9 was landed on Landing Zone 1 (LZ-1) at Cape Canaveral. The Trasnporter-5 mission carried 59 spacecraft onboard, such as satellites (incl. CubeSats and microsats) to be deployed to SSO (from Iceye, Satellogic, Spire. Fleet, GeoOptics, NASA, HawkEye 360, GHGSat, and Umbra), non-deploying hosted payloads (Nanoracks' Outpost Mars Demo 1 experiment), and orbital transfer vehicles.[660]

657 Iran puts second military satellite into orbit – Tasnim, Reuters, March 2022
658 Russia puts Iranian satellite into orbit, Reuters, August 2022
659 SpaceX launches fourth dedicated rideshare mission, SpaceNews, April 2022
660 SpaceX launches Transporter-5 dedicated smallsat rideshare mission, SpaceNews, May 2022

OneWeb deploys its constellation through new launch service providers

Credit: ISRO

On October 22nd, OneWeb launched a new batch of 36 satellites from the Satish Dawan Centre, in India. This was the first fully commercial launch for the GSLV Mk. 3 to LEO, while it is usually employed to send communication satellites in GEO. This was also the **first launch of OneWeb in 2022**, which has suffered from the start of the war in Ukraine. Indeed, until then, the company was reliant on Soyuz launches operated by Arianespace but, with the invasion of Ukraine and the sanctions that ensued, the cooperation between Arianespace and Russia was terminated. A set of satellites expected to launch in March was "seized" by Roscosmos as a retaliation against the United Kingdom.[661]

As a consequence, the company decided to diversify its launch providers, including with India and SpaceX. A **launch** with the latter company took place on December 8th and another one in January 2023. An agreement was nonetheless found with Arianespace, keeping the door open to fly part of the second-generation constellation of the company on Ariane 6.[662]

Falcon Heavy flies after three years of absence

On November 1st, SpaceX launched a **Falcon Heavy rocket** to directly inject into geosynchronous orbit, after more than six hours of travel, several spacecraft for the U.S. Space Force. This was the fourth launch of the rocket, which flew for the last time on June 25th, 2019, and was the first National Security Space Launch taking place on a Falcon Heavy. The primary payload, the Shepherd Demonstration spacecraft, will allow testing technologies related to rendezvous and proximity operations.[663]

The first satellite of AST SpaceMobile is deployed in orbit

On September 11th, SpaceX launched 34 Starlink satellites in orbit with a Falcon 9. The unusually limited number of spacecraft on this launch was due to the presence of another payload, BlueWalker 3, onboard the rocket. BlueWalker 3 is SpaceX's first satellite launched for AST SpaceMobile, a company that plans to provide direct satellite-to-phone services. The spacecraft, the company's second in space, is a prototype, will help test applications such as voice and video. The satellite, which weighs 1.5 ton, is particularly remarkable for its size. Indeed, it measures around 64 square meters, making it the largest commercial antenna ever deployed in LEO.[664]

However, the commercial constellation that AST wants to deploy will be made of spacecraft (the BlueBirds) that are expected to be even larger. The first batch of BlueBirds is planned for launch in 2023.

Credit: AST SpaceMobile

[661] Watch an Indian rocket launch 36 OneWeb internet satellites today, Space.Com, October 2022
[662] OneWeb aims to deploy a record 40 satellites in SpaceX mission, SpaceNews, December 2022
[663] Falcon Heavy 'simply outstanding' on SpaceX's first launch to geosynch orbit, Spacceflight Now, November 2022
[664] AST SpaceMobile secures communications with prototype, September 2022

4.4.2 First launches and successes

Vega-C performs its inaugural launch

On July 13th, Europe and Arianespace operated for the first time one of their new launchers: Vega-C. The original date of this inaugural flight had to be postponed several times due to the COVID-19 pandemic and a previous malfunction of a Vega launcher, which occurred in November 2020 and triggered investigations. The launcher, whose prime manufacturer is the Italian company Avio, is an improvement of the initial Vega vehicle and can carry 2300 kg to a reference 700 km-polar orbit. Moreover, the first stage of Vega-C will be used as a booster on Ariane 6. For this inaugural flight, Vega-C sent seven spacecraft, mostly Cubesats, to an unusual orbit 6000 km away from Earth. This orbit was selected to fulfil the mission of the primary payload, the Lares-2 satellite, which aims at measuring the distortion of space-time cause by the rotation of the Earth.[665] A second Vega-C launch took place in December 2022, which resulted in a failure and has grounded the launcher for several months.

Credit: ESA, CNES, Arianespace

Long March 6A launches for the first time

On March 29th, China performed the first launch of Long March 6A, with two kerosene-liquid oxygen stages and and four solid propellant side boosters.. The rocket is designed to launch 4 tons to SSO, thus filling a gap in current capabilities. It will also be a "modular" launcher, as it can be launched with either four, two boosters or none at all. Finally, a dedicated launch complex was built for the rocket in the Taiyuan Centre.[666]

A new Chinese solid rocket successfully flies for the first time

On July 27th, the company CAS Space, a spin-off of the Chinese Academy of Sciences, performed the first launch of its Zhongke-1A (also called Lijian-1) rocket. The launcher is a four-stage vehicle, all of them making use of solid propulsion, and has been developed based on the DF-31 ICBM. It can launch up to 1500 kg to SSO, making it appropriate for both small- and medium-mass payloads. A new launch pad at Site 130 in Jiuquan was built specifically for the Zhongke rockets, which launch from an erector launcher. Six satellites were onboard the inaugural flight, including the second quantum communications satellite launched by China.[667]

Russia inaugurates a new launcher

On April 29th, a new version of a rocket from the Angara family was launched by the Russian Aerospace Forces from the Plesetsk cosmodrome. The Angara-1.2 rocket is expected to provide a light-weight orbital delivery capability to the Russian Ministry of Defence and Roscosmos. The payload sent to orbit on this inaugural flight was a military satellite, likely used for radar observation purposes.[668]

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[665] Vega-C set for inaugural launch, ESA, June 2022
[666] China launches first Long March rocket with solid boosters, SpaceNews, March 2022
[667] CAS Space puts six satellites in orbit with first orbital launch, SpaceNews, July 2022
[668] Angara-1.2 flies its first mission, Russian Space Web, April 2022

South Korea succeeds in the launch of its indigenous rocket

On June 21st, South Korea managed for the first time to reach orbit with Nuri (also called KSLV-2), a rocket that is fully built domestically. This success follows the failure that happened during the first launch of the rocket, which took place in October 2021. The payload of this second flight was a performance test satellite, which will later release four smaller satellites built by Korean universities. A heavier dummy payload was also onboard, in order to simulate the mass of a more "traditional" satellite and to assess the performance of the launcher. Four more launches of Nuri are planned by 2027.[669]

Credit: KARI

Rocket Lab performs its first lunar launch

On June 28th, Rocket Lab launched the CAPSTONE CubeSat for NASA, the first satellite to launch under the umbrella of the Artemis programme. After a four-month journey, the spacecraft reached a Near Rectilinear Halo Orbit around the Moon, and started the operational phase of its mission that consists of testing this specific orbit. Indeed, the Lunar Gateway will use the same orbit but its characteristics are not well known. To deploy this payload, the company used a new version of its rocket, equipped with Lunar Photon, which acts as both the upper stage of the rocket and an independent spacecraft once CAPSTONE deployed. Lunar Photon will thus fly by the Moon and take a few pictures after having accomplished its primary mission.[670]

Firefly reaches orbit for the first time – yet deploys satellites lower than planned

On October 1st, Firefly Aerospace managed to reach orbit with its rocket, Alpha, slightly more than one year after a previous flight ended in failure. This is the first success of Firefly, whose rocket is able to lift up to 1300 kg in LEO. The payloads were several experimental satellites for NASA and universities. However, despite the rocket reaching orbit, it was revealed that spacecraft had been released in a lower orbit than initially planned. As a consequence, their decay was quicker than expected and almost all payloads re-entered Earth atmosphere, where they got destroyed. Despite this situation, Firefly reiterated that the launch was a success.[671]

[669] South Korean rocket puts satellites in orbit for the first time in second flight, SpaceNews, June 2022
[670] CubeSat launches on scouting mission for NASA's Artemis moon program, Spaceflight Now, June 2022
[671] Firefly says Alpha launch a success despite payload reentries, SpaceNews, October 2022

4.4.3 Some noticeable failures in 2022

Among the 185 launches taking place in 2022, a few of them (7) failed. Some of these failures are noticeable.

The first launch of India's SSLV fails


Credit: ISRO

On August 7th, ISRO launched the first iteration of a new rocket, the Small Satellite Launch Vehicle (SSLV). SSLV is a three-stage vehicle able to place up to 500 kg in LEO. The rocket was carrying two satellites, EOS-2, an Earth observation satellite dedicated to civilian applications, and AzaadiSAT, a CubeSat built by Indian students. However, the launch failed due to a computer issue with the injection module[672], which deployed the two payloads in an unintended orbit, then leading to their destruction in the atmosphere. According to ISRO leadership, all other phases of the launch went smoothly, and a quick return to flight is expected for the rocket.[673]

Vega-C fails its second flight

On December 21st, Arianespace conducted the second launch of the Vega-C launcher, whose first flight took place in July 2023. The rocket was carrying two EO satellites from Airbus' Pléiades Neo constellation. After the failure, an independent inquiry commission was set up to investigate its causes and concluded that it was due to an eroded nozzle component.[674] In between, it was decided that all Vega launches would be postponed, thus leaving Europe with virtually no access to space once the last Ariane 5 will have flown and before the start of operations of Ariane 6.[675]

Chinese private companies suffer failures

Chinese private companies suffered several failures in 2022. In May, the iSpace's Hyperbola-1 rocket failed for the third time in a row.[676] In addition, the Zhuque-2 rocket, operated by LandSpace, failed in December. Zhuque-2 was the first attempt to reach orbit with a methane-fueled rocket and the first launch attempt for a Chinese commercially-developed liquid propellent rocket.[677]

[672] ISRO's SSLV-D1 launch failure: What went wrong? Explained here, Financial Express, August 2022
[673] India's new SSLV rocket fails in first launch, SpaceNews, August 2022
[674] Nozzle erosion blamed for Vega C launch failure, SpaceNews, January 2023
[675] European Vega C mission fails due to motor anomaly, Spacewatch Global, December 2022
[676] Chinese rocket company suffers third consecutive launch failure, SpaceNews, May 2022
[677] China's launch of world's 1st methane-fueled orbital rocket fails, 14 satellites lost, Space.Com, December 2022https://spacenews.com/chinese-rocket-company-suffers-third-consecutive-launch-failure/

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