2024

Main Trends & Challenges in the Space Sector

4th Edition

strategy&

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As the only at-scale strategy business that's part of a global professional services network, we embed our strategy capabilities with frontline teams across PwC to show you where you need to go, the choices you'll need to make to get there, and how to get it right.

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Foreword

Space is a complex sector driven by macro-level dynamics that go beyond simple market forces. It comprises multiple domains/segments with different specificities; it is characterised by an ever-evolving regulatory and policy environment, which can heavily dictate the evolutions of the sector. It has significant reach and implications in other industrial sectors thanks to the services and applications it enables. Finally, space has considerable strategic, societal and economic impacts, justifying the significant government spending in the sector.

Dr. Luigi Scatteia

Partner, PwC Space Practice Global Lead

PwC France

Space requires a holistic view to be decoded.

Space has experienced significant growth and profound transformation. Historically driven by institutional agendas and heralded by a few spacefaring nations, the sector has experienced major changes in the past two decades with numerous new entrants. Increased private capital inflow into the industry and major evolutions and disruptions driven by the NewSpace paradigm and digital drivers (which recently resulted in major advancements propelled by new AI offerings like Generative AI) have significantly reduced barriers to entry for both governments and private actors and caused business models to change. This has resulted in the involvement of many new nations in space activities and the entry of various types of companies, ranging from start-ups to non-space companies exploiting adjacencies into the market.

The recognition of the role space plays in the development of knowledge-based societies mandates institutions and policymakers to create appropriate conditions for space market expansion to successfully develop technology-driven national and regional economies. More countries around the world are adopting the concept of Space Economy-driven policies intended as measures to maximise the uptake of space and space applications and the positive impacts they bring to the wider economy.

The sector's transformation also offers fresh opportunities and challenges to both new and established private stakeholders. Seizing these opportunities and addressing the challenges coming from such a rapidly evolving playing field is indispensable to remaining competitive.

Overall, space's prerogatives and specificities, diversity of domains, and reach into the broader economy require a holistic view of the relevant trends and challenges affecting the sector. With its dedicated global space practice, PwC has had the opportunity to support public and private entities in strategy, policy, technology road mapping, market assessments, financial, technical and commercial due diligence, and economic studies worldwide across all space domains (launchers, satellite services, space domain awareness, in-orbit economy) and all along the value chain (from the upstream to the utilisation of space data). This has allowed PwC to maintain a close watch on the key challenges and dynamics affecting the sector. Also, it provides insight from the point of view of non-space users and verticals adopting space-related products/services. Since 2019, the PwC Space Practice has synthesised its view of the main space trends and challenges in a compendium publication covering macro- and domain-specific trends, of which this volume represents the fourth edition.

We trust and hope this can be useful to both experienced professionals and newcomers in the space sector. We remain available for contacts and queries to delve deeper into all the areas covered in this publication. With our genuine enthusiasm for space, we are committed to providing effective support to our clients across the entire space value chain and continually tackling new challenges!

At PwC, our dedicated Space Practice supports a wide range of activities to help unlock the value of Space

PwC Space Practice Overview

PwC is one of the largest professional services networks in the world. With historical roots going back some 160 years, our network has over 328,000 professionals in 152 countries and 688 locations. The network also includes Strategy&, a strategy consulting firm dating back to the early days of management consulting, with a strong heritage in Aerospace and Defence.

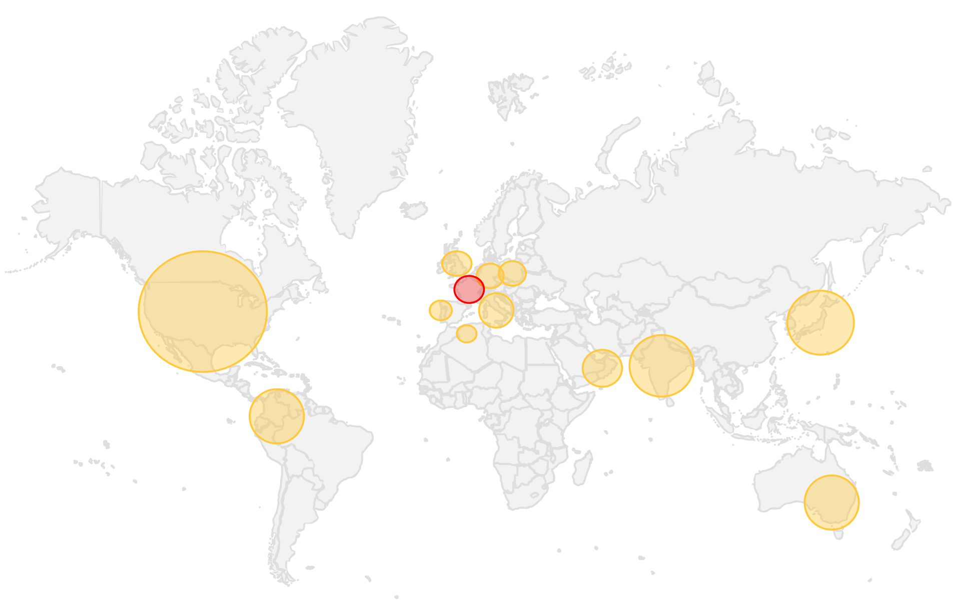
PwC has a dedicated Space Practice with a global footprint and a core strategy and transformation-oriented team distributed across the globe. Unique among large professional services firms, our Space Practice combines dedicated and focused space expertise with a significant reach into the broader downstream.

The scope of the core global team encompasses **strategy, policy, economic studies, governance, technology, people and organization, and regulatory analysis,** for tailored support accounting for all the specificities of the space sector.

Our core space team acts as an enabler across the broader space practice, which encompasses service lines like **Audit and Assurance, Tax, Technology and Operations,** in a seamless fashion.

Our unique perspectives and engagements focus on offering our traditional services to Space companies (i.e. audit, tax, business transformation, and market insights), as well as offering space-tailored services to all companies outside of the traditional A&D and Space sectors that focus on "unlocking the value of space."

Our Global Footprint



Global network of focal points, and teams in key regions (US, UK, Middle East, India, Japan, Australia)

PwC Strategy& Global Space Hub (France) | *PwC Strategy& International Space Teams*

We have extensive experience working with major institutional and commercial players in the space value chain

1.

Strong experience in space strategy, market, policy, governance and regulation

- Support in the definition of **national space strategies, policies and supporting schemes** for the development of space; supported the definition of **national governance schemes and national regulatory frameworks**
- Delivery of **growth strategies, market entry strategies, business case assessment** and **modeling**, and **due diligence** for the space industry as well as for non-space companies looking for adjacencies
- Continual assistance to major **international space organisations** in conducting numerous studies on policy, strategy and economics.

2.

Vast repository of projects across the space value chain and in all domains

- Extensive experience across the **space value chain** in all space segments, including frontier ones
- Experience working with **multiple space stakeholders** (space agencies and institutions, governments, incumbents, NewSpace players, investment funds and regulatory authorities worldwide)
- Strong expertise in **flagship programmes and policies worldwide.**

3.

Extensive experience in operations

- Specialized know-how across the PwC network within **digital and IT transformation**, helping companies set up their operations for the future based on **AI, IoT, digital twins, or agile methods**
- Strong track record in **restructuring companies** based on new market situations or supporting them in **post-merger integrations** and setting up **new target operating models.**

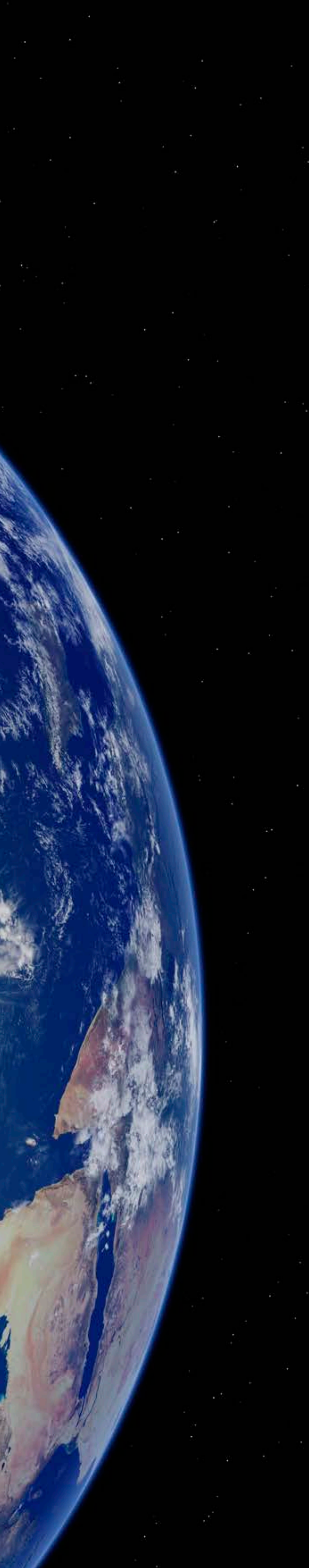
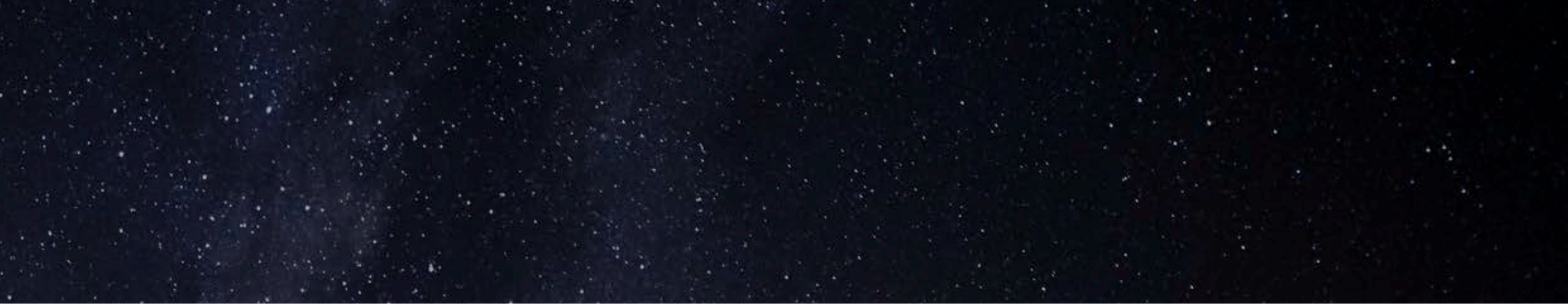


Table of Contents



Introduction

Space economy basic taxonomy and definitions, global estimations and socio-economic impacts

Space is a complex sector comprising different domains and specificities.

The space economy has blurred boundaries which can lead to a difficulties estimating its global value. Nonetheless, the societal and economic impacts of space are vast and far reaching in the wider economy.

Space is a sector comprising different domains with multiple specificities along the value chain

Space sector's taxonomy and segmentation

No univocal taxonomy exists for the space sector's segmentation, therefore trying to navigate the sector often creates issues. The taxonomy we propose here for the breakdown of space domains and value chain segments (pages 12 and 13) is commonly accepted and consistent with the main international conventions on the matter.

Value chain segments

Upstream

Development, manufacturing and testing of space systems, subsystems, components and infrastructures (e.g. MAIT of satellites, launchers, ground segment systems)

Midstream

Operations of space systems and infrastructures to maintain their availability and safety and ensure service provision (e.g. space launch operations, satellite TT&C, space stations control)

Downstream

Exploitation of space systems and infrastructures, encompassing space-based products and services (e.g. SatCom broadband, broadcasting, Earth observation value-added services). This also includes the manufacturing of user equipment (e.g. GNSS chipsets, satellite dishes) needed to deliver the services

End Users

Users of space services and products from various industry verticals: energy, infrastructure, agriculture, marine, defence and security, location-based services, etc.

Space domains

Earth observation

Acquisition of data using Earth observation satellites and processing of this data into value-added services targeting a variety of verticals

Access to space

Development and operation of launch vehicles for orbital and suborbital flights, also covering the associated ground facilities

Satellite communication

Communication services from GEO satellites and MEO/LEO constellations for direct-to-home, fixed and mobile communications

Space safety

Also called Space Domain Awareness, this entails the monitoring of orbital activities of satellites and debris to maintain situational awareness

Satellite navigation

Global and regional positioning, navigation and timing services provided by MEO and LEO constellations

Beyond Earth economy

Exploration and commercial activities in Low Earth orbit (human spaceflight and space stations) and in outer space (lunar/deep space)

In the past years, the space industry's value chain has undergone a shift from the traditional upstream-driven technology push towards a market-demand pull. Instead of creating upstream assets for exploitation by the downstream markets, the needs of end users for new services and products drive more extensive space systems development. **The increasing vertical integration of services, by both traditional space actors (towards downstream services) and non-space actors (towards space asset deployment), is blurring the boundaries between upstream and downstream activities.**

The Space value chain

Reading the value chain

Reading the value chain map from left to right provides an overview of value chain segments, space domains and corresponding main activities along the value chain in each domain.

Domains	**Upstream** Development, manufacturing and testing		
Access to space	Uncrewed vehicles		Spaceport infrastructure
	Crewed vehicles (Human spaceflight – HSF)		
Earth observation	Satellite platforms	Remote sensing payloads (active and passive remote sensing)	Ground segment
Satellite communications		Satellite communication payloads (incl. quantum communications and deep space communications)	
Satellite Navigation		Satellite positioning, navigation and timing (PNT) payloads	
Space safety		Space situational awareness payloads	Ground segment and ground telescopes
Beyond Earth economy		Space exploration payloads and probes	Deep space ground segment networks
		Mission-specific payloads (SBSP)	
		In-orbit manufacturing and servicing	Ground segment
	Orbital stations		HSF mission control

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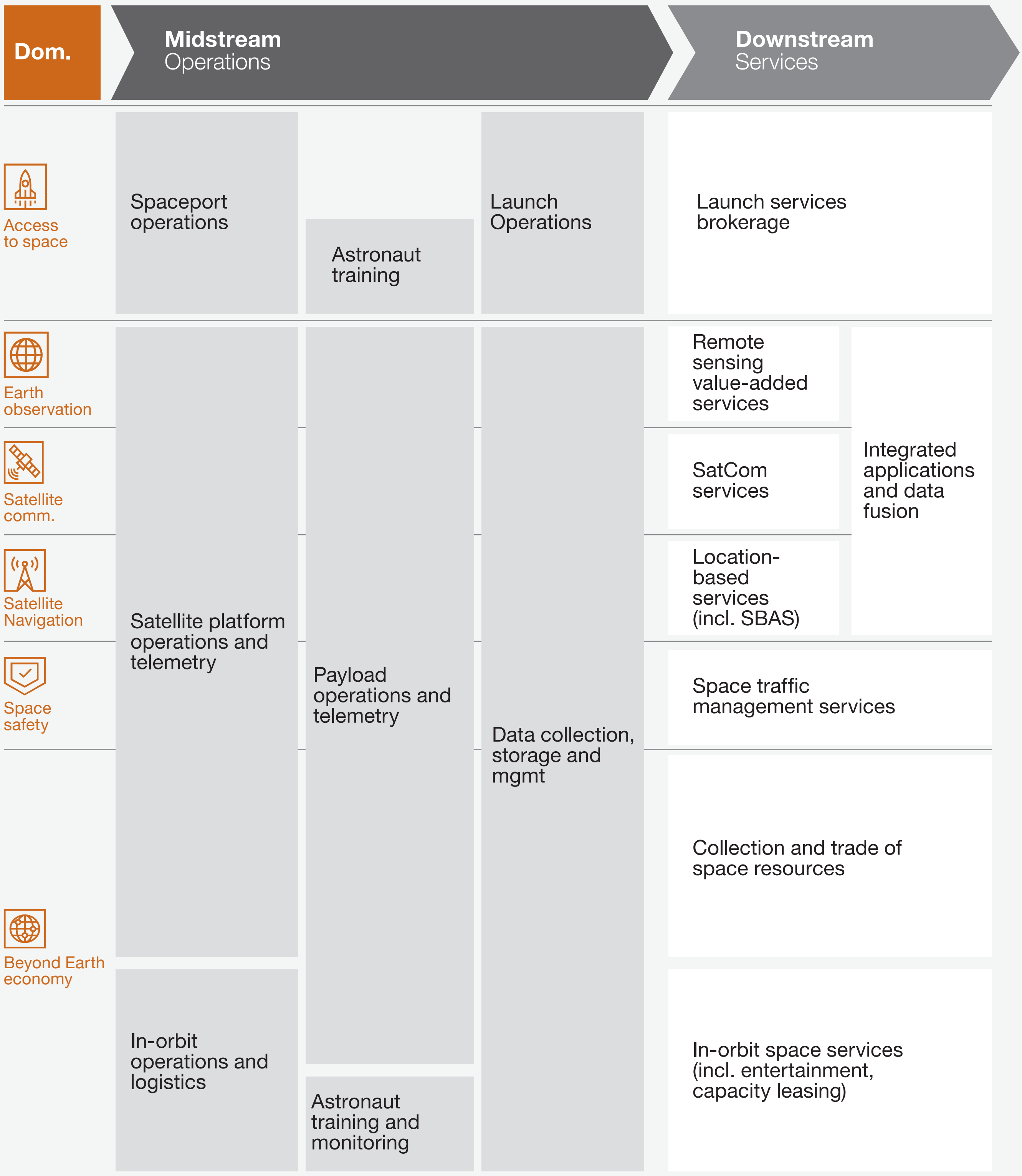

The space economy is complex to measure due to the lack of a universally recognised taxonomy and a clear downstream perimeter

Measuring the space economy

The space economy is defined as "*the full range of activities and the use of resources that create value and benefits to human beings in the course of exploring, researching, understanding, managing, and utilising space*" (OECD, 2012).

Considering the breadth of such a definition, differing figures can be retrieved on the size of the global space economy. This is because no international standard of industrial classification exists for space, leading to differences in market sizing studies' definitions/ taxonomies, perimeter and methodology.

Non-univocal taxonomy and difficulty setting the perimeter of the space economy, particularly downstream

Difficulty in measuring the direct cause-and-effect relationship between space products and services and the benefits delivered to end users

Given the above, when considering global and regional figures related to space economy sizing, it is extremely important to understand what they encompass in their perimeter. Although, in all estimations, we can expect an order of magnitude on the difference between upstream/midstream and downstream.

Space economy value estimations

General orders of magnitude | **Up/midstream (10s+ of USD B)** | **Downstream (100s+ of USD B)**

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$410B
in 2023

- **Core space (~$137bn):** satcom capacity, satcom commercial, EO commercial, satellite ground equipment, launch commercial, manufacturing commercial, institutional upstream & downstream
- **Wider space market (~$273bn):** DTH content and subscriptions, other user subscriptions, user chipsets etc

Market research

Value of space economy in 2022

BRYCE TECH	$384B	(2023)
Euroconsult	$424B	(2023)
Space Foundation	$596B	(2023)

Financial institutions

Space economy reaching 1 trillion $ in:

Bank of America	in 2030	(2023)
Morgan Stanley	in 2040	(2023)
UBS	in 2040	(2023)

Note: Space Economy includes and is much broader than space as an industry sector, defined as the ensemble of actors involved in the systematic application of engineering and scientific disciplines to the exploration and utilisation of outer space (an area extending beyond the Earth's atmosphere, typically beyond the Karman line, which is ~100km altitude).

Space leads to substantial societal and economic impacts that are extremely important to measure and communicate

Rationale for Socio-Economic Impact Assessments

Investing in space brings economic benefits that go far **beyond the space sector itself,** enabling a substantial portion of the global space economy. In fact, the societal and economic impacts of investing in space are **vast** and **far-reaching across all space domains.** Space also effectively and efficiently contributes to **knowledge creation, workforce upskilling** and **strategic non-dependence.**

Since space is dependent on public spending, there is often a need to justify investments in the sector, especially with other sectors or policies also vying for investments. For these reasons, assessing the socio-economic impacts of space programmes is key to providing **transparency on the benefits of investments in space, justifying them and supporting decision-making in case of concurrent public policy priorities.**

We provide a non-exhaustive, indicative overview of the type of impacts that are typically targeted in socioeconomic impact assessments below, and we also provide the main associated indicators and multipliers, with a range of typical values expected for these based on past studies carried out by PwC on various space programmes spanning multiple space domains (from satellite services, launchers, human spaceflight and space safety to space science and exploration).

1. Impacts associated with developing and building space assets

Economic

Transactional impacts: impacts on GDP, employment and taxes as a consequence of investing in the space sector.

1	**GDP impact:** total impact of investment in space activities in terms of gross value added (GVA) – *Direct impact*: GVA related to the space industry – *Indirect impact*: GVA related to spending in the subsequent tiers of the supply chain supported by the spending made in the space industry (e.g. procurement of materials and equipment from other industrial sectors) – *Induced impact*: GVA related to consumer spending, covering employees in the space and non-space industry spending their incomes on goods and services in the wider national and regional economy.	
	Typical values of multipliers and indicators	GVA TYPE II : **1.4-2.2x times the investment.** The Type II GVA multiplier quantifies the total impact of space-related spending on the overall GVA, incorporating the direct, indirect, and induced economic activities generated from such investment.
2	**Jobs supported by investment in space activities:** The financial inputs into space-related employment lead to job creation within the space industry and across its supply network, bolstered by the uptick in overall economic dynamics.	
	Typical values of multipliers and indicators	Employment: represents the number of jobs created due to the investments. It equals **12 persons per year for €1m** of spending.
3	**Government tax revenue:** the government (tax) revenues associated with the increased economic activity generated by the investments in the space programme	
	Typical values of multipliers and indicators	**Tax %** represents a sizeable percentage of the original investment for all space programmes (generally well over 35%).

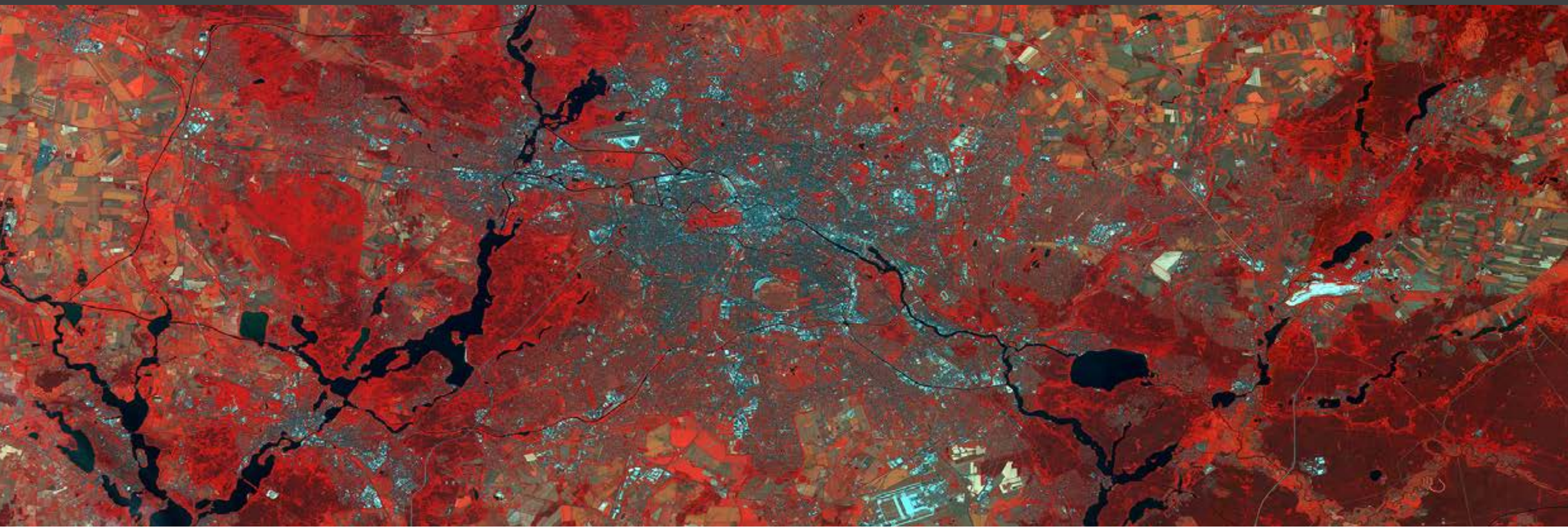
Economic impacts occur as a result of developing space assets and become much larger when exploiting such assets

1. Impacts associated with developing and building space assets

Economic	**Spillovers:** Contracts placed as a result of public investment in a given space programme may lead to additional contracts placed by the company with other customers (e.g. the company might sell the product developed within the space programme to other customers).	
	1	**Market effect spillovers** result from the transfer of technology and expertise in products developed for space activities, leading to increased sales, funding, or cost reductions in other industrial sectors.
	2	**Network effect spillovers** occur when an organisation supporting space projects gains a reputation, enabling it to form new partnerships or attract new customers that result in increased revenues or cost savings.
	3	**Organisation effect spillovers** result from established players transferring improved organisational methods, such as standardisation, to smaller organisations through space activities, leading to productivity gains, increased revenues or cost reductions.
	Typical values of multipliers and indicators	**Spillover factors (1.8x to 3.2x)** refer to the ratio between the amount of spillover revenues generated and the initial funding received.

2. Impacts associated with exploiting space assets

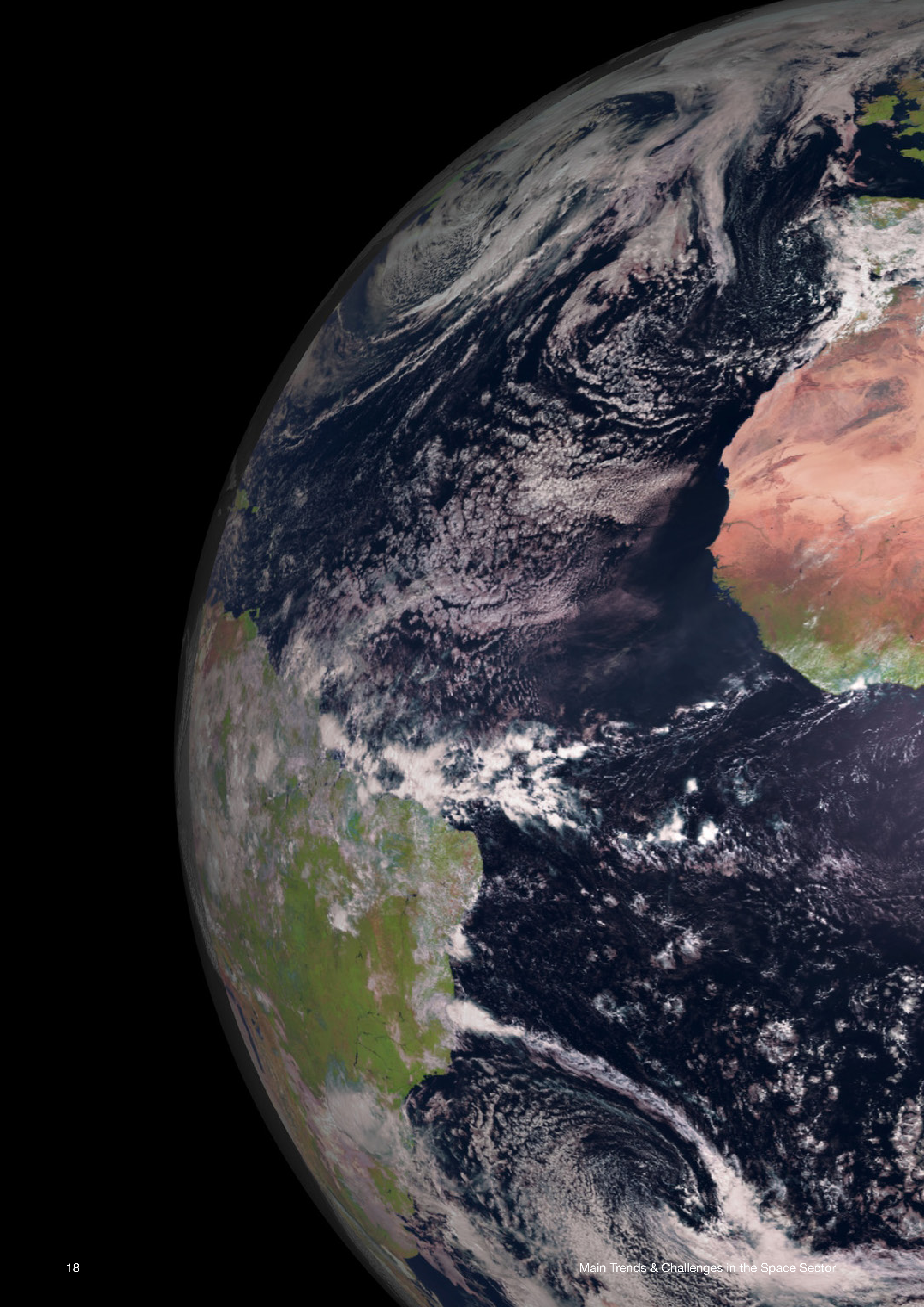
Economic	**Enabled revenues**: revenues generated by exploiting space assets	
	1	**Enabled revenues** are the estimation of the sales generated through the exploitation of the space assets built and deployed with the original investment in the space programme. Examples include the revenue generated in satellite service provision or in sales of value-added products and services.
	Typical values of multipliers and indicators	**Sales multipliers at 4x to 8x** represent the ratio between the initial spending for the space assets and the revenues generated due to their exploitation. Some examples are the revenues enabled by the exploitation of satellite data, such as EO or navigation, the utilisation of a rocket or the technological progress of scientific missions.

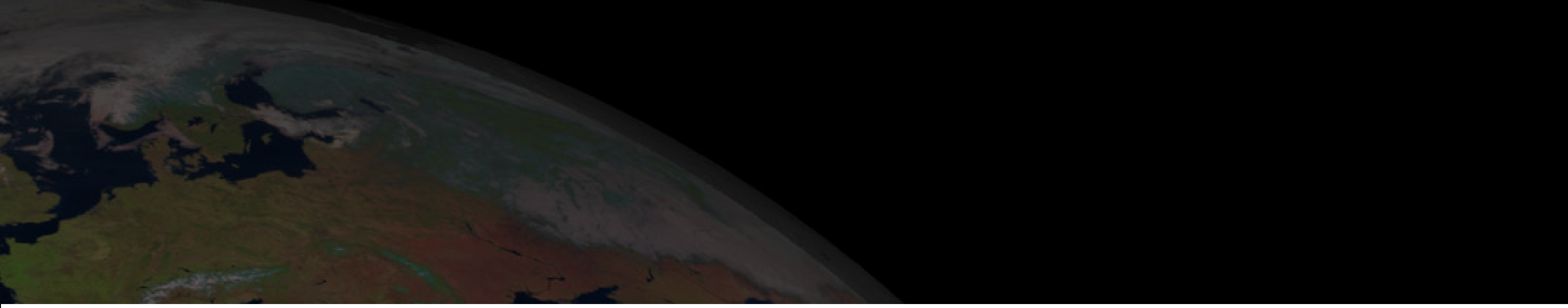


3. Impacts associated with building, developing and exploiting space assets

Strategic	**Industry competitiveness**	
	1	**Access to cutting-edge technology:** The extent to which the country is able to foster its industrial tissue thanks to the development of space activities
	2	**Support to local SMEs:** The estimated number of SMEs created following the implementation of space activities.
	3	**Support to adjacent sectors:** Mapping of space and non-space sectors which are expected to grow following the creation of a space market and space activities.
	National leadership	
	1	**Creation of hubs for space activities:** The number of foreign entities attracted by national facilities and services related to space
	2	**Positioning:** The extent to which capabilities developed for space activities (e.g. spaceports) can be used as a bartering instrument
	International collaboration/space diplomacy	
	1	**Collaboration with international partners:** The number of international partners collaborating with the entity following the creation of space activities and capabilities.

Environmental	**Environmental benefits**	
	1	**Environmental indicators**: Several environmental indicators can be assessed to understand the impacts an initiative or project may have on the environment. This assessment can help decision-makers understand the potential environmental benefits of a project and weigh them against any potential adverse effects. These indicators may include: – reduced emissions – more efficient use of resources – reduced waste – air or water quality.





Macro trends

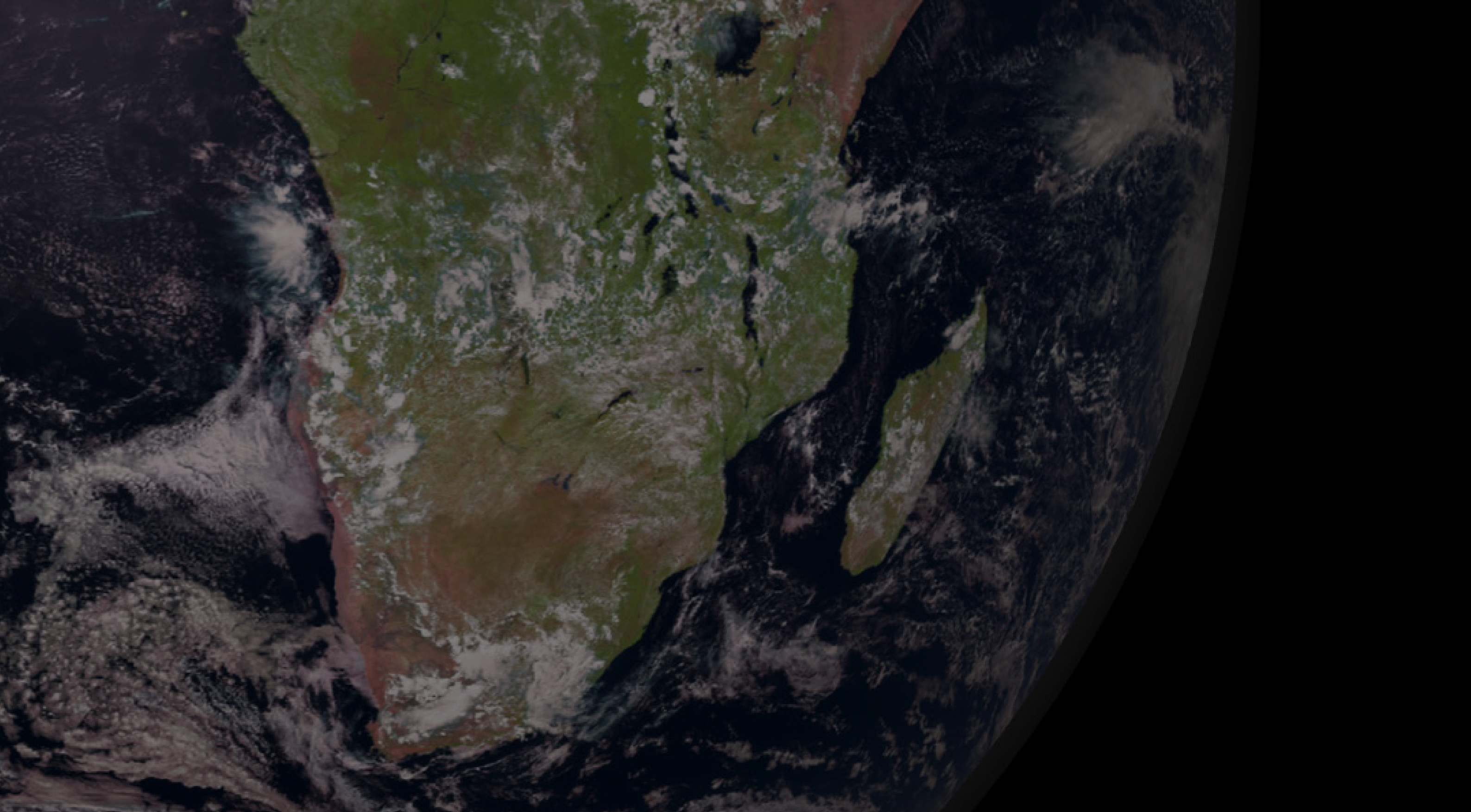
Transversal trends impacting the space sector broadly, irrespective of the specific domain

Space is becoming increasingly regionalised as national ambitions become stronger

There is a push to have tighter ESG practice in the sector, and at the same time space positions itself as a powerful enabler to implement environmental policies and ESG

Technology remains a strong driver for innovation all along the space value chain

Even with global private investments in the sector decreasing, the outlook and the interest for the sector remains strong on account of its strategic value



Four main categories of macrotrends impact the space sector's dynamics across all domains

Geopolitical landscape and global trade

- Overall trend towards regionalisation of space: regional and national ambitions counterbalancing global cooperation on space programmes and affecting also global trade
- Space is becoming increasingly militarised, expanding "Space for Defence" to "Defence in Space"
- Emerging countries in the space scene reinforce their role in the global ecosystem by ramping up their weight in space programmes

Access to finance

- Global private investments in the space sector are decreasing
- SPAC in the space sector did not meet their high expectations
- Deal dynamics continue to evolve
- Stock markets reward legacy space companies having ties in defence and security

Enviroment and society

- Space data is increasingly used for environmental policies and ESG strategies
- There is an increasing push for ESG practices in space and towards a mitigation of the environmental footprint of space activities (e.g. space launches)

Technology and innovation from upstream to downstream

- Digitalisation of the value chain progresses steadily from Industry 4.0 to Earth digital twins
- There is an increasing adoption of AI to optimise data management and processing as well as constellation management
- 5G and IoT usage advances, opening new business opportunities
- Evolution of the make-or-buy trade-off in satellite manufacturing: no standard approach exists across operators, with the general trend to focus internal manufacturing ('make') on core differentiating factors and potential for platform standardisation seen as the key driver for internalisation (mostly for constellations)

Evolutions in the geopolitical landscape led to a regionalisation and militarisation of the sector and impacted global supply chains and trade

Multi-polarisation/ Regionalisation of the global scene

In the context of revived tensions between the US, China, and Russia, international alliances play a strategic influence, with renewed interest in joining groups like NATO (Sweden, Finland) or BRICS (six new joiners expected in 2024). However, economic relationships remain more opportunistic and third-party nations can influence the global landscape through their partnerships with one nation or another.

Nationalist measures to protect strategic sectors

In the context of globalisation and international supply chains, nations have witnessed the consequences of dependence on other countries for the supply of critical products or services. Semiconductors, weapon systems, AI, cybersecurity tools or strategic raw materials are examples of components and resources increasingly protected by nationalistic measures, with long-term investment plans and economic war measures to weaken rivals.

Revival of interest in defence capabilities

The resurgence of war at the doorstep of Europe and its escalation in other areas, particularly energy-rich ones, prompted concerns for national military capabilities by many nations to complement the protection ensured by international alliances. Defence budgets have largely received a push in order to modernise equipment and keep up with warfare techniques.

Consequences for the space sector

Emerging countries in the space scene reinforce their role in the global ecosystem by ramping up their weight in space programmes. They define long-term strategies, provide attractive regulatory frameworks for space companies to grow their ecosystem and plan for substantial investments to take part in international collaboration programmes with spacefaring nations.

The West-East dichotomy remains a reality in space endeavours. The post-ISS era shows two distinct paths for LEO stations, with the Tiangong station on one side and commercially driven US projects on the other. Lunar exploration also witnesses parallel projects for research bases between the orbital gateway as part of Artemis and the ILRS on the lunar south pole, whose ambitions extend beyond pure scientific discovery to strategic dominance.

Militarisation expands to space, shifting from “Space for Defence” to “Defence in Space”. Active capabilities—from orbital proximity spying to signal jamming, blinding of optical satellites or physical destruction—have largely been demonstrated. Only a few are operationally used for now, but they play a role in geopolitical power, as illustrated by recent rumours on Russia’s plans for a space nuclear weapon.

National ambitions become prevalent, with substantial sovereign measures aimed at building non-dependency on space and securing access to key technologies and systems. National programmes become more ambitious, and links between civilian space agencies and national DoDs become stronger.

Responsive Space as a concept to reach the highest system resilience becomes of interest for defence

In an era of changing geopolitical landscapes, increasing dependency on space systems and escalating space threats, **resilient space infrastructures** are paramount.

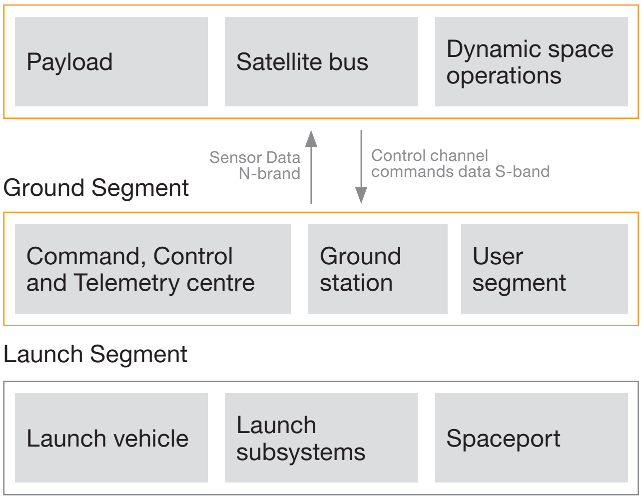
Resilient space systems are engineered to withstand or swiftly recover from disruptions, ensuring continuous operations. They underpin **Responsive Space capabilities**—agile and adaptive technologies that can be rapidly deployed or reconfigured to meet emerging threats and needs, thus guaranteeing uninterrupted services amid adversities. This quality of resilience and responsiveness is vital for **maintaining global communication, navigation and security** in an increasingly contested space domain.

Responsive Space

Achieving **space system resilience** necessitates **an architecture that includes all stakeholders** in the space sector. A foundational space infrastructure enables responsiveness, requiring **modular scalability and integration capabilities** for new assets.

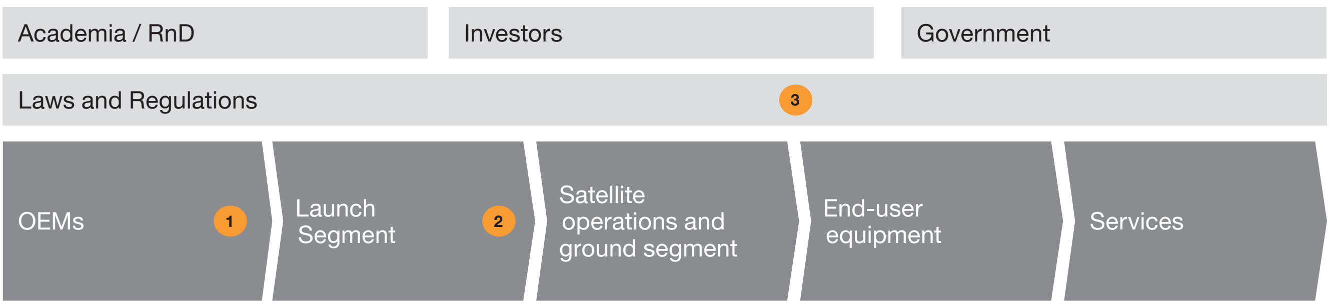
Responsive Space strategies focus on (1) **the reprogramming and reconfiguration of existing assets**, (2) the **rapid launch of new assets**, and (3) **the rapid integration of assets into a proprietary system.**

Particularly in the last area, the **NewSpace scene**, which is marked by **diversification of business models** and an extended asset and service range, fosters **operational agility**, for example through “as a Service” offerings across the value chain. This opens doors for **new cross-sector collaboration possibilities.**



The bottlenecks of Responsive Space

Space systems value chain



1. **Modularity in manufacturing**
   Standardise satellites and payloads for quick integration and reduced launch prep, enhancing fast adaptation and scalability

2. **Increase orbital Access**
   Diversifying access to orbit by increasing availability to operational spaceports and launch vehicles

3. **Simplify regulations**
   Standarise space regulations, including launch licenses and frequency allocations, for more efficient operations

The global trade and supply chain of space were significantly impacted by the regionalisation of the economy

The pace of globalisation has slowed since the global financial crisis in 2008-9 and should remain at current levels as the recent crises showed the lack of resilience provoked by globalisation:

COVID-19 Crisis	Critical disruptions of supply chains during COVID-19 led to scarcity of raw and advanced materials, and port congestion, among others
Russia-Ukraine War	Increased prices for metals, energy and foods as materials come from RUS/UKR

EU

- EU Chips Act: directed at strengthening domestic EU semiconductor market
- EU carbon levy: promoting greener industry

US

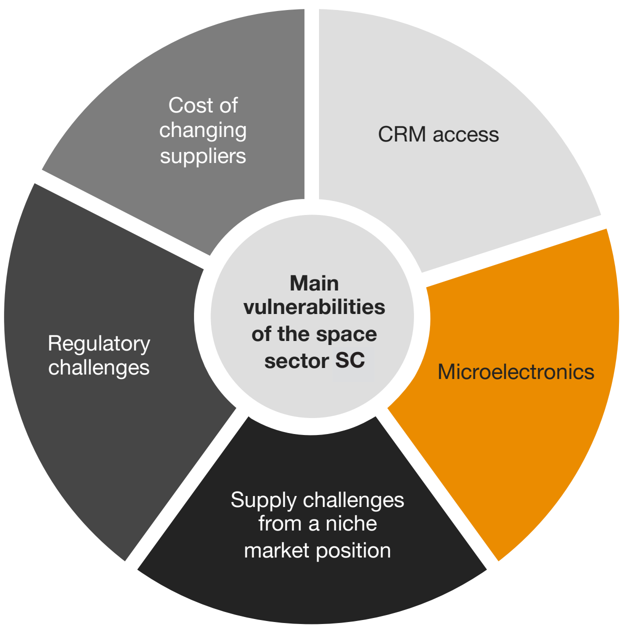
- US CHIPS and Science Act: aimed at keeping manufacturing and research of semiconductors in the domestic market

China

- China's Dual Circulation Strategy: putting a stronger focus on domestic consumption
- Export constraints

On the other hand, existing agreements at regional level are lowering trade barriers (e.g. EU, USMCA, CETA, RCEP, AfCFTA, Mercosur, CPTPP) and there are ongoing efforts to establish new agreements (e.g. EU-Mercosur, EU enlargement).

Challenges for the space sector



Cost of changing suppliers

Changing suppliers of critical space components can escalate costs and causes projects delays (need for requalification, new production line…), highlighting the need for a strong supply chain strategy.

CRM access

The space sector must diversify suppliers and innovate in critical materials to sustain progress and avoid supply disruptions from main production countries like China and Russia.

Microelectronics

The space sector's reliance on external high-performance computing and chip miniaturisation poses risks to its autonomy and future progress. The dependence on Taiwan is a high risk considering the tensions with China.

Supply challenges from a niche market position

The niche space sector needs partnerships and diversified capabilities to overcome supply hurdles in critical technologies

Regulatory challenges

The space sector faces challenges from strict environmental laws and rising energy costs due to sanctions against energy-producing countries. In addition, adapting to new qualification standards is time and resource-consuming.

The proliferation of space ops leads to reflections on the sector's environmental impacts, and at the same time opens up opportunities on the value of space data for climate action and ESG

A growing focus on the enviroment and society

Increasing emphasis on **ESG** (environment, social, and governance) criteria appears across all industries. Companies are increasingly integrating ESG scorecards into their annual reports, whilst governments lead efforts to enhance standards and policies, emphasizing societal and environmental considerations.

While discussions in the space sector often center on the sustainability of the space environment, there is growing acknowledgment of the need to broaden the scope of the discussion. The link between the space sector and environmental and societal factors can be viewed from two perspectives:

The environmental footprint of space activities on Earth, as well as social concerns such as diversity and inclusion in the workforce, including broader impacts of space operations on communities across supply chains

The role of space as an enabler of applications and services aimed at validating and monitoring ESG criteria in non-space sectors and as a key contributor of data for solving global challenges

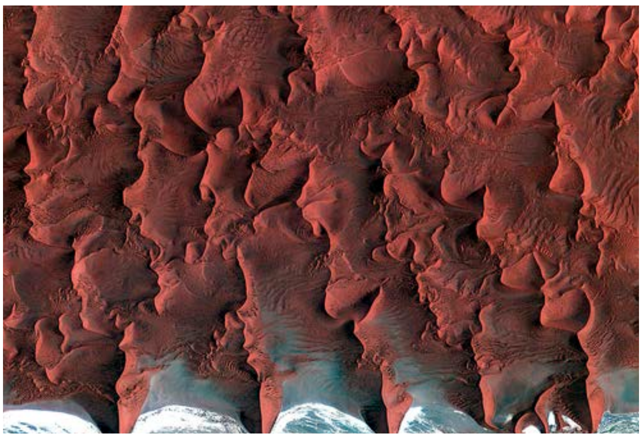
The enviromental footprint of space activities on Earth

As the space sector evolves, it will increasingly be held accountable for its ESG performance, necessitating a holistic approach to its practices and operations.

In view of the rapid increase in space activity, marked by an ever-growing number of launches per year and the rise in the development of satellite constellations, this is gaining relevance. Selected players are already paying attention to this macro trend in everyday operations.

As an emerging trend, there are challenges in assessing the environmental footprint of space activities due to data gaps as well as the complexities in carrying out life cycle analysis.

Space data – a key input for ESG monitoring across industries and to solve global challenges



The space sector is also a key data provider for ESG monitoring in non-space sectors and to global challenges through a variety of use cases.

Satellite data serves as a powerful tool, enabling the monitoring of environmental factors such as GHG emissions, carbon footprint, changes in biodiversity and deforestation, as well as facilitating efficient water and waste management practices, amongst others.

Additionally, satellite data supports the monitoring of social factors, allowing for the identification of risks related to human rights violations and illegal labor practices within companies. This is often achieved through the fusion of in situ and satellite data, providing valuable insights for addressing these critical issues. This integrated approach allows for a more holistic understanding of phenomena.

Efforts are ongoing to estimate and mitigate the environmental footprint of space activities

Governments are focussing on environmental protection and following up on the implementation of the Paris Agreement as well as environmental policies and climate strategies on a regional level. Mounting regulatory pressure has led to several efforts by space agencies and private players globally to measure and mitigate the environmental footprint of space activities. Some actors have now committed to a concrete reduction in their Green House Gas (GHG) emissions.

There are **two main challenges** ahead in the decarbonisation of the space sector:

– the need for greater **assessment** and comprehension of the space industry impacts overall across domains and segments
– the **implementation** of environmentally conscious designs from the outset as well as innovation in the development of sustainable space technologies.

Ongoing efforts for impact monitoring

GHG emissions

A carbon footprint assessment measures an organisation's carbon footprint by quantifying all the direct and indirect GHG emissions it generates.

The assessment is divided into several scopes:

– **Scope 1** (direct emissions)
– **Scope 2** (indirect emissions associated with energy)
– **Scope 3** (other indirect emissions)

Measuring GHG emissions precisely can help put in place accurate and targeted mitigation measures.

Initiative example:
Lockheed Martin targets to reduce scope 1 and 2 absolute carbon emissions by 36% from a 2020 baseline.

Life cycle analysis

LCA represents the most accurate method to quantify the environmental impact of a product.

This exercise is particularly complex because challenges arise from insufficient data, partly due to limited transparency associated with the close ties to the defence sector, alongside a competitive industry landscape, limiting information sharing.

Moreover, space products involve various components, testing phases as well as numerous employees to design, manufacture and operate these products, which complexifies the life cycle analysis.

Initiative example:
SES targets to complete LCA on all their products and services together with technology partners by 2030 to understand the impacts of their products and services.

Emissions in the atmosphere

An effort to quantify the real environmental impacts of space activities would include quantifying the emissions in the upper layer of the atmosphere as well. These emissions remain challenging to estimate due to the complexity of performing the industrial footprint assessment as well as the altitudes at which some emissions take place in the upper layers of the atmosphere. Impacts of soot, alumina and water vapor are indeed poorly measured at such altitudes and could be superior to the CO2 impacts.

Initiative example:
CNES is financing important research on upper atmosphere emissions with results expected in 2025. These findings will likely integrate into CNES' upcoming open-source OASIS eco-conception software, fostering eco-friendly practices among all space players, especially start-ups that lack resources for custom tools.

Eco-design

Eco-design consists of integrating environmental considerations into the design, manufacturing and operation of space systems and equipment.

This type of approach aims at reducing the environmental footprint by taking into account the environmental impacts of a product from the earliest stage in the design phase.

Initiative example:
ESA's EcoDesign initiative aims to mitigate environmental impacts and promote green technologies by developing a unified eco-design framework for the European space industry.

Sources: https://sustainability.lockheedmartin.com/sustainability/beyond-the-smp/carbon-strategy-and-climate-related-risk/ | https://www.ses.com/sites/default/files/2022-03/AR2021_ESG.pdf | https://www.esa.int/Space_Safety/Plans_for_the_future

As a result of increasing launch activity, there is a strong case for sustainable rocket propellants

A sustainable production of rocket propellants to reduce the carbon footprint of access to space

A substantial part of GHG emissions in launch activities emanates from propellants used and their production. The development of sustainable rocket propellant (SRP) or 'green' propellants, as opposed to 'grey' alternatives, thus represents an opportunity to reduce the carbon footprint of the sector as it introduces more sustainable ways of producing the most commonly used propellants that include RP-1, hydrogen and methane.

A transition that would essentially be costless for launch service providers

Developing a sustainable rocket propellant (SRP) can have an outsized influence on driving decarbonisation in the entire space industry. This is not only because the CO2 intensity can be up to 93% lower compared to today's fossil-based propellant, but also because the switch to sustainable rocket fuels will have a very limited impact on the overall cost per kg of payload being carried to space. Fuel costs are indeed only a small share of total launch costs—typically below 2%. This limits the overall cost impact of switching to SRPs. The potential for producing scalable sustainable propellants is achievable now and its successful deployment could send a signal to the entire industry.

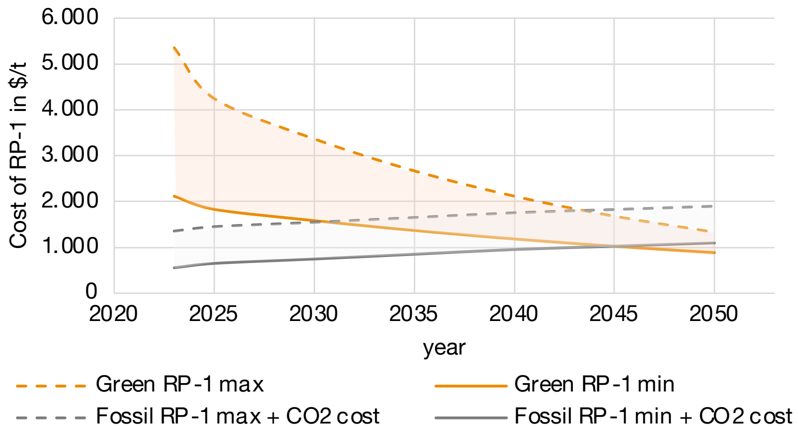
Spaceports have an integral role to play

Spaceports should be equipped with renewable power and fuel processing plants in the future to provide the renewable energy needed to produce SRP. Some existing spaceports are already transitioning. In Guyana, the French spaceport in Kourou has engaged its ecological transition by building two photovoltaic plants, and it is looking to biosource both hydrogen for Ariane 6 and methane to be used for its future engine, Prométhée. But spaceports under development also have a role to play as appropriate infrastructures for SRP production can be integrated by design. There is therefore a unique opportunity to use future spaceports as critical infrastructures that will encourage and enable further adoption of sustainable technologies by a broader set of access to space players, thus becoming key in the journey to net zero emissions for the space sector.

Several initiatives at governmental level

Governments worldwide try to channel efforts to develop SRP with initiatives coming from technical agencies like ESA's Innovative Propulsion and Cross Cutting Initiative (IP CCI) or ISRO's works on a green rocket-grade version of kerosene they call ISROSENE. These efforts are usually coupled with working groups from research and industry associations of the likes of the 3AF's "International Conference on Space Propulsion".

RP-1 'grey' vs 'green' alternative price estimates



Minimum and maximum cost development estimates of fossil-based RP-1 with CO2 price and synthetically produced RP-1 from 2023 to 2050.

Source: PwC Space Practice estimates, also available for other propellants.

Satellite technology plays an important role in addressing the ESG data gap, particularly regarding environmental factors

Use case examples

Sustainable finance

With a growing number of regulatory requirements in finance, such as the Sustainable Finance Disclosure Regulation and Taxonomy Regulation, investment firms and funds are seeking more reliable and quantitative solutions to determine ESG requirements.

€33t

global ESG assets under management in 2022, growing to €40t by 2030, with Europe accounting for approximately half of investments[1]

Enviromental data for ESG

Environmental factors that can be determined from EO include GHG emissions, carbon footprint, and water and waste management.

Risk assessment

EO data can be used to identify potential hazards on the ground, forecast natural disasters and climate-related concerns as part of asset risk calculations.

Asset monitoring

ESG factors can also tie into the creation of investment portfolios and identify new opportunities for sustainable investment.

Sustainable tourism

Tourism is a significant contributor to climate change, pollution, damage to biodiversity and poor labour practices.

Therefore, the sector is taking steps towards sustainable tourism practices across the value chain to ensure long-term socioeconomic benefits.

$2.2t

the sustainable tourism market in 2023, expected to reach $8.7t by 2030[2].

Enviromental monitoring

Tourism indicators related to climate change and pollution can be extracted from satellite data to provide a more quantitative and transparent view of tourist activities.

Site planning

EO data can be used to monitor biodiversity and help build sustainable infrastructure, specifically in remote destinations.

Destination management

Sites can be monitored regularly to detect changes, determine tourism trends and assess the impact of tourist activities

1. https://www.bloomberg.com/company/press/global-esg-assets-predicted-to-hit-40-trillion-by-2030-despite-challenging-environment-forecasts-bloomberg-intelligence/ | 2. Global News Wire

While the application of space data to track ESG measures unlocks wide ranging possibilities, there are limitations to consider

Technical limitations

Data bias	**Data bias** can lead to dangerous consequences, particularly for marginalised groups, if such concerns are not addressed in the algorithms.
Resolution	**Resolution** (spatial, temporal, spectral) can be a limitation for certain use cases, although the increasing number of operational spacecraft reduces this limitation.
Cost	**Cost** can be a consideration, since while data is generally affordable, the cost of analytic solutions can be a barrier to some price-sensitive users.
Integration	**Integration** of space into existing solutions can be a hurdle due to varying levels of standardisation and digitalisation within the sector and across other sectors.

While technical limitations are smaller than business limitations, **sustainability use cases in particular can be sensitive** given that vulnerable populations is at stake. Therefore, development must be equitable and unbiased.

Business limitations

Lack of awareness	**Lack of awareness** is probably the biggest single hurdle as users outside the space community are unaware of the benefits of space data. **Weak stakeholder/user engagement** is another limitation that exacerbates the awareness problem.
Pricing models	**Pricing models** are difficult to build as use cases often have different needs. Sometimes, neither volume- nor subscription-based models perfectly fit customer demands.
Bulding a business case	**Building a business case** can be complicated since, while the absolute price of space technology may not be high, non-technical users may have difficulty appreciating the added value of space.

It is not relevant that many end users in sustainability are 'decision-makers' who are potentially non-technical. There may be a problem in '**trust**' **of the space data** or seeing it as an 'alternative to' rather than 'support for' the human analyst.

Beyond environmental factors, satellite services are key in the face of broader global challenges

Satellites facilitate various applications and help address global environmental and social challenges by providing timely and accurate information.
Their **data can guide decision-makers towards making informed choices** and implementing effective solutions across various sectors.

Humanitarian support

The recent geopolitical context, especially the Ukraine war, has prompted nations to re-evaluate their interest in and commitments to humanitarian affairs, leading to increased investment in aid and budgets.

Space-based technologies can serve multiple purposes, for instance:

- **Displacement monitoring** – monitoring flows of people over the long term.
- **Vulnerability assessment** – predicting risks for certain populations which helps in facing crises more effectively once they occur.
- **Environmental impact assessment** – identifying environmental impacts caused by aid itself.

Monitoring climate change

Monitoring climate change is crucial to understand patterns and trends in global warming and to mitigate its impacts.

Satellite data can track environmental changes, such as deforestation or ice melting, providing essential information for research and policymaking. This increases the effectiveness of disaster management procedures and systems.

Disaster management

Space-based technologies play a crucial role in the full disaster management cycle by providing reliable and timely data to decision-makers.

Space-based technologies can help in anticipating and facing natural and human-made disasters by:

- **Enhancing awareness and preparation** by predicting risks of natural hazards through climate and natural hazards monitoring (by EO satellites).
- **Facing the event more effectively** by improving mapping accuracy in disaster zones (GNSS) or by coordinating emergency response efforts through the facilitation of communication between multiple actors (communication satellites).

Agriculture and food security

Ensuring food security and sustainable agricultural practices is crucial to meet the needs of a growing population.

Space-based technology can help farmers optimise agricultural practices, for instance, by:

- Providing accurate estimates and forecasts of **crop health**.
- Providing accurate estimates and forecasts of **yield**, reducing uncertainty in food security.
- Monitoring **soil moisture** to better manage water resources.

Diversity and inclusion practices are increasingly emphasised by space players in response to societal trends

A push for progress on social inclusion in the space sector

Governments are elevating the **importance** of **workforce Diversity, Equity, Inclusion** and **Accessibility** (**DEIA**) through new policies and standards. Driven by these new directives, **space agencies** are **increasingly embedding DEIA** as part of their strategy. This is leading to a **broader impact** on the space industry, **with** some **private players** and **non-profits** playing a role in **advocating** for **change**.

As with many technology-oriented sectors, the **space sector** faces **challenges with respect to DEIA,** with limited improvement in the last 30 years[1]. **Women** make up **approximately 20%** of the **global space workforce**, with minorities and **people with disabilities** also highly **underrepresented**. This offers an **opportunity for change.**

Key ongoing initiatives promoting DEIA are highlighted

- Following two executive orders[2] directing federal agencies to advance DEIA efforts, NASA drew up a new **strategic plan** for **Diversity**, **Equity**, **Inclusion** and **Accessibility** (2022-26).
- A 2023 Office of the Inspector General report[3] analysed the root causes of the agency's lack of progress on DEIA in the last ten years, recognising the **lack** of **consistent** and **reliable data** as a **limiting factor**.
- In 2023, NASA appointed its **first Diversity Ambassador** and reorganised its existing Office of Diversity & Equal Opportunity.

- **Equality** was confirmed a first-time **high priority** in the European Commission's Political Guidelines (2019-2024). Following this, an EC-wide **Gender Equality Strategy** was rolled out in 2021[4].
- As a result, the EC Directorate-General for Defence Industry and Space (DG DEFIS) **launched a survey on equality, diversity and inclusion** in 2022 to assess the status quo on DEIA among employers and employees in European and national agencies, organisations and academia.

- As part of the **ESA Agenda 2025**, ESA has the **objective** to *"boost its effectiveness and attractiveness" by becoming "**younger** and more **diverse organisation**" with "**women ... better represented,** including at **management level.**"*
- In 2022, ESA selected the agency's first parastronaut as part of the European Astronaut Corps. Concurrently, the ongoing Parastronaut Feasibility Project studies the technological adaptations needed to extend human spaceflight to a broader demographic.

- **Gaining momentum** with **UN member states, UN Space4Women** is a project of the United Nations Office for Outer Space Affairs to f**orward women's empowerment in space.** Aligned with the Sustainable Development Goals, it **ensures** that the **benefits** derived from **space reach women and girls** and that they play an **active and equal role** in space science, technology, innovation and exploration.
- UNOOSA, in partnership with hosting member states, convenes an Expert Meeting annually to discuss these topics. The meetings have been hosted by **Canada** (2023), **Korea** (2022) and the **UAE** and **Brazil** (2012).

- Founded in 2021, AstroAccess (part of SciAccess) is a non-profit organisation promoting **disability inclusion in human space exploration.** To date, they have carried out **five microgravity missions** in which disabled individuals perform demonstrations onboard parabolic flights with the Zero Gravity Corporation. This is a first step towards the goal of democratising human spaceflight.

1 https://news.un.org/en/story/2021/10/1102082
2 Executive Order 13985, Advancing Racial Equity and Support for Underserved Communities Through the Federal Government (20 January 2021) & Executive Order 14035, Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce (25 June 2021)
3 https://oig.nasa.gov/docs/IG-23-011.pdf
4 The Gender Equality Strategy 2020-2025, European Commission

Technology trends are changing the space industry which, in turn, also contributes to several of these cross-cutting innovations

Industry

Industry and manufacturing

- Industry 4.0 concepts have made their way into the space sector and are deeply changing the development and manufacturing side of the industry.
- Examples include **additive manufacturing**, enabling the rapid prototyping of systems but also becoming a mainstream manufacturing process (for launcher components for example), and **digitised advanced manufacturing**, leading to connected "smart" factories.
- Other technology and manufacturing trends impacting the upstream include **IoT**, **cybersecurity**, **cloud computing**, **BDA**, **advanced robotics**, **digital design**, **scaled manufacturing**, and **smart and connected products**.
- **Evolving decision-making criteria for operators regarding satellite manufacturing, particularly on SmallSat (make or buy).**

Connectivity

Networks

- Better integration of space in Earth-based **5G networks**, forming hybrid networks.
- Extension of **low-latency**, **high-speed communication** to areas that are less populated or inaccessible, including battlefields, natural disaster locations and offshore locations.
- Integration of **LEO SatCom** into 5G connectivity.
- Increased push of the **space-as-a-node** paradigm.

Internet of Things (IoT)

- **Integration of space networks** into IoT is a growing trend, with the intention of decreasing latency and increasing distance of communications.
- Companies in the private sector are looking to operate **SmallSat constellations** for IoT connectivity; **the main challenges include user segment chipset miniaturisation, energy minimisation and resilience, among others**.

Data and analytics

Artificial intelligence and deep learning

- Increasingly used in data applications, such as **analysing large amounts of data** or **processing data directly on board**.
- Applications in other parts of the value chain include **advanced mission operations, innovative security concepts, improving image quality, detecting and tracking features for EO, GNC hive learning.**
- Many other cross-cutting applications indirectly affect space, including **language processing, generative AI and R&D.**
- Big data analytics (BDA) continues to push the boundaries in **Earth observation data exploitation** through data fusion, powering increasingly sophisticated applications in agriculture, urban planning, environmental monitoring, among others.
- **Predictive modelling and deep learning help to optimise mission parameters** and reduce risks in complex space missions.
- **Processing the vast datasets** from space instruments is another important application of BDA

The evolution of operators' business models and the de-risking of their activities lead to varying degrees of outsourcing in satellite development

There is **no standard practice** across satellite operators and integrators on the preferred strategy for the 'make or buy' decisions. The key driver remains the **trade-off between cost competitiveness and risk management** for the missions and is, therefore, dependent on the 'way to play' in the market: constellation operators vs single mission operators, affordable and expandable solutions vs risk-averse and long-duration assets.

Cost	Preference for vertical integration for most large-scale constellation operators, as one of the main pain points is the redundant cost of satellites (including design, manufacturing, launch and operation).
Critical internal know-how related to manufacturing activities	Some players are investing in core expertise in satellite manufacturing which they consider part of their competitive advantage.
Protection (IP) of key technologies	Most operators start by developing innovative payloads (especially in EO) and then proceed to integrate them into a satellite platform.
Delays and flexibility of manufacturing	New entrants require highly flexible procurement, with manufacturers being able to take a request, produce and deliver CubeSats or microsatellites ready to launch in less than a year (a few months in most cases).
Dependency on external partners	Vertically integrated players see the dependency on external partners for some critical parts of their satellites as very risky.

Illustration for Earth observation

Optical Payloads

- Moving from CubeSats to bigger platforms (more risky) pushes most commercial operators to outsource the manufacturing of their capabilities
- Companies capable of manufacturing standardised CubeSats have the interest to internalise production to create economies of scale and reduce dependency

SAR Payloads

- Strong interest outsourcing upstream activities to focus all capabilities (i.e. talent and investment) on key differentiators of satellite operators (e.g. software)
- Protection of core competitive advantages pushes commercial operators to internalise most of the manufacturing process

Space as a node: How the rise of the space economy is unlocking new data-driven business growth

Defining the concept of Space as a node

Space as a node refers to the full realisation, long in the making, of the space sector's shift in value from satellite infrastructure to data and value-added content. As space-oriented networks proliferate and space infrastructure rapidly matures, emerging companies are increasingly leveraging satellite 'nodes' for:

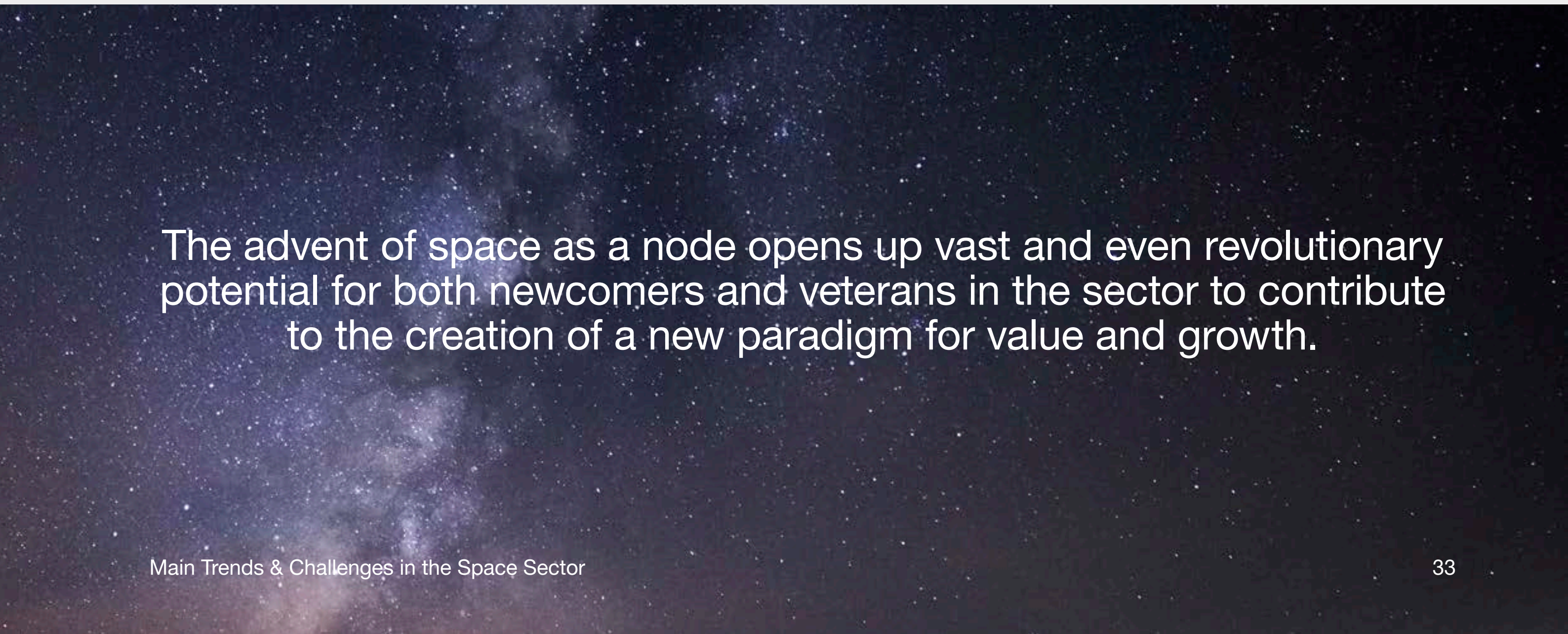
- information
- access points
- data creation and movement
- application development
- new business models/service offerings

Looking ahead: developing nodes in the network

The integration of space capabilities into the terrestrial commercial economy is progressing via multiple access points to networks, including transcontinental terrestrial, undersea cable and satellite-based systems. Viewed holistically, this exciting development could create a new hub in the world's industrial, technological and economic infrastructure.

Refining the space's value chain: the **data paradigm shift**

The life cycle of space data: from generation to application	Transitioning to advanced business models	The chronology of industry advancement
The space sector shifts focus from providing data to delivering insights. This shift in turn lays the foundation for **Insights as a Service**.	The space sector's offerings are not merely informational but prescriptive; they guide stakeholders toward informed actions and decision-making.	Space firms are differentiating themselves by how effectively they can turn data into strategic assets. This strategy marks a transition from firms as data handlers to knowledge providers.



From design to launch and beyond, AI is accelerating the space industry at rapid momentum and scale

Space AI trends and use cases

Engineering acceleration

- GenAI copilots for engineering design, analysis and knowledge transfer
- Machine learning for flight sciences analysis
- GenAI parts rationalisation
- Digital twins and AI simulations

Predictive programme management

- Synthetic programme intelligence
- Predictive financial forecasts
- Resource and productivity tracking
- Risk and scenario modelling
- GenAI programme insights

Satellites and sensors

- Computer vision and GenAI solutions for sensors
- Satellite data synthesis and noise filtering
- Embedded and IoT Edge AI services
- Ground station data analysis

Payload and launch

- Machine learning-powered demand forecasting
- GenAI payload configuration
- Resource allocation
- Real-time fuel and launch analysis
- Risk assessment and mitigation

AI in the NewSpace economy

Artificial intelligence (AI) is rapidly transforming the space industry, offering unprecedented opportunities for innovation, efficiency and commercial growth. This white paper examines AI's profound impact on spacecraft design, Earth observation, autonomous space operations, space domain awareness and the regulatory landscape governing its use, with an emphasis on both government and commercial applications.

AI acts as a force multiplier within the space industry, significantly enhancing our capabilities in the following key areas:

- **Streamlining spacecraft design and analysis:** AI accelerates the iterative design process through rapid prototyping; optimises structures for weight, performance and resilience; and simulates spacecraft behaviour in the extreme conditions of space.
- **Unlocking insights from satellite and sensor data:** AI reveals patterns and trends within vast Earth observation datasets, driving groundbreaking applications in areas like precision agriculture, natural disaster response, environmental monitoring and resource mapping.
- **Advancing autonomous systems:** AI is the backbone of autonomous spacecraft, rovers and robotic systems for space exploration and resource utilisation. These systems operate with reduced human intervention, navigating and adapting within unpredictable environments.
- **Bolstering space domain awareness:** AI is vital for tracking space objects, predicting potential collisions, analysing orbital manoeuvres and assessing space threats. This ensures a safe, sustainable and responsible space environment.

Regulatory compliance considerations

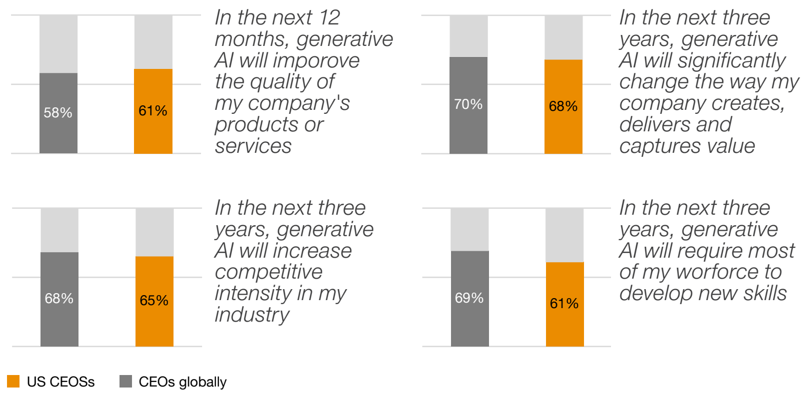
Data and AI ethics

- Responsible AI
- AI and data governance
- Explainable AI documentation
- Racial and gender bias
- Risk mitigation

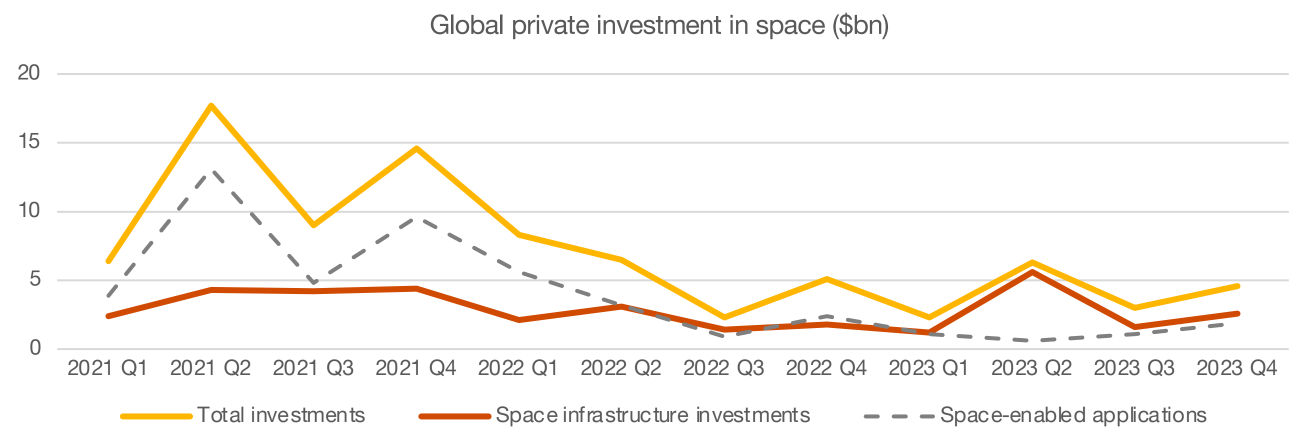
Government cloud

- FedRAMP compliance
- ITAR/EAR compliance
- DoD IL sensitivity
- Data classification
- Air-gapped AI

2024 Global CEO AI Survey Results



Private investments in space are decreasing due to political/economic uncertainty and an overall rationalisation



The upstream segment becomes more and more solid. Investors in 2023 are more selective, rewarding companies with strong fundamentals and governmental or defence contracts.

Trends in brief

Private investments dropped significantly in the last three years:

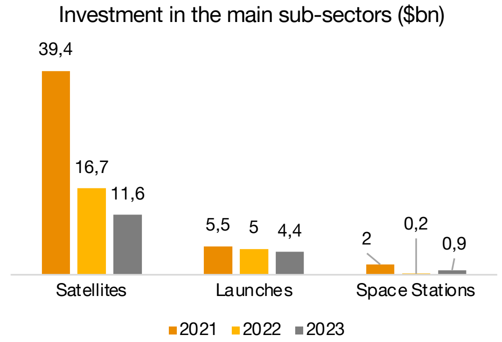
$49.1bn (2021) → **$24bn** (2022) → **$17.9bn** (2023)

-51% (2021 to 2022); -24% (2022 to 2023)

General investors' wave of financing space companies has slowed down as investments become much more selective, and the number of rounds and unique companies keeps decreasing.

Applications steep decrease in money flow is mainly related to GPS-enabled applications, which dropped by almost $20bn between 2021 and 2022.

Segmentation of investments



2021	2022	2023
Rounds: **603**	Rounds: **438**	Rounds: **417**
Unique Companies: **505**	Unique Companies: **387**	Unique Companies: **395**
Corporate Investments: **$14.9bn**	Corporate Investments: **$1.7bn**	Corporate Investments: **$2.1bn**
Vencture c. investments: **$18bn**	Vencture c. investments: **$13bn**	Vencture c. investments: **$6.8bn**

SPAC deals did not meet the high expectations they set and consolidations take place to face market threats

Domains	Company		Valuation at SPAC (M$)	Market cap (M$) *2nd April 2024*	Revenue 2022 (M$)	Revenue 2023 (M$) *Companies' info/ projections*
Access to space		Virgin Orbit	3800	Bankruptcy	33.1	-
		Momentus	1500	5.68	0.3	1.7 (half year)
		Astra	2600	15.92	9.3	0.96 (until Q3)
		Rocket Lab	4800	2025.04	211	244.6
Earth observation		Satellogic	1100	142.56	6	10-20
		Planet Labs	2800	647.16	170	220.7
		BlackSky	1500	197.45	65.4	94.5
		Spire	1600	299.55	80.3	105.7
Satellite manufacturing		Terran Orbital	1800	264.47	94.2	135.9
Satellite communication		AST SpaceMobile	1800	659.19	13.8	- (until Q3)
		SatixFly	365	52.90	10.6	8.9 (until Q3)
Lunar economy		Intruitive Machines	1200	811.23	85.9	48.9 (until Q3)
In-orbit economy		Redwire	675	286.58	160.5	235

High cash burn to deal with

During the years 2022 and 2023, the number of **SPAC deals in the space sector dramatically decreased**. Some SPAC companies are in fact evaluating a **return to private ownership**. The market cap of all the mentioned companies **dropped significantly** after their acquisition, and most of them announced layoffs or reverse stock splits.

Growing and demonstrating

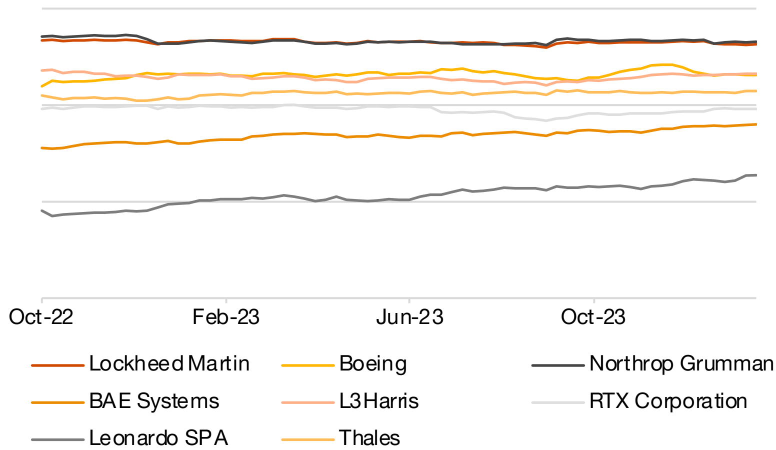
Almost all the SPAC companies are **reporting increasing revenues** over the last two years and are trying to find ways to cut costs that impact their profitability. Some of them are **still in the process of demonstrating** their technology. Companies that win **governmental contracts** are those that manage to attract more private investments.

Sources: companies' websites

The stock market still rewards legacy space companies while NewSpace companies struggle to maintain their market cap

*Legacy space companies' stock history, logarithmic scale**

(Oct 2022 - Feb 2024)



28% growth

Legacy companies accounted in this analysis reach an average growth in stock prices of 28% in Oct 2022 -Feb 2024 timeframe.

These companies are generally heavily involved in the defence sector and gather significant government contracts.

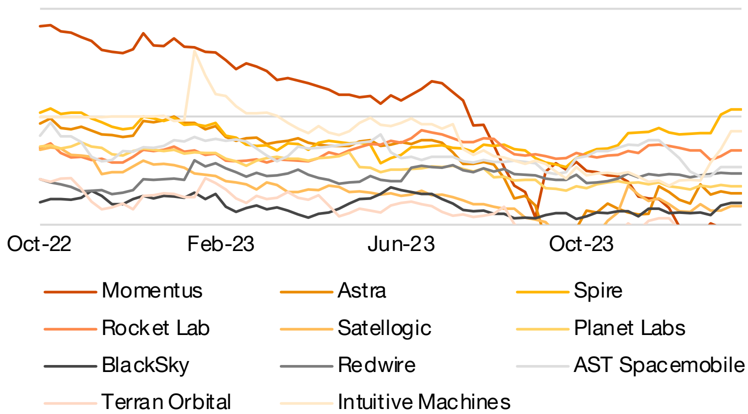
Highest and lowest per stock value as of 19 February 2024

$450,96 Northrop Grumman

$18,77 Leonardo S.p.a

*NewSpace SPAC companies' stock history, logarithmic scale**

(Oct 2022 - Feb 2024)



-39% decrease

The NewSpace companies that went public through SPAC are seeing their stocks decrease, with an average drop of 39% in stock % in Oct 2022-Feb 2024.

Some of these companies executed a reverse stock split, trying to keep a higher share value.

Highest and lowest per stock value as of 19 February 2024

$11,74 Spire Global

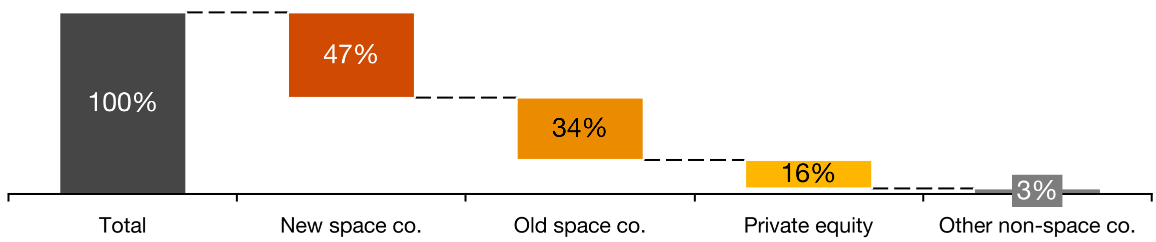
$0,82 Momentus

**The logarithmic scale has been chosen instead of the value of single stock prices: it allows the comparison of different prices on the same chart by highlighting their stock value percentage growth.*

Deals in the space sector are driven by an increased threat of competition and by potentially undervalued assets

~35-40 M&A space transactions in 2023

M&A space transactions in 2023 by type of acquirer, % share

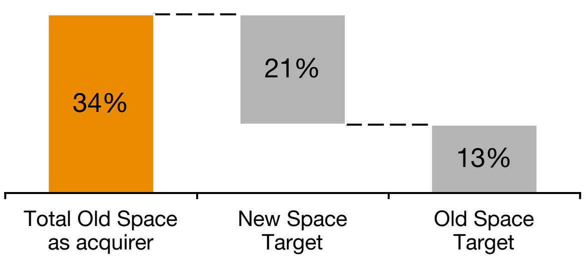


Four key trends shaping M&A in the space sector in 2023

1. The impact of SpaceX

legacy space companies join forces to survive

Distribution of transactions with Old Space co. as acquirer, by type of target (NewSpace vs Old Space), % share



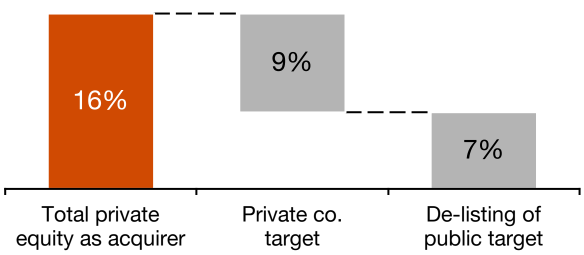
SpaceX's relentless pursuit of **innovation** and **ability to offer more cost-effective launch solutions** have profoundly challenged traditional players' market positioning, **intensifying competition** within the industry. As a result, **heritage space communications companies** (and more recently, **legacy space** companies in general) started to recognise the **need** to **join forces** to **remain competitive**.

Examples: Viasat – Inmarsat for $7.3bn; Eutelsat's – Oneweb valued at $3.4bn

2. The role of private equity

capitalising opportunities on undervalued assets

Distribution of transactions with private equity as acquirer, by type of transaction (private co. vs de-listing), % share



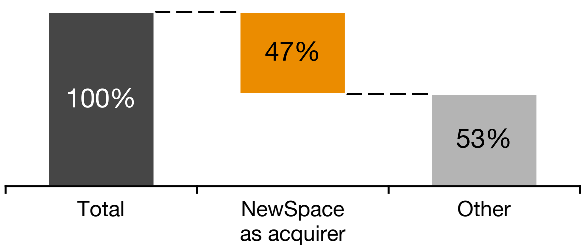
In 2023, private equity investors **seized M&A** opportunities by leveraging the **underappreciated potential** of space companies that were also **struggling** to **raise capital** and facing **investors'** increasing **pressure** for **profitability**. Targets not only included private companies but **also public ones**, mainly via the **de-listing of SPAC companies** that **didn't meet expectations** after listing.

Examples: AE Industrial Partners – Firefly Aerospace, Redwire, York Space Systems; Advent de-listing Maxar

3. Consolidation

NewSpace companies claiming role as acquirers

Distribution of transactions by type of acquirer, focus on NewSpace companies, % share



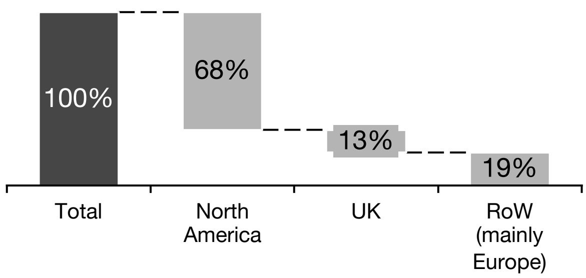
In 2023, space companies started to **leverage** M&A **to strengthen their positions**. Established firms acquired **crucial capabilities**, **teams** and **technologies**, driven by **favourable market conditions** and low **valuations**. Most notably, **NewSpace companies** consolidated their **role** as **acquirers**, **highlighting** the **growing influence** of **those players** in **shaping** the **industry's future trajectory**.

> **Examples:** Firefight – Spaceflight; Redwire – Qinetiq Space; Voyager Space – ZIN technologies; Planet Lab – Salo Sciences

4. More than just the US

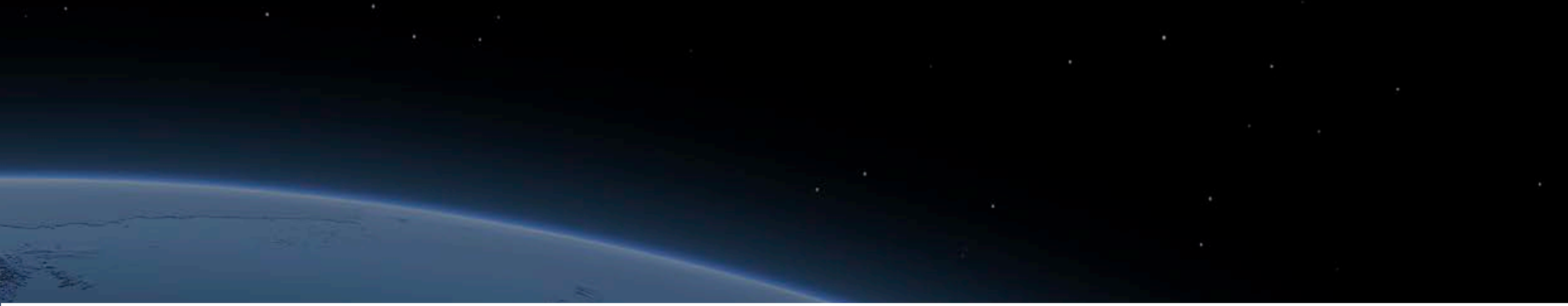
the emergence of local strengths

Distribution of target companies by geographical area, % share



Top space deals also included targets from **countries** like **Canada**, the **UK**, **Germany** and **France**, alongside traditional leaders like the **US** and **China**[1]. This shows a more **balanced industry** and the increasing **internationalisation** of space M&A activities. Noteworthy start-ups, driven by **local space sovereignty** concerns and leveraging their unique strengths, could **potentially gain** a **lasting advantage** over US competitors.

> **Examples:** KKR de-listing of OHB (DE), Viasat – Inmarsat (UK), CNH Industrial – Hemisphere GNSS (Canada)



Domain-specific trends

Overview of specific trends and challenges per space domain

Six main domains in the space sector are described with their trends and challenges

Earth observation

Push for EO sovereign strategic assets

Market push comes from governments thanks to the emergence of new sovereign Earth observation initiatives for security and defence and increased efforts to acquire data and assets. Market expansion to non-traditional users continues but is hindered by barriers.

Satellite communication

TAM expansion enabled through D2D

D2D communications offer satellite operators the chance to greatly increase their TAM (total addressable market) by reaching billions of devices.

Navigation

Navigation technology advances

All GNSS are being upgraded, also following the emergence of new use cases. On the other hand, LEO PNT constellations that are GNSS-independent are starting to materialize, attracting institutional interest.

Access to space

Need for some changes

Due to its challenging endeavour, the launcher market is facing supply concentration dynamics and players need to reinvent their business models to survive. Smaller launchers are seen as strategic steps towards autonomy.

Space safety

New frameworks to avoid saturated orbits

The surge in small satellite deployments is worsening space traffic in LEO, emphasising the critical need for collaborative space traffic management and debris mitigation efforts involving all stakeholders to ensure space sustainability and security.

Beyond Earth economy

Time to demonstrate

While business cases are mostly uncertain, in-orbit economy is demonstrating new technology. Private space station projects evolve and both public/private entities find success in lunar landing.

Earth observation

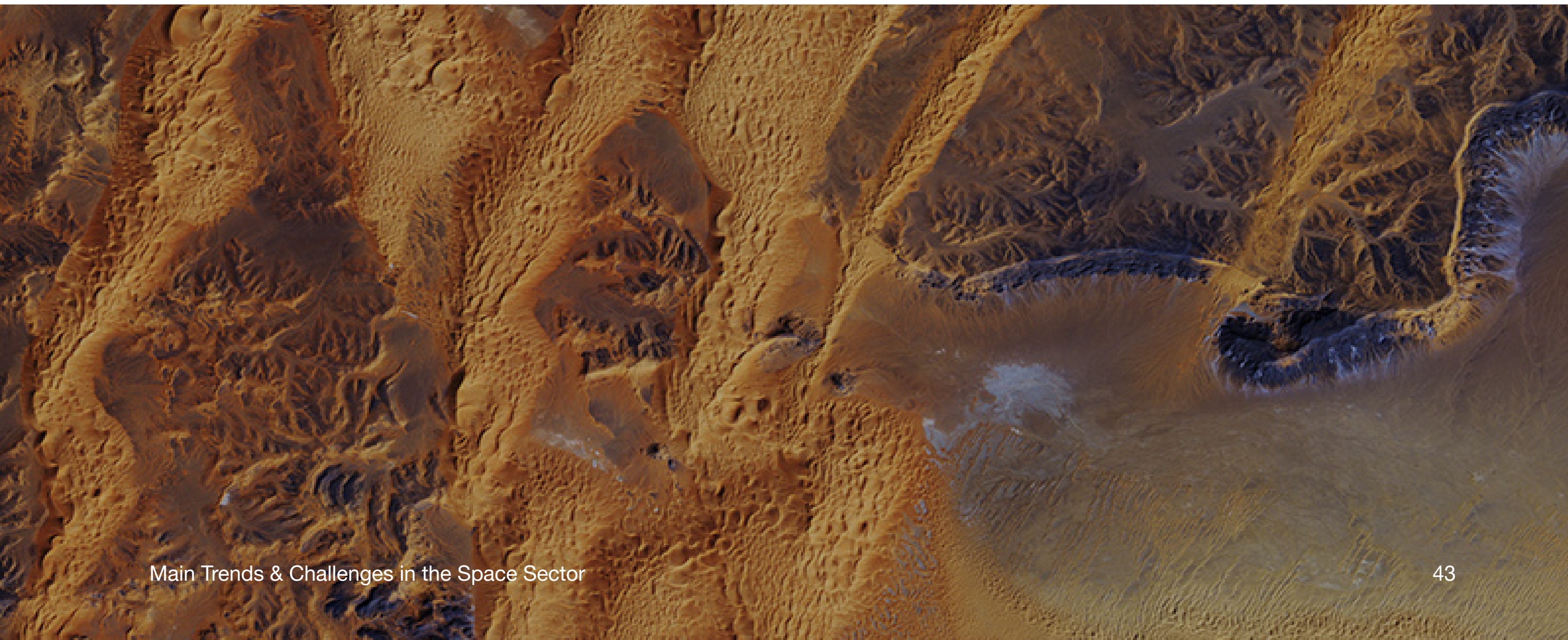
Key trends at a glance

Demand is still largely driven by governmental demand (Mil/Gov).

Evolution and uncertainties in the geopolitical context are driving the emergence of new sovereign Earth observation initiatives for security and defence applications.

Application for natural managed resources, environment and sustainability is also growing.

While democratisation to non-traditional users continues (e.g. industry, services), adoption is still hindered by existing barriers (lack of awareness, fragmented offering and pricing).



The EO market continues to grow, driven by downstream products and services

Earth observation value chain

Segment	Activities	High-level description
Upstream	**Satellite / Payload Manufacturing** **Ground equipment manufacturing**	Manufacturing and integration of space assets, including satellite buses, Earth observation payloads (e.g. radar and optical) and ground systems
Midstream	**Satellite operations** **Data acquisition** **Data Storage**	Satellite operations, acquisition of data via tasking or continuous monitoring and data storage for further processing and utilisation
Downstream	**Data processing**	Processing of raw imaging into a usable data format
	Data fusion, analytics and algorithms, Big Data **Insight provision** **Application development**	Processed imagery transformed into advanced products and services for end users (e.g. value-added services, information products, insights)

End Users

Key figures

~$5bn
Estimated EO downstream revenues in 2023

8-10% CAGR
Estimated EO downstream growth for the next decade

~$4bn
Cumulative downstream investment in commercial EO (2018-2022)

EO demand is primarily driven by Mil/Gov and environmental use cases, while barriers still hinder broader adoption by non-traditional users

Demand trends

Rise of sovereign national EO missions

Governmental customers (Mil/Gov) still represent the majority (~50-60%) of the overall demand. In addition, the evolving geopolitical situation is driving the emergence of national EO missions and constellation

Interest in specialised products and insights, particularly for the environment

Interest in environmental, sustainability and emission monitoring applications continues. At the same time, driven by the pressing need to address climate change, private companies are innovating to complement public weather data.

New regulation can open opportunities

A potential boost for the adoption of EO data comes from new regulations: an example is the EU Deforestation Regulation, which could drive the adoption of EO for collecting the geolocation of wood suppliers and monitoring the deforestation of targeted areas.

Supply trends

Emergence of new business models

Market fragmentation and a variety of solutions lead to the evolution of downstream business models, from traditional single-image purchase to subscription/volume-based. At the same time, new "as-a-service" models emerge (e.g. CaaS)1)

Emergence of new technologies

Non-imagery technologies (e.g. Thermal Infrared, Radio Occultation, AIS, hyperspectral) emerge and are experiencing a rise in investment influx and in the number of planned constellations. Nevertheless, current applications are mostly driven by specific use cases, with widespread demand yet to materialise.

Innovation in ground segment and processing

The adoption of cloud-based services is on the rise, driven by lower costs, scalability and ease of data dissemination, while concerns related to the security of sensitive data remain. At the same time, operators are aiming to capitalise on the potential of ML/AI algorithms, e.g. for on-board processing.

Market challenges: barriers still slow down adoption by non-traditional users

The democratisation of EO continues as satellite data is no longer a niche technology. Nevertheless, realising the full market potential and attracting non-traditional users (e.g. services or industry) still encounter barriers:

Lack of awareness of the potential and value of EO by non-space-savvy users

Lack of standarisation of data interfaces across platforms, preventing easy access for end users

The **high cost per image** of cutting-edge technologies like SAR and VHR may pose a barrier for certain business cases

Demand for increased bandwidth and higher data transmission rates is driving mobile wireless service providers to request broader access to radio frequency spectrum. The upcoming World Radiocommunication Conference in 2027 (WRC-27) will debate on enhancing spectrum access to 5G and 6G operators in frequency bands primarily used for Earth Observation applications. This risks significant radio frequency interference to Earth Observation satellite sensors and ground station receivers particularly in the 7GHz – 10GHz range. New initiatives such as European Scientists on Spectrum for Earth Observation (ESSEO), led by the European Space Agency, as well as industry efforts emerge in response to advocate ahead of WRC-27.

Governmental systems with a focus on defence and security reflect an overall push for sovereign strategic assets

Evolution and uncertainties in the geopolitical context are driving the emergence of new sovereign Earth observation initiatives

The evolving geopolitical landscape and its militarisation and regionalisation effects on the space sector also impacted EO. The conflict in Ukraine has sparked increased demand for satellite imagery among defence players and beyond and has highlighted the interest in use cases related to situational awareness and intelligence gathering. Moreover, a focus on safeguarding sovereignty, bridging demand gaps and achieving data autonomy is driving the emergence of sovereign EO initiatives for security and defence applications.

Selected examples

EC's feasibility studies for an EU-wide EO Governmental Services (EOGS)

Context and objective

- The EU Space Strategy for Security and Defence (March 2023) stresses the key role of EO in decision-making and supporting the EU's security and defence.
- While Copernicus delivers security services, it was not designed to comply with defence requirements.
- For this reason, the EC is working towards the implementation of a new EO Governmental Service, with the aim to provide complementary EO capabilities to member states and EU institutions, for security and defence applications.

Current status

- Studies awarded to two consortia for feasibility assessment
- Potential start of testing of pilot/precursor service by end of 2024

US National Reconnaissance Office (NRO) constellation of satellites

Context and objective

- SpaceX's Starshield unit is reportedly building a constellation of 100s of EO satellites, with the capability to operate in swarms in low Earth orbit.
- The total value of the contract is reported to reach $1.8bn[1)].
- Successful deployment would reportedly significantly advance US EO government and military capabilities.

Current status

- Contract reportedly awarded in 2021, manufacturing under way[1)]

Soure: 1. Reuters

Several countries are developing national EO assets and expanding efforts to acquire data and services

Several countries are extending or developing their EO upstream assets through constellations, targeting multiple applications

Several nations are investing to build new EO constellations, not necessarily aimed at reinforcing security and defence applications but covering a broad spectrum of target applications, including ESG reporting, infrastructure monitoring, civil protection and coastal monitoring.

Selected examples

IRIDE	Italy is developing a multi-payload EO constellation (SAR, Optical and Hyperspectral) with the support of a budget from the EU National Resilience and Recovery Plan (PNRR).
ATLANTIC	Spain, Portugal and, more recently, the UK are partnering with ESA to develop the Atlantic Constellation, which consists of EO and telecom satellites.
CAMILLA	Poland signed an agreement with ESA to launch their first EO constellation, Camilla, planned for launch in 2027.
SIRB	The UAE Space Agency recently signed an MoU with the EDGE group, a UAE defence conglomerate, to develop Sirb, a SAR constellation planned for launch in 2026.
GISTDA	MHESI and GISTDA launched a new EO satellite called "THEO-2" in 2023, which is expected to play an important role in various sectors.

Nations are also investing in expanding efforts to acquire EO data and services from the industry and in developing the downstream sector

In addition to developing upstream capabilities, some governments are investing in downstream capabilities (e.g. development of data platforms) and acting as anchor customers for EO through the direct procurement of commercial data.

Selected examples

NASA	NASA's commercial SmallSat Data Acquisition programme aims to acquire commercial EO data and service contracts, valued up to a total of $476m.
NGA	The NGA issued a call for commercial EO data providers under a new programme, Luno, with a planned ceiling of $290m.
ESA	ESA and EU are enabling more commercial data providers to join the Copernicus Contributing Missions. Nine NewSpace entities joined the programme for the first time in 2023.
JAXA	Japan's satellite data platform called "Tellus" was established in 2019 with the goal of creating a new business market for satellite data (JAXA provides EO data).
ISRO	India's National Remote Sensing Centre (NRSC) and the National Geospatial Program (NGP) aim to strengthen national EO capabilities and promote R&D to various user sectors.

Several use cases are consolidated along a specific sustainability angle

GHG monitoring	As attention to climate becomes paramount, so does the role of EO: different companies position themselves in the GHG emission monitoring process, which involves the detection of GHG emissions, their quantification and the identification of sources.
Ocean monitoring	Ocean monitoring is a growing area of focus within the EO domain. Since Nov 2023, CASC, NASA and ISRO have launched ocean monitoring satellites that can enable key applications in the domain including an improved understanding of climate change, pollution tracking and monitoring of marine life.
Smart cities	The integration of space data and advanced modelling capability represents a significant innovation that enables cities to be smarter, climate-neutral and better connected. From digital twins to urban heat islands, the applications are many and so are the impacts on the citizens.

Smart cities case study

Urban Heat Report is an EO-powered tool developed by PwC Slovakia that helps cities tackle the issue of Urban Heat Islands (UHI).

It uses thermal satellite imagery to analyse areas in cities that are getting significantly warmer than their surroundings. By combining the remote sensing data with other layers such as land use, population density and environmental sensitivity, it aims to pinpoint the causes and effects of excessive heat on the city and its inhabitants.

Urban climate resilience is quickly becoming a key focus area for many cities, being pushed into the foreground by ever more frequent and severe heat waves that catch people off guard.

EO data is also key in engaging the citizens and explaining what the problems are and how we can address them. The tool uses it to visualise various aspects of UHI directly in the city, making the topic immediately accessible. Satellite imagery allows for delivering insights globally. The solution is not constrained to any specific city or region.

You can find a preview of the Urban Heat Report tool at urbanheatreport.sk.pwc.com

Satellite communication

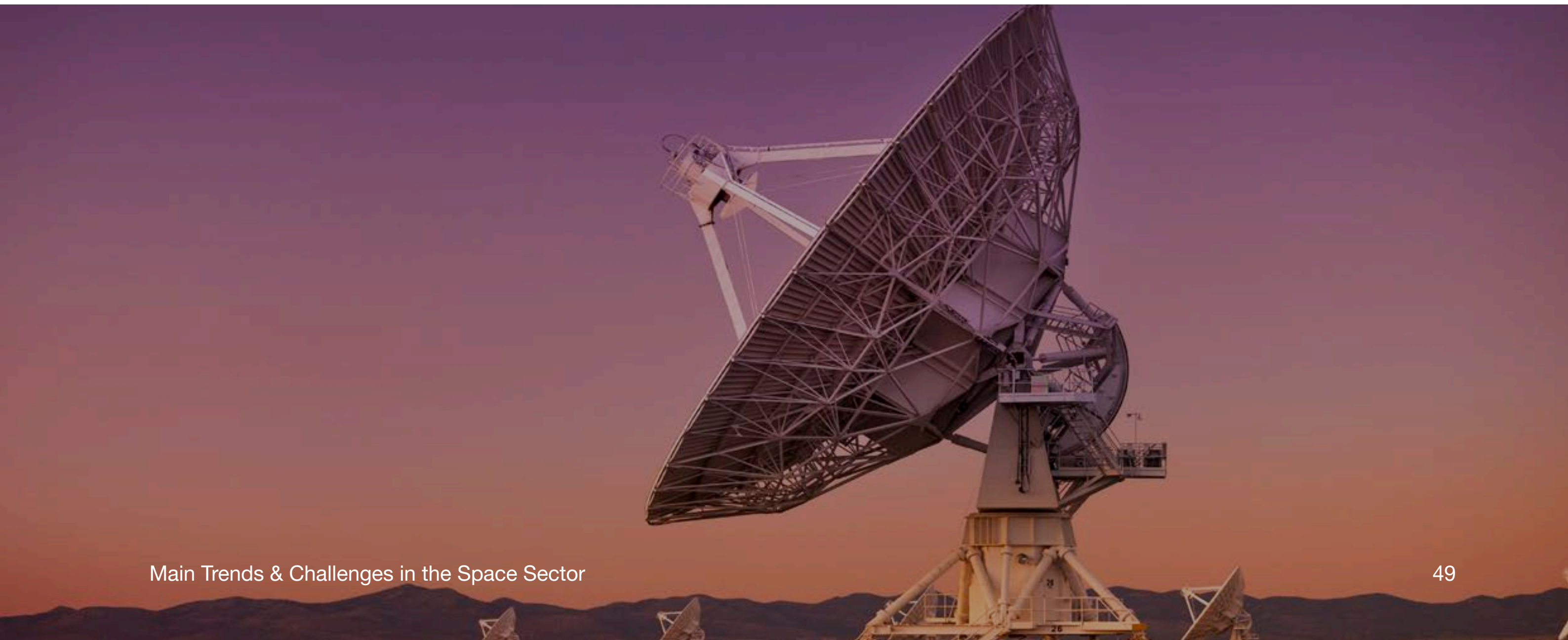
Key trends at a glance

Institutions are increasingly seeking sovereign satellite capabilities for their connectivity needs.

Direct-to-device communication services are on the horizon, spurred by collaborations across tech sectors.

GEO satellite operators are strategically moving to expand their presence in LEO through M&A.

Consumer broadband markets are being increasingly served by LEO operators like Starlink, attracting customers with flexible contracts, competitive pricing, higher bandwidth and reduced latency.

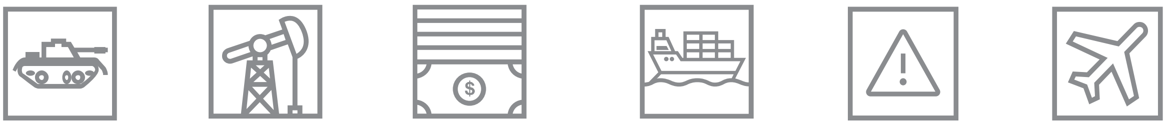


LEO SatCom operators represent the predominant source of supply, outpacing GEO by a factor of six

Overview of the SatCom value chain

Upstream	Midstream	Downstream
Satellite and ground equipment development	**Network/Gateway operators**	**Value-added connectivity solutions**
– Manufacturing and integration of communication satellites – Manufacturing of fixed antenna, mobile antenna, routers, etc.	– Operators of teleport facilities, hub infrastructure – Communication network operators	– Provision of raw satellite capacity to service providers – Provisioning of user-centric and managed services

End Users



Defence Security | Mining & Energy | Financial Institutions | Maritime Logistics | Emergency services | Aviation sector

Key facts and figures

In 2022, there were over **120 active satellites** with a capacity of more than **5 TBps** and an additional traditional capacity of over **12k in 36Mhz TPE**

In 2022, three **mega constellation** operators have **over 3,700 active satellites** in the market, boasting a combined capacity of **more than 30 TBps**

$13bn

Estimated market size for SatCom services in 2022

$25bn

Estimated market size for SatCom services in 2030

The SatCom market is experiencing notable expansion even as it navigates through a condition of oversupply

Supply trends

The market continues to be oversupplied

- Since 2020, LEO capacity has grown 110 times, with fill rates remaining in the single digits.
- Upcoming capacity from LEO was set to reach a CAGR of 20% by 2023, growing from 30 TBps in 2022.

Resurgence of institutionalised SatCom programmes

- IRIS² aims to develop sovereign capacity for the EU.
- The US through SDA is developing the Proliferated Warfighting Space Architecture (PWSA), within which the Tranche 2 (transport layer) is anticipated to consist of 216 LEO communication satellites.

M&A for LEO market access

- Viasat acquired Inmarsat for an estimated $7.3bn.
- Eutelsat and Oneweb's merger was completed for $3.4bn.
- Discussions of a merger between Intelsat and SES were considered, but the proposal did not come to fruition.

Demand trends

Declining demand for video services more pronounced

- In both developed and developing countries, Pay TV is experiencing a steep decline, owing to the surge in OTT platform adoption.
- The hybrid pay TV model with embedded or subsidised OTT subscriptions is dampening the decline.

Household connectivity growing with LEO constellations

- Flexibility and affordability contracts, higher bandwidth and low-latency connectivity drive the adoption of LEO consumer broadband offers.
- The rise of the Amazon Kuiper Project and Telesat Light Speed is poised to intensify competition, in turn stimulating demand further.

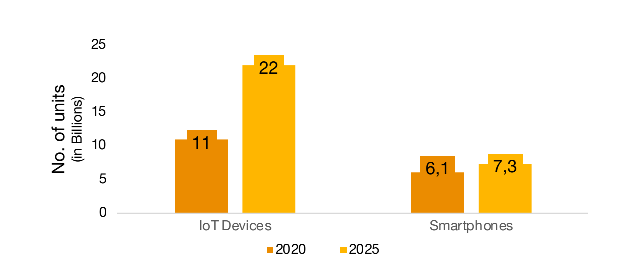
New wave of demand for direct-to-device (D2D)

- Several partnerships between device/ hardware manufacturers, SatCom operators and MNOs are taking shape.
- Near-term use cases include emergency services and low data rate IoT applications, eventually evolving towards roaming services for data and voice, among others.

With backing from MNO and chipset manufacturers, D2D technologies are set to drive the SatCom market towards mainstream adoption

The direct-to-device (D2D) market is expected to create opportunities for SatCom operators, mobile network operators (MNOs) as well as device/hardware manufacturers

- A surge in IoT devices and smartphones is anticipated, presenting a unique chance for MNOs and device manufacturers to offer stand-out products with emergency connectivity features.
- Simultaneously, D2D communication offers satellite operators a significant opportunity to expand their presence in the consumer market, a sector they previously found difficult to penetrate.
- In order to address this market, there are two main partnership types taking shape.

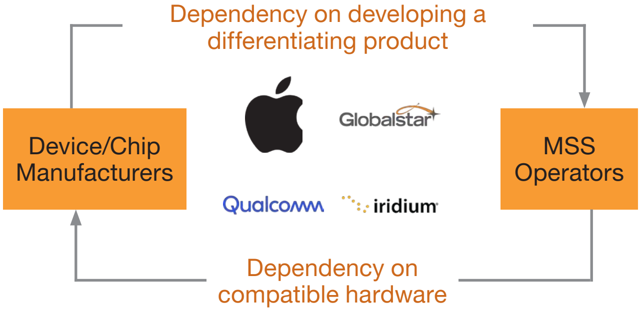


The two main go-to-market options for satellite operators are through partnerships with either MNOs or device manufacturers

Mobile network operators and SatCom operators' partnerships for D2D

- **Regulatory hurdles and interference** are viewed as barrier for the transmission of cellular frequencies from space
- **Timely global market entry** is contingent upon the establishment of several partnerships with MNOs worldwide
- **Backward compatibility** with existing smartphones is a major advantage of this partnership model
- **Upgrades to space assets** are required for constellations such as Starlink

Hardware manufacturers and SatCom operators' partnerships for D2D

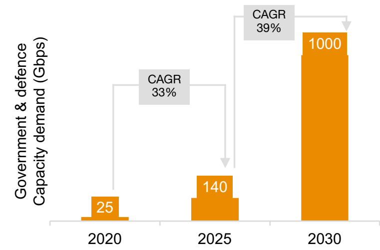


- **Enables swift market** entry as existing MSS spectrum can be utilised on new devices
- **Backward compatibility** with existing handsets limits the market addressability and creates a strong dependency on chipset manufacturers
- **Market cannibalisation risks** for satellite phones may emerge over time, though currently, D2D and satellite phone users are distinct
- **Lack of bandwidth** to expand use cases beyond basic messaging

Sovereign LEO capacity is becoming a strategic dimension for major space fairing nations

The global demand from civil government & defence sector is expected to grow from 25 Gbps in 2020, to 1000 Gbps by 2030, thus growing at a CAGR of 40%

- Recent geopolitical conflict in Europe highlighted the dependency of many countries on commercial providers, particularly those in LEO, who maintain control over critical communications infrastructure. This has prompted both the EU & US to strongly push for sovereign capabilities that address the growing demand for civil government and defence capacity
- China too has recognized the importance of strategic assets in LEO and identifies space-based connectivity as its core priority of focus



U.S Space Force

Proliferated Warfighter Space Architecture (PWSA)

Service Timeline

2024
Initial services

2028
Coverage expansion

2030
Advanced services

Contracts Awarded

+2.5 Bn
In awarded contracts

Contractors

L3HARRIS, NORTHROP GRUMMAN, YORK SPACE SYSTEMS, LOCKHEED MARTIN

European Commission

Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS²)

Service Timeline

2025
Initial services

Mid-2027
Full services

Budget Allocation

2.4 Bn
EU budget allocated

Consortium members

AIRBUS DEFENCE & SPACE, SES, THALES, Deutsche Telekom, TELESPAZIO a LEONARDO and THALES company, EUTELSAT, hispasat, hisdeSAT, orange

SASAC[1]

GUOWANG Constellation

Service Timeline

2028-2029
Initial services[2]

2032-2036
Full services2

Founding Capital

≈10 Bn
Founding capital

Contractors

SASAC

China Satellite Network Group Co., Ltd, owned by SASAC, will design, manufacture, and operate the constellation.

1 State-owned Assets Supervision and Administration Commission of the State Council | 2 Based on submissions to the International Telecommunication Union (ITU) and expected adherence to ITU's satellite launch conditions

The development of mega-constellations is impacting the user terminal and antenna market

Multi-frequency terminals

Multi-beam and multi-frequency terminals allow access to both Ku and Ka-band, and GEO, MEO and LEO satellites are being developed to comply with emerging user needs and requirements.

A growing flat panel antenna market

Flat panel antennas appeal to users supported by mega-constellations as they are smaller and more discreet than traditional antennas, and thanks to the phased array, they offer the possibility to electronically follow satellites while remaining stationary.

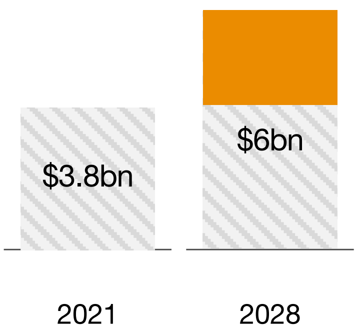
Mobility features for marine and military

Both marine and military domains include a mobility requirement that implies the need for uninterrupted communications. Satellite Communication on The Move (COTM) enables users to sustain communications in vehicles reaching a speed of 130 km/h.

Increased demand for anti-jamming features

A few days prior to the beginning of the conflict in Ukraine, Russia launched a cyberattack jamming the UHF and VHF of terminals in Eastern Ukraine. Both military and commercial demand are expressing more and more the need for anti-jamming features.

Evolution of the Satellite Communication Terminal market



+ 6.5 CAGR projected between 2021 and 2028

Emerging technologies for user terminals and antennas

Phased array

System of computer-scanned and controlled antennas producing steerable beam of radio waves

Meta-materials

Scattering of radio frequency to form holographic beams

Optical beam shaping

Combination of active and passive components to transmit unguided data through air

Source: PwC analysis and InsightsPartners (https://www.theinsightpartners.com/pr/satellite-communication-terminal-market)

Navigation

Key trends at a glance

GNSS is being upgraded with the roll-out of GPS III, Beidou 3 and Galileo Second Generation.

Commercial PNT is becoming a reality with GNSS-independent LEO PNT constellations.

There is increasing institutional interest in LEO PNT, particularly in Europe and China.

More use cases relying on GNSS emerge, particularly regarding safety of life applications like for ILS-independent approaches in aviation.

Satellite navigation is an essential tool that creates value for a range of end users in various domains

Overview of the SatCom value chain

Upstream

Satellite and ground equipment development

- Manufacturing and integration of navigation satellites
- Manufacturing of ground stations, control stations, reference centres, etc.

Midstream

Ground and space segment operation

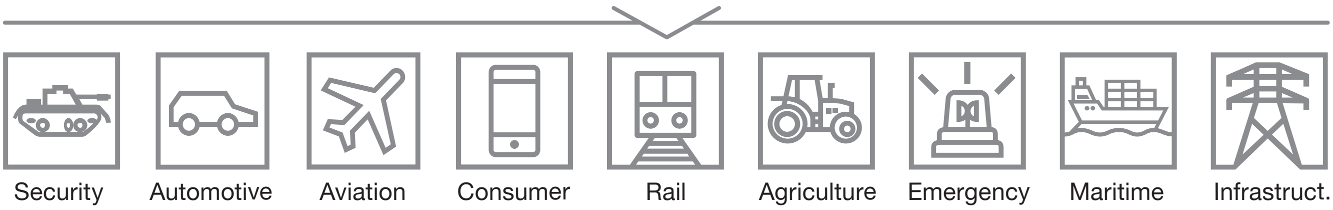
- Monitoring of system integrity and security
- Provision of GNSS services

Downstream

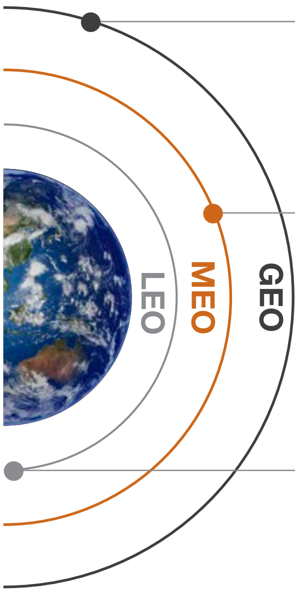
End user receiver manufacturing and services

- Receiver manufacturing and integration (into services or infrastructure)
- PNT exploitation

End Users



Key facts and figures



Both navigation satellites and SBAS in GEO across eight national and various commercial systems

US, Russia, Europe and China operate four GNSSs, totalling over 100 active GNSS satellites

LEO PNT is an emerging technology that is expected to improve the performance of existing MEO GNSS

6.5 billion
Est. number of GNSS devices in 2021

€198.9 billion
Est. value of GNSS market in 2021

10.6 billion
Est. number of GNSS devices in 2031

€492.2 billion
Est. value of GNSS market in 2031

Source: EUSPA (2022)

The supply side is constantly improving itself while new use cases are being generated in the downstream

Upstream trends

LEO PNT constellations begin to launch

- Several actors have launched test and operational spacecraft.
- At least $65m is known to have been invested in LEO PNT. It is expected that the actual investment will be significantly larger.
- The EU, US and Chinese governments have shown interest in LEO PNT.

Advancements in institutional GNSS

- The first ten GPS III satellites have been launched, with the more advanced Block IIIF expected to begin launch in 2026.
- The final batch of Galileo First Generation satellites is expected to launch in 2024, with the Second Generation expected in the coming years.
- BeiDou 3 was completed in 2020, though additional features are incrementally rolled out.

More freely available satellite augmentation coverage globally

- In addition to EGNOS (EU), WAAS (US), GAGAN (IN) and MSAS (JP), China, Korea, Russia, ASECNA, the UK, Australia and NZ are developing their own SBASs.
- PPP services, like Galileo HAS, will offer high precision to users worldwide.

Downstream trends

Consumer devices remain the overwhelmingly largest installed base

- Consumer devices represent over 80% of installed capacity, and this is expected to increase as more of the world buys GNSS devices like trackers, smartphones and watches.
- These devices are increasingly multi-constellation, with a few multi-frequency devices arriving on the market.

Safety-of-life cases demand more from satellite navigation

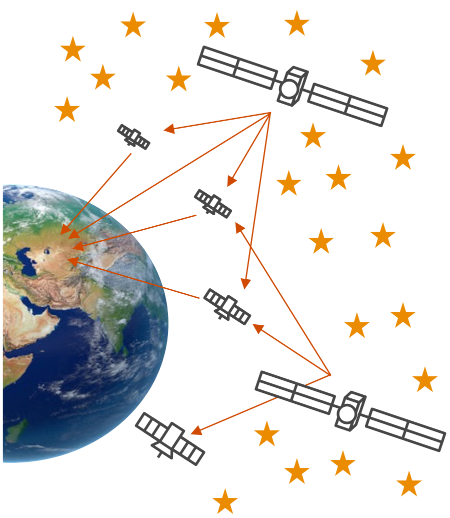
- More stringent requirements are arriving in various safety-of-life use cases, notably in aviation where CAT-1 approaches are increasingly common.
- There is interest from the rail and maritime sectors to use GNSS/SBAS for safety-critical use cases.

Data fusion use cases are more interesting

- In LBS, this includes merging accelerometer data with GNSS to extend the life of wearables.
- In autonomous vehicles, integrating IMU data with GNSS (incl. with Galileo HAS) is an emerging use case.

LEO PNT is an emerging approach to positioning which is based on LEO constellations

LEO PNT



LEO PNT aims to use MEO GNSS to enable a LEO constellation to provide PNT from many fast-moving satellites that are physically much closer to the end user.

This affords several advantages when complementing MEO GNSS with LEO PNT.

- Significantly higher availability in constrained environments and latitudes
- Reduced vulnerability from jamming and spoofing due to higher signal strength
- Increased resilience due to multilayer architecture
- Increased indoor penetration due to frequency/signal diversity and strength
- Ground-independent centimetre level accuracy with very low convergence time
- Can leverage the many LEO constellations as a hosted payload

American efforts

Xona is developing a constellation of 300 CubeSats and has launched test satellites. They are GNSS-independent, with a patented ‘distributed clock architecture’. They target agriculture, construction and surveying.

Trustpoint is developing a constellation of 300+ satellites and has launched one test satellite. They are GNSS-independent and target automotive, aviation, infrastructure and defence.

Satellites has had payloads on Iridium since 2016 and is the only operational LEO PNT service. They serve various domains, including telecom, power grids, financial services and maritime.

The **US Military SDA** is developing the T2TL of the Proliferated Warfighter Space Architecture, a 216-satellite military constellation that may carry a LEO navigation payload.

xona space systems | TRUSTPOINT | Satelles | UNITED STATES SPACE FORCE

European efforts

ESA has approved a LEO PNT infrastructure and will test the concept with ten satellites. The ITT has been launched.

Porsche and VW Group announced their own constellation for autonomous driving in 2021, but there have been no more recent details or concrete plans made public.

Chinese efforts

Centispace will augment BeiDou. It aims for 50 cm precision in 5 seconds and 10 cm in 1 minute. One satellite was launched in 2018.

Geespace, part of Geely, plans a 240-satellite constellation with the modular GeeSAT-1 bus. It is a hybrid PNT EO communication satellite aimed to support autonomous driving, logistics and drones, first in the Chinese market and then globally. Twenty satellites have been launched.

Galileo and BeiDou both offer various differentiating services, pushing their use cases beyond that of traditional GNSSs

GPS

GPS is currently the primary GNSS as most, if not all, receivers have a 'GPS first' architecture. There are an estimated 7 billion GPS devices globally.

- The first block of GPS III is nearly launched, bringing higher accuracy, resilience and new civilian signals (L2C, L5, new L1C).
- GPS High Accuracy Robustness Service (HARS) is being considered to provide PPP and authentication, potentially over the internet.

Galileo

Galileo is the EU GNSS and the only civilian GNSS, offering a range of differentiating features. The constellation counts about 2 billion installed devices globally.

- Freely available global PPP service through the Galileo High Accuracy Service (HAS) broadcast from Galileo over the E6
- Authentication through OS NMA increases resilience
- Search and Rescue Service (SAR) offers a return link, enabling beacons to receive acknowledgment
- Public Regulated Service (PRS) offers increased resilience and service for authorised users
- Downstream uptake supported by EU and EUSPA programmes

BeiDou

As infrastructure, BeiDou is financed and exported under the Belt and Road Initiative, along with other infrastructure projects under the intiative. China leverages its position in the downstream sector (notably in 5G roll-out) to increase BeiDou penetration.

- Short Message Service offers 40 characters outside APAC and 1000 characters within APAC. It can be used in conjunction with BeiDou's Search and Rescue Service.
- BeiDou standards are increasingly disseminated due to global Chinese infrastructure investment
- PPP B2B service offers BDS and GPS augmentation
- Downstream uptake is encouraged through "industrial park" initiatives, such as the BeiDou innovation base in Beijing.

Access to space

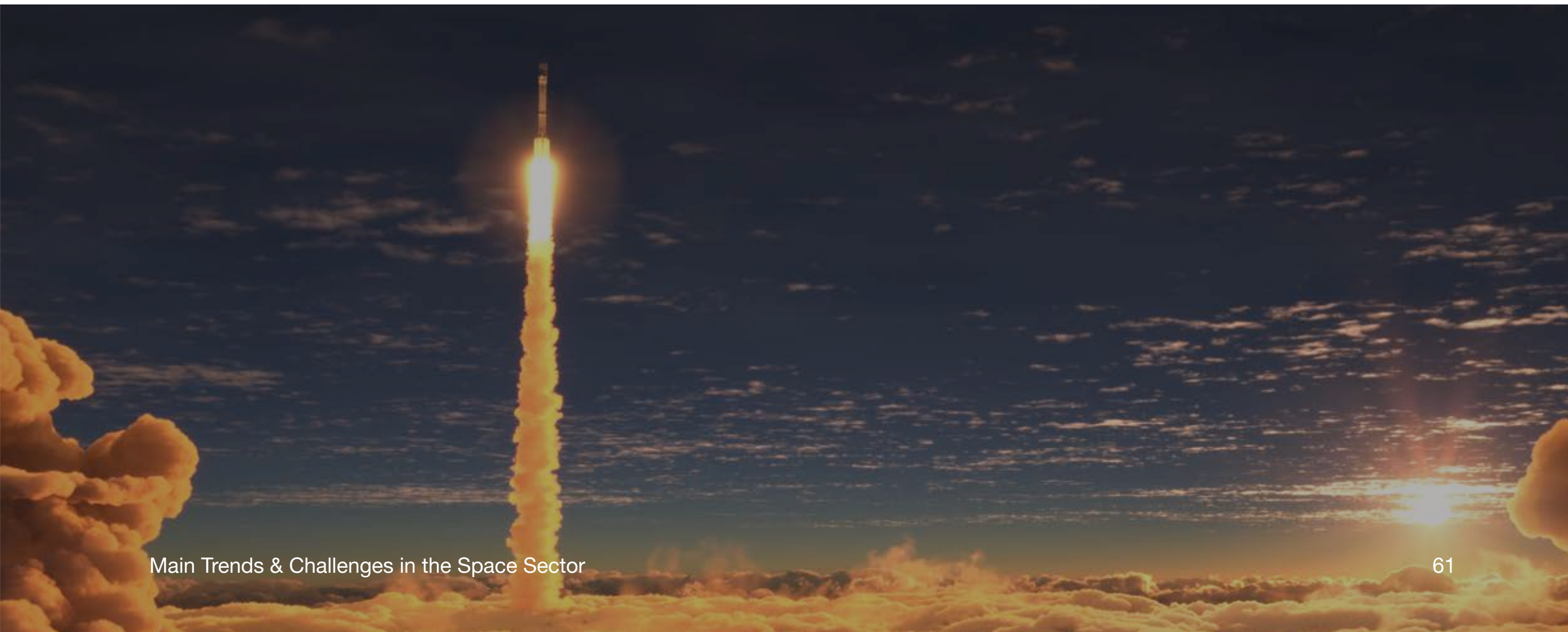
Key trends at a glance

Launcher development remains a highly challenging endeavour as reflected in delays and failures of new vehicles developed by both incumbent and new entrants.

Despite a higher-than-ever launch cadence globally, the sector faces a supply shortage due to the high market concentration, particularly for medium to large payloads.

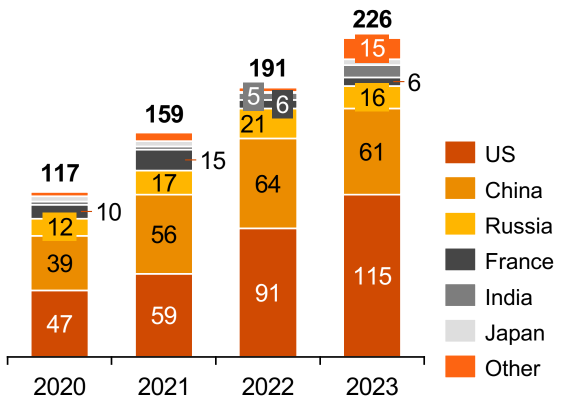
Both legacy players and new entrants, faced with challenging market conditions, need to reinvent their business models to survive.

In the context of strong national ambitions towards non-dependency, micro/small launchers are seen as strategic steps towards autonomy, which mitigates the uncertain market prospects associated with this launcher class.

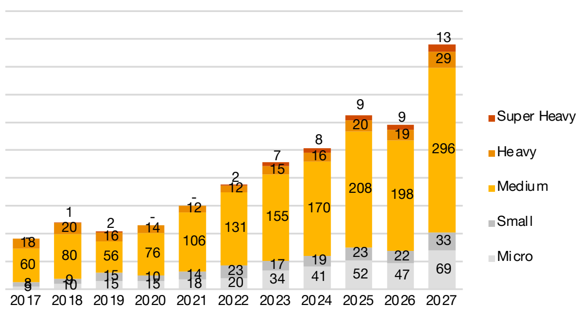


Trends emerging in previous years are confirmed with the US and China reinforcing their market leadership

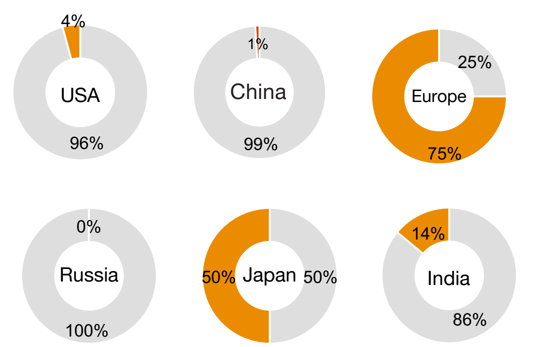
Orbital launches



Historical and Forecasted Launches



Captive and Open markets in 2023



US continues to lead global launch activity amid supply shortage and price increase

The market remains largely concentrated with US and China totalling over 75% of the global launches. The market is expected to continue being driven by medium-lift launchers—particularly by Starlink deployment which aims to reach a staggering 140+ Falcon 9 launches in 2024.

The increase in launch cadence does not prevent a shortage of overall supply with increasing launch delays for satellite operators. In parallel, launch operators have increased their prices, mentioning pressure from historical inflation rates.

Reusability explored by more operators in the wake of SpaceX

Many launch vehicles currently under development are considering reusability. From microlaunchers (i.e. Rocket Lab's Electron) to larger concepts like Blue Origin's New Glenn, reusability is slowly becoming a baseline design choice.

The benefits of reutilisation are not a given for all vehicles due to the performance losses (potentially by two-thirds for a microlauncher), reducing substantially the addressable market. It remains, however, a strategic capability that many industrial and space agencies are exploring in view of their future launchers.

Stimulated interests for sovereign capabilities from global instability

The war in Ukraine has strongly impacted the international supply chain for launchers, affecting not only Russian vehicles but also the availability of components for European vehicles like Vega and Vega-C.

Sovereign access-to-space capabilities are decisive for spacefaring nations to keep control of the deployment of strategic orbital assets. The reliance of Europe on Falcon 9 for the launch of Galileo satellites in 2024 illustrates this risk of dependence.

Maturation of methane engines

2023 has seen the beginning of operations for methane-propelled vehicles with the Chinese launcher Zuque-2, joined in early 2024 by ULA's Vulcan. Methane vehicles are expected to gain momentum with several initiatives under development, including Blue Origin's New Glenn, SpaceX's Starship, Rocket Lab's Neutron, ArianeGroup's Prometheus engine or Avio's engines M10 and M60 for future micro and small launchers.

Both legacy players and new entrants face challenging market conditions and need to reinvent their business models to survive

Access to space remains a challenging market with strong inherent risks for experienced operators as well

Survival tied to large institutional contracts, followed by shift to commercial market

- Eroding market shares with USAF against SpaceX, combined with the exclusion of Atlas V, due to the use of Russians' RD-180 engines
- Internal transformation of the company along with Vulcan Centaur development
- Decisive win of USAF NSSL Phase 2 contracts in 2020, and business plan shift toward commercially driven revenues for Amazon Kuiper

Reminder of technological challenges and risks for new launchers

- Delay of H-III's maiden launch for over two years, undergoing technical failure and loss of satellite
- A reminder of the inherent risks associated with new developments, like the LE-9 engine in this case

Delays on New Glenn and dependence on NASA funding

- New Glenn design initiated more than a decade ago, with a few years' delay on the initial maiden launch
- Financial challenges after the loss of the initial HLS contract in 2018 were compensated by Jeff Bezos' personal investment
- Frontal competition with SpaceX across all market segments: launches, lunar HLS, LEO mega-constellation

The future: emergence of super-heavy launchers, which could disrupt the market

SLS has offered in 2022 the first demonstration of super-heavy capabilities with the Artemis 1 mission. In parallel, SpaceX should continue to test its Super Heavy Starship concept in 2024, aiming at full reusability. In the longer perspective, China is also working on a giant launcher concept with its Long March 9 (CZ-9), which should become operational in the 2030s in support of its lunar ambitions.

Impact of Starship on the market

With its outlying size and performance, SH Starship is expected to disrupt the current levels of pricing per kg.

The business case for the rocket remains unclear but could be suitable to deploy large constellations.

With constellations concentrating over 85% of the addressable market in the coming decade, Starship could heavily reinforce market concentration and the global lead of SpaceX.

The response from governments

Governments try to avoid a monopoly situation in the future by preserving multi-sourcing and by supporting their national actors:

- NASA's $3.2bn contract to Blue Origin for Lunar HLS, partly to avoid dependence on a single provider
- DoD contracts like NSSL awarded to at least two suppliers
- Governmental subsidies by Europe to ArianeGroup

Setbacks and difficulties in European institutional launchers revive national ambitions

A gap in European launch supply

European capabilities for access to space are facing difficult circumstances, with only one vehicle operational since the end of 2022.

- **Delays in the Ariane 6 programme** led to an inaugural launch currently* planned for mid-2024
- In addition, the **failure of Vega-C** in Dec 2022 and issues in investigation tests in 2023 led to only one operational launch vehicle in Europe (Vega) and the absence of medium and heavy launch capabilities since the end of 2022

**As of March 2024*

- The agreement by the European Commission with **SpaceX to deploy Galileo satellites** in 2024 reflects the current dependence of Europe on foreign launchers
- The future of Ariane 6 and its commercial success, initially driven by a target cost of €70m per launch, is increasingly **dependent on the availability of public subsidies to support ArianeGroup**, as illustrated by the recent request from its mother companies Airbus and Safran.

A turn towards national ambitions

In this uncertain context, various member states are pushing for what can be seen as nationalist strategies in parallel to ESA-governed activities.

- In 2023, Italian manufacturer Avio was allowed by ESA to market and operate **its own launches of Vega vehicles**, previously in the scope of Arianespace along with the Ariane family
- In addition, Avio announced the development of a **new national vehicle**, developed with sovereign funds, leveraging its development efforts on M10 methane engines to create a medium-class launcher. There are not enough details on its performance, and it remains unclear how this will combine with European plans for the future Vega-E.

Several EU member states like France, Germany, the UK and Spain also **try to promote national champions** for microlauncher vehicles, which could fill the gap left at the international level.

- With 15+ actors announcing their ambitions in this market segment, it is unlikely that many will survive. Time-to-market and cost competitiveness will be decisive for these players
- European microlauncher operators combine investments from public organisations (COVID-19 recovery funds in France and Italy, UKSA investment in HyImpulse and Orbex), private investment rounds (€330m to date for ISAR, €30m in 2023 for RFA, €42m to date for Latitude) and mother companies (ArianeGroup, OHB).

European collaboration remains an important component of microlaunchers' success.

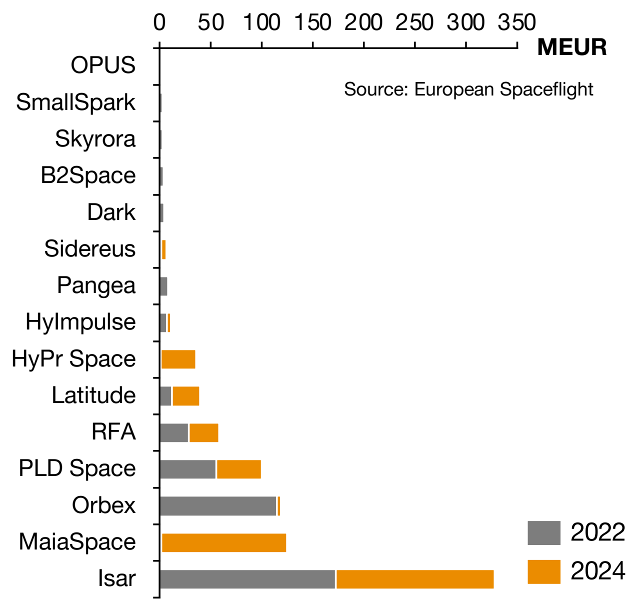
- National ambitions on microlaunchers are **supported by ESA and EC**, which provide respectively funding and support through the **Boost! Programme**, and space start-ups earmarked investments in VC
- European cooperation is also **decisive for spaceports**, with several states ramping up their capabilities to host these new actors and agreements signed, for instance with Andoya's (Norway), SaxaVord (UK) or Kourou (French Guiana).

Microlauncher projects and space launch infrastructures are seen as entry points in the access to space domain

Microlaunchers

- For several competitors, developing microlaunchers is seen as a stepping stone into larger vehicles.
- There is a large increase in European launch start-up funding in 2023 and the beginning of 2024.
- Infrastructure for launch is already in place in Europe and projected demand is high, conferring importance to first-mover advantage.
- Recent investments predict more maiden flights in the future.
- The success of the first flight is decisive, with failure leading to financial pressure, as exemplified by Virgin Orbit's bankruptcy following a failed launch attempt
- ESA is progressively opening the door to new European launch companies, putting out contracts for the future supply of ISS.
- A dedicated launch business model pressured by cheaper ridesharing options is offered by SpaceX, with companies investing in availability, flexibility and customisation.

Funding received for each launch startups



Spaceports

- Microlauncher launch infrastructure is ready in Europe, but due to the lack of active vehicles, the market is open for capture.
- A streamlined regulatory and licensing framework is a differentiating factor.
- Launcher companies are negotiating the use of launch pads (exclusive or not), but deals are volatile and final configurations have yet to crystallise.
- Delays from the launcher side may leave some spaceports struggling to stay open with an absence of revenue.

Highlights

- Swedish and Norwegian spaceports inaugurated in 2023
- In the UK, Spaceport Cornwall saw the failed launch from Virgin Orbit and Saxavord Spaceport became licensed
- German offshore spaceport announced suborbital launch in early 2024
- Portugal had its space legislation approved, while Spain saw the launch of Miura-1 from El Arenosillo
- Contracts awarded for the rehabilitation of the Diamant launchpad in French Guyana
- 20 registered spaceports in the US, 15 of which are FAA licensed
- China has completed a new commercial launch pad in Hainan
- Oman unveiled plans for a new spaceport
- MoUs signed for launch from Arnhem Space Centre in Australia

Suborbital space tourism has yet to gain momentum, while commercial space stations offer moderate prospective tourism opportunities

Suborbital tourism revenues to remain driven by rockets and spaceplanes

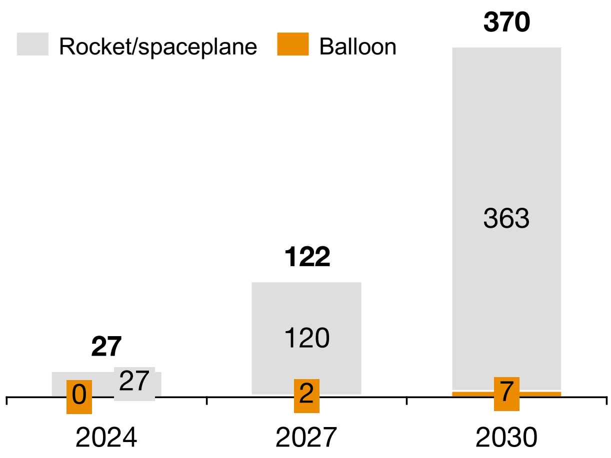
Suborbital rocket and spaceplane tourism is stalling but offers sizeable opportunities in the medium term

- Blue Origin's New Shepard was grounded for 15 months following failure in 2022.
- Virgin Galactic's commercial flights were winded down to one per quarter in 2024, followed by a flight incident in Jan 2024.
- The recent resumption of Blue Origin's flights and Virgin's plans to develop a new spaceplane vehicle suggest positive market perspectives.

The larger customer base but cheaper ticket price of balloons (one-tenth of rocket and spaceplane) implies a marginal market share

- Stratospheric balloons aim at a different demographic and different space experience: smooth flights with no training required, a longer and more comfortable experience, accessible through more affordable tickets for flights with lower altitudes of 30 km.
- Space Perspective, the lead prospect, is planning for a first commercial launch in 2024, while World View is still developing its crewed version but faces a delayed SPAC merger.

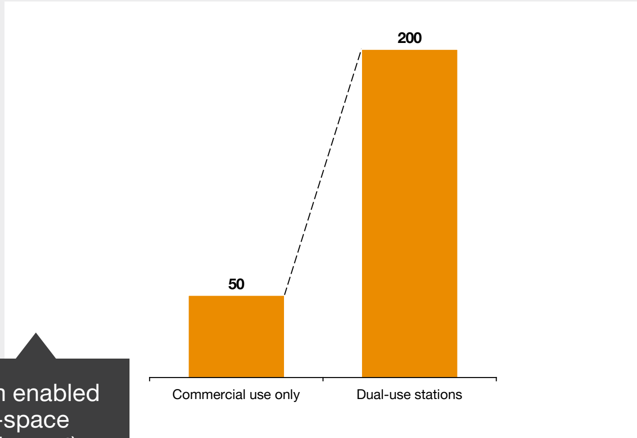
Suborbital market size ($m)



Orbital tourism to remain a niche market

- Historical space tourism, involving private individuals financing their ticket to the ISS, began in 2001 with Dennis Tito and cumulated 13 passengers in 20 years.
- Since May 2022, Axiom Space has boosted the pace of orbital tourism with three fully private missions to the ISS aboard SpaceX's Crew Dragon. However, ticket costs in the 10s of $m remain a critical barrier to market growth. The progressive reduction of launch costs should contribute to improving the situation.
- With the advent of commercial space stations, 'dual-use' business models serving both institutional and commercial customers could further contribute to creating more affordable conditions.
- Overall, the market should remain niche, largely due to its non-recurrent demand ('once-in-a-lifetime').

Impact of space stations business model: serviceable customer base for orbital tourism (cumulated, up to 2040)



Launch cost reduction and subsidisation of private tourism enabled by post-ISS institutional and commercial customers (in-space manufacturing, R&D, technology demonstration, entertainment)

Space safety

Key trends at a glance

The surge in small satellite deployments is exacerbating space traffic in LEO, threatening sustainability and underscoring the need for robust space traffic management.

The value chain for space safety measures spans data collection to service provision, involving a mix of established entities and emerging participants.

Cooperation in the field of space safety is still contingent upon balancing the sharing of data with the safeguarding of sensitive information.

The global imperative to maintain a secure space environment requires recognition and action on space debris by all spacefaring nations and industry players, including NewSpace entities initially unfamiliar with such concerns, to uphold the security and reliability of space activities.

Space debris are non-operational man-made objects that have lost their capacity to be independently deorbited

Orbit	Number of objects
LEO Below 2,000 km	19694
MEO Between 2,000 and 36,000 km	511
GEO & GTO 35,786 km	2136
Other EGO, NSO, LMO, MGO, HEO	10199

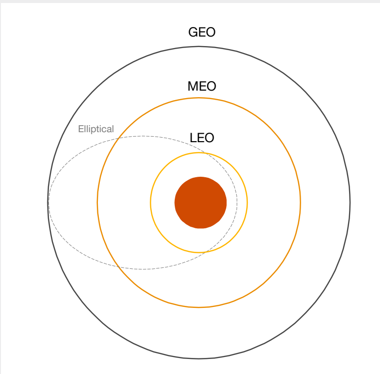
32540

observed objects orbiting Earth

2022

The number of spacecraft launched and of associated space operations is rapidly increasing, especially in LEO where the deployment of constellation projects is expected to significantly increase. Such expansion of space traffic is driven by the development of small satellites that is perceived as a real market opportunity. The increasing volume of space objects is jeopardising the sustainability of the space environment and driving the need to consider space traffic management systems.

Source: ESA's Annual Environment Report, Number of objects orbiting Earth (2023)



Orbit	Operating satellites
Elliptical	41
LEO	8408
MEO	149
GEO/GSO/GTO	582

9180

operating satellites

as of Mar 2024

Source: UCSUSA, PwC analysis

What can be done?

- Implement pragmatic, applicable and binding guidelines for debris mitigation in new missions.
- Monitor and reduce collision risks for active and debris objects.
- Develop technologies for active debris removal.

The EU Space Law is expected to enhance debris mitigation and orbital safety

The upcoming EU Space Law is a significant step towards sustainability in space, with a strong focus on mitigating space debris. By establishing uniform regulations to prevent the generation of debris and enhance the safety of space operations, this law aims to ensure the long-term usability of space for all. This proactive approach promises a cleaner and safer orbital environment, vital for the continued success of space activities.

From data collection to service provision, the value chain of space safety activities is populated by both established and new players

Data collection

Raw data about space objects are gathered (surveillance/tracking of objects). Involves the use of ground-based radars, telescopes or space-based sensors, such as satellites, space debris and other space objects.

Database management software

Management of collected data via specialised software. Involves the storage, organisation, updating and maintenance of the collected data. Ensures that the data is accurate, accessible and secure.

Analysis software

Usage of analysis software to interpret data, predict trajectories, detect possible collisions and perform other analytical tasks to understand the current and future situation in space.

Service provision

Delivery of services based on analysed data. Includes alerting satellite operators of potential collisions, assisting with satellite manoeuvre planning and providing data for scientific research or commercial use.

Data providers

- SDA
- ExoAnalytic Solutions
- LeoLabs
- ArianeGroup
- North Star
- ALDORIA (former Share My Space)

Database management software

- AGI
- Applied Analytics Solutions
- Omitron
- Solers
- ExoAnalytic Solutions
- Schafer
- A.I. Solutions
- Lockheed Martin
- LeoLabs
- ArianeGroup
- ALDORIA (former Share My Space)

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A trade-off between sharing data and protecting sensitive information still conditions cooperation in this domain

The security paradox

Data sensitivity

SST information is often highly strategic, as the surveillance and tracking of objects imply that SST operators may detect sensitive S/C.

Duality of removal activities

Space debris removal capabilities can, in principle, be used to damage and disable other satellites.

Strategic benefit of independence

1) Maintaining an independent SST capability ensures that a nation has access to data regardless of their international situation.

2) Independent SST capabilities can be shared with other entities in sharing agreements, but the owner of the network can decide on the amount shared.

3) Maintaining independent capabilities enables a nation to verify information provided by other nations. In the earliest examples of collisions, all claims were made by the US.

4) An independent SST network can support national security initiatives and defence.

Resulting challenge

Collaborative efforts are highly important to attain a

global catalogue of space debris.

It is important that nations also maintain an independent SST capability and not rely solely on their allies for information.

The issue of space debris is a global concern necessitating a common and international alignment

Recognising the collective space debris issue

The preservation of a safe space environment is a global concern affecting everyone. Therefore, the issue of space debris must be recognised not only by all spacefaring nations but also by all actors involved in the value chain of space activities.

Data sensitivity must be solved

Defining a proper international network for data exchange to solve the issue of data sensitivity will be key towards the development of an efficient and sustainable space traffic management system.

Supporting a sustainable model for ADR

In order to support the long-term development and operations of active debris removal activities, suitable and efficient business models must be identified. Instigating and framing active debris removal solutions must be led to support the safeguarding and sustainability of the space environment.

Educating new players

Some NewSpace players that have initially developed practices and processes from non-space sectors may not be aware of the issues related to space debris. Supporting new players in the adoption of best practices ensures that the security and reliability of their activities will contribute to the reduction of threats caused by space debris issues.

Enforcing legal measures

The legal enforcement of mitigation and prevention measures will incentivise satellite manufacturers and operators to play by the rules and further ensure space sustainability. However, legal regulations should not prevent commercial space players from developing their activities.

Beyond Earth economy

Key trends at a glance

The growing satellite population in Earth's orbits and the maturation of lunar exploration programmes lead to new opportunities for in-orbit support services.

Debris management gains in criticality and reinforces the relevance of deorbiting services, with some uncertainties regarding the business model for such services.

Lunar exploration opens opportunities for revenues to commercial actors, but the market remains exclusively driven by institutional actors and investors remain cautious, particularly regarding upstream services.

The commercialisation of space exploration creates economic and strategic opportunities ranging from LEO to the lunar economy

Beyond Earth economy

The beyond Earth economy has historically been driven by space agencies funding exploration missions into outer space and the operation of orbital stations until now with the ISS. The rising global interest in **establishing a sustainable human presence** on the lunar surface and the pressure on space agencies' financial resources call for a progressive reallocation of the agencies' means and opens opportunities for increasing involvement of the commercial sector to maintain orbital capabilities. As a result, the Beyond Earth economy covers an ensemble of activities where the private sector will be able to capture more and more opportunities in the coming years. "While the activities are to be institutionally driven, commercial actors will be able to provide multiple services to support the agencies, **including**:

In-orbit servicing (IOS)

Driven by the drastically growing number of satellites in space, leading to an imminent debris crisis, and by the need to decrease costs for satellite operators.

Commercial players can provide different types of spacecraft servicing activities, namely:

- Spacecraft life extension, e.g. refuelling and maintenance
- Space tugging
- Active debris removal
- Space situational awareness

$14.3bn

Estimated cumulative IOS revenues between 2021 – 2031, including satellite servicing, ADR and SSA*

Orbital space stations

Driven by the need to sustain orbital station activities following the anticipated retirement of the ISS.

Addresses in particular the astronaut programmes and micro-gravity experimentation, both for scientific research and for commercial purposes (in-space manufacturing, research, entertainment and marketing)

$556m

Cumulative NASA funding awarded to commercial space station consortiums**

(Cis-)Lunar economy

Driven by strategic and policy objectives set by international space agencies to develop a sustainable human presence and research bases around the moon and on its surface.

While the activities are to be institutionally driven, commercial actors will be able to provide multiple services to support the agencies:

- Lunar transportation
- Lunar communications and positioning
- Space resources utilisation

$142bn

Cumulated market for lunar transportation and in situ resources up to 2040 ***

Status quo

In-orbit servicing (IOS)

- First demonstration mission MEV-1 launched in 2020 by Northrop Grumman
- Technology maturation beginning with space tugging and in-space SSA applications

Orbital space stations

- ISS retirement currently foreseen in 2031
- Operational Chinese station with astronauts on board since 2021
- Ongoing development of the commercial SS concepts by four US-led consortiums, following funding from NASA, that are all planning for a launch and beginning of operations between 2027 and 2028

(Cis-)Lunar economy

- First Artemis mission (uncrewed) successfully conducted in lunar orbit
- To be followed by Artemis II crewed lunar orbital mission (planned in 2025) and Artemis III crewed lunar landing around 2027

NSR report 2022, In-Orbit Services: Satellite Servicing, ADR and SSA, 5th Edition; **Orbital Reef, Axiom, Northrop Grumman, Starlab; * PwC, Lunar Market Assessment, Market trends and challenges in the development of a lunar economy, 2021*

In-orbit servicing gains maturity in technology demonstration but with some market opportunities still to be confirmed

In-orbit servicing activities

Mission management	Modification of spacecraft positioning (precise orbit injection) or prolongation of mission lifetime through interventions on the spacecraft: refuelling, maintenance and refurbishment of critical parts. Requires proximity operations to approach, grapple, dock and connect with the satellite.
SSA	To complement ground capabilities, space awareness allows operators to monitor spacecraft orbital surroundings to detect and monitor objects and improve collision avoidance calculations. Also allows to react to potential spying threats.
Deorbiting	When a spacecraft reaches its end of life and must be deorbited by changing its orbit through an external vehicle's action. Can apply to operational satellites or to orbital debris—rocket stages or other (large enough) inert infrastructures.

Market drivers

- SSA remains the most ubiquitous service needed across GEO and non-GEO satellites
- Constellation models and an overall increase in the number of satellites drive general opportunities for precise orbit injection
- While still non-binding, some guidelines are increasingly driving debris mitigation by operators: US Space Policy Directive (2018) or the EU Strategy for SSA and STM (EU 2021-2027 Space Programme)
- In addition to safety aspects, suspected spying activities have been detected around sensitive satellites, stimulating the needs for in-space SSA capabilities

Market challenges

- Technology developments are still at an early stage, with first demonstration missions just launched and technological challenges still to be overcome
- Business cases' viability and market attractiveness are still to be confirmed for some applications like repairing
- Deorbiting and debris removal remain unclear with respect to the mission sponsors (governments or others)
- Absence of a binding and harmonised legal framework at the international level creates uncertainty about the future rules to be followed by operators
- Largest revenue opportunities on GEO life extension (one-third of the market) but highly concentrated on a few missions per year globally

Illustrative IOS missions

2020	2021	2024	2025	2026	
Northrop Grumman	Astroscale	NASA	Astroscale	ClearSpace	Thales Alenia Space, D-Orbit
Mission Extension Vehicle-1 (MEV-1) demo on Intelsat GEO satellite	Astroscale demo mission for its magnetic capture system (ELSA-d)	Cancellation of OSAM-1 refuelling and servicing mission due to costs overrun	Astroscale demo mission for end-to-end debris removal mission	ClearSpace-1 active debris removal demo mission on Vega payload adapter	Multipurpose IOS servicer: refuelling, repair and replacement, orbital transfer and reentry

With the ISS decommissioning, commercial players are working to enter a market still driven mostly by science and research activities

The present: ISS

The International Space Station's life is coming to an end, with an **envisioned decommissioning in 2031.** Intergovernmental treaties and agreements have established the ownership and use of the station, and so its retirement will lead to challenges and opportunities for actors in different domains and segments.

Challenges

- **Deorbiting the station** will require significant financial efforts from all its members
- **Human presence in LEO** could be interrupted or be limited to Chinese capabilities if other stations are not ready when the ISS is decommissioned
- **Business case uncertainties** question the viability of multiple co-existing commercial stations

Opportunities

- Retirement of the ISS does not imply the interruption of institutional astronauts' presence in LEO, providing an **opportunity for sustained revenues** for commercial stations
- New business strategies and **opportunities will arise** as a consequence of commercialisation of the market
- NASA released in Sep 2023 the request for proposal for the **United States Deorbiting Vehicle** (USDV)

The future: market and initiatives

The context leads to the advent of many initiatives, as the market is promising:

Total addressable market for commercial space stations is between **€15bn** and **€40bn** cumulatively in the 2025-2040 timeframe. This means between €1bn and €2.6bn of revenue per year.

Astronaut accommodation will represent around **66%** of the market revenues

Experiment hosting will represent around **22%** of the market revenues

Space tourism will represent around **11%** of the market revenues

United States

Axiom Station
Currently operating some flying missions to the ISS, Axiom signed MoUs with several countries and is planning to attach a commercial module to the ISS which will then become a free-flying station in the future.
Programme: NextSTEP
Funds: $140bn

Starlab Station
Voyager Space is leading the consortium and owns NanoRacks. Recently, AIRBUS joined the partnership as technical partner, and Northrop Grumman abandoned its project to join Starlab and provide cargo transportation.
Programme: CLD
Funds: $217.5bn

Orbital Reef
The main actors of the consortium are publicly announcing a shift in priorities: Blue Origin on the Lunar Lander; New Glenn, New Shepard and Sierra Space on the LIFE habitation module and Dream Chaser.
Programme: CLD
Funds: $172bn

Vast
Vast is developing an artificial gravity spinning station and will launch with Starship.
Programme: CCSC-2
No funds

Think Orbital
What attracted NASA's interest is their will to demonstrate in-space welding.
Programme: CCSC-2
No funds

China

The Tiangong station is the only station in orbit besides the ISS.

- It is composed of three modules (Tianhe, Wentian and Mengtian) but a multi-functional **expansion module with six docking ports** will be launched soon.
- The CMSEO has been looking at **fostering the future commercial use** of the Tiangong station.

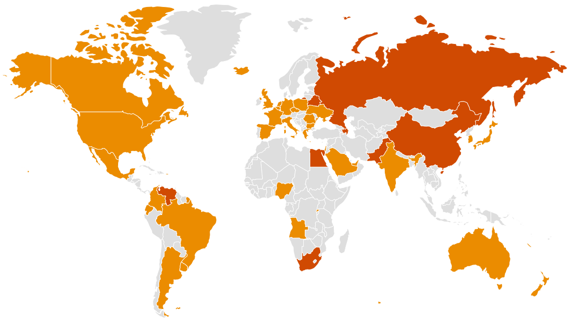
Europe

ESA is more involved in the sector:

- Terranovae 2030+ strategy includes the **SCIHAB** concept for stimulating the industry and recently a competition has been announced to develop commercial cargo vehicles.
- In addition, ESA has **signed a MoU with Starlab** to evaluate future uses of the station for the agency.

The lunar market is strongly driven by governmental initiatives, but the private industry is stimulated to grow

Lunar exploration agreements map



Artemis Accords (US) signatory members
ILRS (China) signatory members

US initiatives

The **Artemis programme** includes Orion spacecraft, SLS, Gateway, Human Landing System and Artemis Base camp. The other main initiative is the **Commercial Lunar Payload Services** (CLPS)

Artemis programme:
~$60bn (2012-2023)

Artemis I was successful (2022), but Artemis III may shift to 2027

36 Artemis accords parties as of 7 December 2023

European initiatives

EU strategy involves heavy support to and reliance on the Artemis programme

Main projects: Moonlight, Lunar Pathfinder, Argonaut lander, Orion European Service Module

China's initiatives

The **International Lunar Research Station (ILRS)** programme will establish a lunar base, with a planned astronaut on the moon before 2030.

Agreement with eight countries and six organisations as of 7 December 2023

Chang'e missions are operative and working. Queqiao-2 missions for lunar communication launched in March 2024

Lunar value chain

Value Chain	Moon logistics	Enabling life on the moon	Moon exploitation
Activities	Transportation to/from the moon; transportation on the moon	Communication and navigation, energy and power, supplies and services on the moon, construction and manufacturing, habitation and storage	Agriculture and food on the moon, lunar resource extraction
Players Non- exhaustive			

Considerations

- The market is institutionally driven, and investors are not yet ready to fund moon-related business models
- Business cases are immature, and companies are diversifying their business models with more reliable products and services (propulsion, in-orbit servicing, etc.)
- Logistics, communication and ISRU are the most populated subsegments

Recent success in lunar landing: India became the fourth country and Japan the fifth to land on the lunar surface

India

The Indian Space Research Organisation (ISRO) has successfully landed its Chandrayaan-3 Lander Module on the surface of the moon in Aug 2023. India has made history as its lunar mission becomes the first to land in the lunar south pole region. This successful landing made India the fourth country to land on the moon, after the US, the former Soviet Union and China.

Landed on the lunar south pole

- Chandrayaan-3 made history by becoming the first country to reach the lunar south pole.
- The lunar south pole has long been of interest to space agencies and scientists because the region is thought to hold greater concentrations of water ice.
- Due to its rugged terrain, this attempt at landing on the lunar south pole was assumed to be highly challenging.
- On the mission before this, Chandrayaan-2's lander crashed on the moon's surface in 2019. India made use of the experience and achieved this successful outcome.

India's low-cost space programme

- The success of India's Chandrayaan-3 has not only proved India's growing space capability but also underlined its characteristic feature: the surprisingly low costs.
- The total cost of the Chandrayaan-3 mission is estimated at only $74m or about Rs. 600 crores (according to the Indian Government), which is far lower than the cost in other countries.

Japan

SLIM, Japan's Smart Lander for Investigating the Moon, landed on the lunar surface on 19 January 2024. The Japan Aerospace Exploration Agency (JAXA) mission succeeded in demonstrating highly accurate landings that can boost the scientific value of missions. This successful landing made Japan the fifth country to land on the moon.

The 'pinpoint' landing technology

- SLIM is a small-scale exploration lander designed for pinpoint landings on the lunar surface and investigation into the Moon's origin.
- The spacecraft accomplished this precision landing using an optical navigation system loaded with maps built using data from Japan's lunar orbiter (SELENE).
- The preloaded images were matched with data collected during SLIM's descent, allowing it to locate itself and guide the spacecraft to its target landing site.
- This landing technology could enable the future exploration of hilly lunar poles seen as a potential source of fuel, water and oxygen, JAXA said.

Exploration robot with toy technology

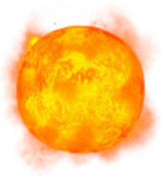
- Right before landing, SLIM also deployed a couple of small, unconventional rovers: LEV-1 and LEV-2.
- LEV-1 and LEV-2 are the world's first fully autonomous lunar exploration robots, and LEV-2 is also the world's smallest and lightest robot.
- Tomy Co., Ltd., one of the Japanese leading toy companies, was involved in the development of LEV-2, which is called 'SORA-Q'.
- SORA-Q was released as a sphere and instantaneously expanded and deformed to the left and right.
- The inspiration for transforming the robot's shape came from a toy company's technology.

India and Japan | Lunar Polar Exploration Misson (LUPEX)

- After 2025, the Lunar Polar Exploration (LUPEX) project is scheduled to be carried out jointly by India and Japan, the leading participants in the Artemis project.
- In this joint exploration, India will develop a lunar lander, and Japan will be in charge of developing a rocket and a lunar rover. The Indian lander successfully landed on the lunar south pole in 2023, and Japan's H3 rocket which is planned to be used in this project was also successfully launched in Feb 2024.
- The LUPEX project will investigate the 'polar region' of the moon, an area that is thought to have the potential for the existence of water resources.

Deep space exploration missions target various celestial bodies in the solar system, with several objectives. Studying Mars remains the primary focus

Main deep space mission update (non-exhaustive)



Sun

Aditya (2023)
In 25 January 2024, it reached the L1 point successfully and is now studying the sun's characteristics and interplanetary magnetic field.

Proba-3 (2024)
Two satellites will study the sun's corona and surrounding atmosphere.

Mercury

BepiColombo (2018)
On te way to the fourth Mercury flyby in Sep 2024, the two probes in the missions will reach Mercury in Dec 2025.

Venus

DAVINCI (2029)
The Deep Atmosphere Venus Investigation of Noble Gases, Chemistry, and Imaging (DAVINCI) probe would explore the atmosphere of Venus.

Envision (early 2030s)
A mission that will investigate Venus from its inner core to its upper atmosphere.

Earth and near Earth objects

Hera (2024)
The objective is to perform a survey of Dimorphos and Didymos, after the DART mission's impact.

JWST (2021)
Successfully launched and with science operations started, the JWST is studying the history of the universe with the 6.5m primary mirror.

Mars

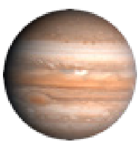
Other Mars active missions:
The Perseverance and Curiosity rovers are still operating, together with the Mars reconnaissance orbiter and Odyssey Orbiter. The INGENUITY helicopter ended its mission in 2023.

Mars Sample Return (2027/8)
The mission is postponed, and it received a budget cut of $300m, followed by the NASA JPL layoff of 530 employees in 2024.

EXOMARS (2028)
The mission has been postponed due to the war in Ukraine as it involved ESA and ROSCOMOS.

MMX (2026)
JAXA project to explore the two moons of Mars and collect samples.

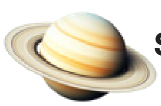
Mangalyaan 2 (2024)
JAXA project to explore the two moons of Mars and collect samples.



Jupiter

JUICE (2023)
Launched successfully in 2023, it will make detailed observations on Jupiter and its three moons: Ganymede, Callisto and Europa. Arrival at Jupiter is expected in Jul 2031.

Europa Clipper (2024)
It will study the Jupiter moon's ice shell and ocean, as well as its composition and geology during some flybys.



Saturn

Dragonfly (2027)
Dragonfly will be a plutonium-powered drone capable of vertical takeoff and landing and will have the objective of studying a variety of locations on Titan for possible habitability.

Policy, regulations and governance

Key trends at a glance

National space legal frameworks are gaining significant importance. Both legacy and emerging space nations are revising or adopting space laws and regulations to keep pace with the sector's evolution, and differentiation in regulations has become an attractiveness lever for countries.

Sustainability of space activities, one of the three pillars of the upcoming EU Space Law, is now a key item in space policy and regulatory initiatives.

The development of norms and standards for space exploration—particularly moon exploration—can be influenced by increased participation in initiatives such as the Artemis Accords and the Chinese/Russian-led International Lunar Research Station project.

Space agencies are adapting to recent changes in the space sector dynamics by increasing private-public partnerships, modernising their ways of working, reorganising internally as well as prioritising environmental, social and governance (ESG) topics. This also entails a gradual shift toward more decentralised governance to account for the growing reach of space at the government level.

Domestic regulation of space activities is impacted by international laws

International laws

Outer Space Treaty (OST, 1967):

State supervision and responsibility

Non-appropriation of space and freedom of exploration

Non-militarisation of space and disallowance of weapons of mass destruction

United Nations resolutions:

Multiple principles including some on Direct Broadcasting (1982) and Remote Sensing (1986)

International conventions, including:

1972: Convention on international liability for damages caused by space objects

1975: Convention on the registration of objects launched in outer space

1979: Agreement governing activities on the moon and other celestial bodies

UNCOPUOS guidelines:

2010: Space Debris Mitigation Guidelines

2019: Space Activities Sustainability Guidelines

International Telecommunications Union (ITU):

ITU Constitution and Convention

ITU Radio Regulations and Frequency Allocations

Bilateral/Multilateral agreements, including:

2023: Artemis Accords (36 nations signed so far)

Regional space working groups

Agreements between space agencies and space corporate entities (i.e. SpaceX/NASA agreements)

Domestic laws and regulations

Compliance with international laws and guidelines

- Space debris mitigation
- Environmental protection
- Liability to third-party and space insurance
- Safety of humans and properties
- Authorisation and registration

Domestic laws directly affect the regulation of the operation of space objects

The operation of space objects

- Sounding rockets and sub-orbital launches
- Uncrewed orbital launches
- Crewed orbital launches
- Operation of satellites

PwC is partnering with the Sirius Academic Chair to develop the **Space LegalTech platform,** a free platform mapping space policies and legislations around the world.

Find out more at https://spacelegaltech.com

Regulatory differentiation has become an attractiveness lever for space nations

Space regulations are mostly country-specific

States that have enacted national space legislation have taken **highly divergent approaches:**

- Some countries have a **general national space act,** while others have **several legal acts dedicated to specific space operations** and related issues.
- **States have defined their legal/regulatory framework according to the state of the national space industry,** actual commercial space activities, or national governance.
- The governance and namely the allocation of responsibilities between the different competent governmental bodies **is country-specific (cabinet office, a ministry, an agency or even several agencies).**

Levers for attractiveness

Regulatory levers can impact the attractiveness to space players of a country in several ways.

Space regulation levers include:

- procedure duration
- application fees
- insurance amount to be underwritten by applicants.

Traditional regulatory levers include:

- tax law
- corporate law (including bankruptcy law)
- economic law in general impacts the ease of doing business.

Elements affecting the attractiveness of a licensing/authorisation process

Duration of licensing procedures

- Duration of procedures can vary from one to over six months.
- Agencies are now trying to reduce that duration via dynamic processes and feedback loops.

Pre-consultation processes

Yes / No

- Pre-consultations can shorten application delays.
- They become a tool of attractiveness for space agencies.

Inter-agency process

Yes / No

- Inter-agency processes increase application delays.
- Efforts in harmonisation of procedures are observed.

Fast-track procedure

Yes / No

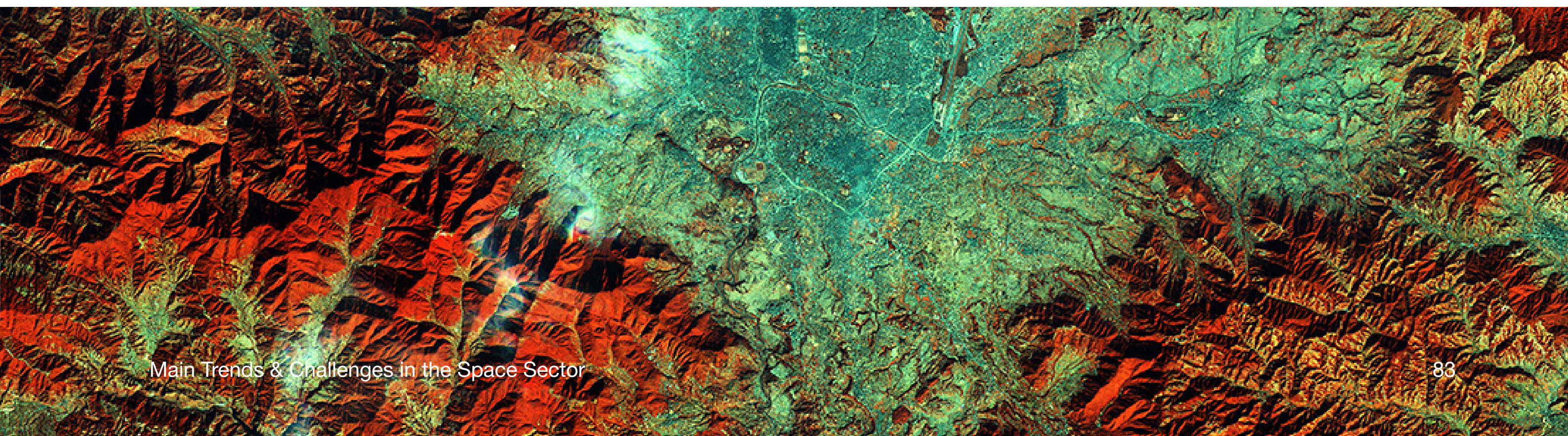
- Fast-track procedures shorten application delays.
- This has become particularly relevant in the SmallSat era.

Insurance requirements

- They can be tailor-made or sometimes be fixed at more than $60m.
- They may have deterrent effects for smaller businesses.

Fees

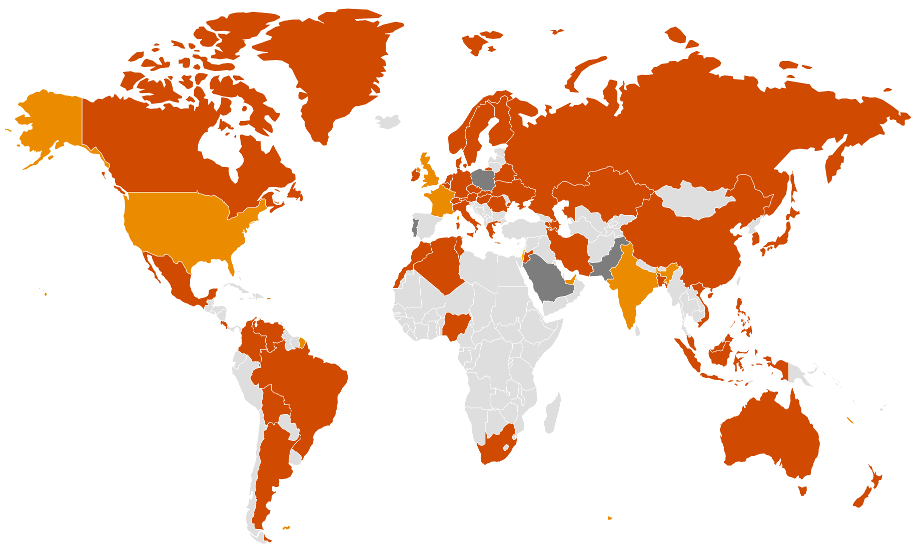
- They can be tailor-made or sometimes be fixed at more than $6k.
- They may have deterrent effects for smaller businesses.



Updates across nations refine space licensing, oversight and innovation

The number of space law initiatives is steadily increasing, reflecting the growing importance of legal frameworks in addressing the complexities of activities in outer space.

National space laws map



Countries having adopted a space law or space-relevant regulations before 2024

Countries officially in the process of making major revisions to their space law as of 2024

Countries known for being in the process of adopting a first space law

Focus on notable regulatory developments

United States

A frontrunner in space regulations, the US has recently brought up major evolutions or proposed evolutions to their space regulatory framework, including:

- a proposed draft bill assigning **oversight for new space activities** between the Department of Transportation and the Department of Commerce
- a proposed draft bill on the **regulation of orbital stations and orbital human spaceflight activities.**

In addition, the US has decided to **extend the moratorium on space tourism in order to continue the incentivisation** of the sector, which is currently experiencing a renewed dynamism with the expected resumption of Blue Origin and Virgin Galactic's tourism spaceflights along with the arrival of new players with stratospheric balloon technologies.

Japan

Japan has set itself as a regulatory innovator with the preparation of **guidelines and safety standards for on-orbit servicing missions.** These will clearly **support the country's ambitions in the domain,** including that of key domestic players like Astroscale or iSpace, the latter having recently entered a partnership with US-based Orbit Fab for in-orbit refuelling services.

India

While already an established space player for several decades, India has recently refreshed its space strategy (2023) and **understood the importance of benefitting from a comprehensive regulatory framework for proper business attraction,** one that should be developed in the coming months.

The Middle East shows dynamism in space policy and regulations

Middle Eastern countries are making the space sector a decisive industry in their post-oil and gas development strategies, with a strong potential for synergies via the Gulf Cooperation Council (GCC)

Qatar:

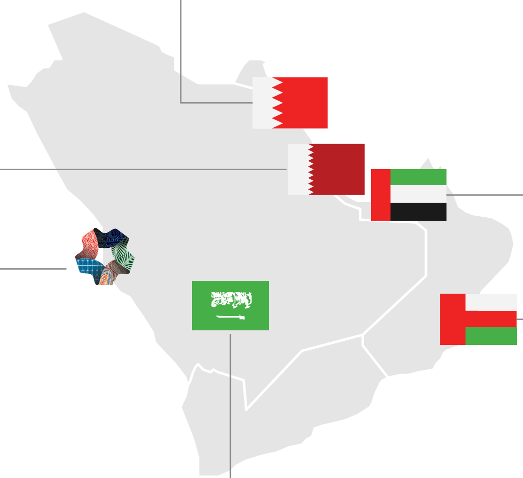
The country has recently announced a strategic partnership on SSA with the US Space Command

Bahrain:

The country's NSSA has so far been focussing on providing downstream services to its citizens, including satellite imagery, and has signed several MoUs with leading partners.

United Arab Emirates (UAE):

A first mover in the region, the UAE adopted its space law in 2019 and has recently published a set of detailed regulations (2023). The country now has an active space programme with successful exploration missions and has started attracting several space businesses.



NEOM (KSA):

A specific territory within KSA, NEOM has bold ambitions for space and is developing strategic plans for the sector that should include space tourism activities as well as immersive experiences that take advantage of its lunar or Martian-like landscape. NEOM is planning on being a cluster for space business activities, leveraging its investment capabilities.

Kingdom of Saudi Arabia (KSA):

KSA is currently in the process of adopting both a space strategy and a space law, along with detailed regulations that should foster business attraction in the Kingdom. Its regulator, CST, has been recognised as a trusted partner by the ITU, and the Saudi Space Agency partners with agencies worldwide. The country can also count on its financial capabilities via its Public Investment Fund (PIF).

Oman:

Oman is currently building plans for a spaceport to leverage is geographical position. The initiative should soon be accompanied with associated regulations in order to start attractive potential launch customers.

The EU Space Law will aim at setting common rules related to space activites

The EU Space Law is expected to contribute to the building of a true EU single market for space

A law to bring legal predictability to space players

By providing a uniform framework, the EU Space Law seeks to **mitigate the current fragmentation** caused by varying national space legislations.

A regime applicable regardless of the player's nationality

The EU Space Law aims at creating a **competitive advantage for the European industrial ecosystem.** Its provisions are therefore intended to be applicable to every company conducting activities in Europe, including companies from third countries. **The rules would be the same for European and non-European players to foster fair competition.**

The EU Space Law will cover three pillars in line with the current evolution in space regulations

Safety pillar: The goal is to limit the risk of collision and damages to space objects and their surroundings.

Resilience pillar: The law will seek to bring coherence and consistence in the protection of EU and national space infrastructures and assets against harmful threats, notably cyberattacks, increasing the collective level of resilience across the Union.

Sustainability pillar: Ensure long-term sustainability of space activities and foster climate-neutral activities to guarantee fair and equal use of space in the long run.

The EU Space Law is expected to be voted on after the next EU election taking place in Jun 2024

Sep 2023
Van Der Leyen letter of intent mentioning a space law for the EU

Nov 2023
Closure of the targeted stakeholder consultation

2024
Expected proposal of the EU Space Law

Voting for the EU Space Law

Space sustainability is at the core of several policy and regulatory initiatives

The increase in space activities and pressing collision threats have urged the entire space community to act in order to devise a framework that paves the way for a more sustainable space environment. While efforts have largely been led the UN through its Space Debris Mitigation Guidelines (2010) and Long-term Sustainability of Outer Space Guidelines (2018), national or organisational initiatives are now emerging, contributing to the global mobilisation for a sustainable space environment.

The UK launches a framework for the private sector

Astra Carta outlines collaboration between businesses and the Government for sustainable space activities. It calls for a review of UK regulations, the creation of a space sustainability standard and funding for a space debris removal programme.

The Net Zero Space Initiative for space traffic issues

This platform brings together stakeholders from the space industry and beyond to highlight the urgent need for the protection of the orbital environment. Since 2022, it has been developing policies for space sustainability and space traffic issues.

The Paris Peace Forum highlights the importance of proper governance to solve space debris issues

To manifest the importance that space debris is now taking in the international cooperation landscape, the Paris Peace Forum dedicated to global governance allotted a fraction of its yearly discussion to the issue, showcasing initiatives like Net Zero Space.

SSC updates its guidelines for satellite operators

The "Best Practices for the Sustainability of Space Operations" aim to reduce collision risks. It introduces rules of the road for coordinating manoeuvers, specifying 'give way' rules for different object classes. However, these rules are not a substitute for operator coordination.

The US FCC imposed a fine on a company for failing to relocate space debris. This sets a precedent for enforcement, sending a clear message to industry to prioritise debris removal. It may also inspire other countries to adopt similar enforcement measures.

Dynamic shifts in international cooperation around space exploration

The Artemis Accords offer an increasingly attractive framework for cooperation while seemingly making the idea of space resources utilisation mainstream

- The Artemis Accords set up the scene for global cooperation in space exploration, science and also commercial space activities.
- The Accords reinforce that space resource extraction and utilisation can be conducted and is often perceived as a progressive and soft move towards greater acceptance of such activities despite ambiguities of international treaties like the Moon Agreement or the Outer Space Treaty.
- By being the first country to withdraw from the Moon Agreement to subsequently join the Artemis Accords, KSA might be showing that there is a shift to a preference for non-enforceable principles over international space treaties, potentially impacting international cooperation.

ARTEMIS

Artemis Accords membership grows: **36 nations in total (Dec 2023)**

Signatories from across all continents, including both major and emerging space powers

Amid a new space race, the Chinese and Russian-led International Lunar Research Station (ILRS) project plans on offering an alternative to the Artemis Accords

- ILRS members expand, including China, Belarus, Pakistan, Azerbaijan, Russia, Venezuela, South Africa, and Egypt.
- New partners: Asia-Pacific Space Cooperation Organization, nanoSPACE AG, International Lunar Observatory Association, and National Astronomical Research Institute of Thailand.

CNSA

ROSCOSMOS

Increasing participation in both projects can influence the development of norms and standards for lunar exploration

Space agencies are changing their way to play to adapt to a rapidly evolving scenario

In an era marked by rapid **technological advancement** and **geopolitical uncertainty,** space agencies find themselves at the **forefront** of a **new frontier.** They grapple **with a myriad** of **challenges** as they strive to **push the boundaries of exploration and innovation.**

New collaborations

Constrained by budgets and escalating costs, space agencies are forging **private-sector partnerships** to accelerate projects, heralding an era of **heightened efficiency.** Collaborations **with start-ups** infuse fresh perspectives and technical prowess, driving pioneering advancements despite resource constraints. They broaden **talent pools** but also **foster a culture of innovation. International collaboration** between space agencies remains **pivotal.** Yet, this transformative shift necessitates **more adaptability, urging space agencies to evolve** alongside dynamic collaborations and emerging challenges.

Modernisation efforts

Potential threats, such as **cyberattacks** or **space debris,** increase in different fields. Space agencies are **enhancing defences** and risk mitigation efforts, **emphasising global collective action.** From research to business and policymaking, the applications of **space data are many.** As the space enterprise **holds invaluable data** that can revolutionise various **industries, space agencies** are prioritising **open access** to this data, **enabling widespread accessibility.**

Moreover, confidence in space programmes' **integrity** is vital, **focussing on responsible conduct and inclusivity** and i**nspiring trust** and **confidence** among the public.

Internal reorganisation

Space agencies are undergoing comprehensive **internal reorganisations** to **adapt** to the evolving landscape and embrace a **new working paradigm.** This shift emphasises the need to **become leaner, more agile** and **flexible,** prompting agencies to **overhaul operational structures** for **enhanced efficiency** and **effectiveness.** At the heart of this transformation lies the **streamlining of bureaucratic procedures.** The aim is to **eliminate redundant processes** and **bottlenecks** that **impede swift decision-making** and hinder progress. Consequently, agencies are **reassessing workflows and flattening organisational hierarchies/ structures,** empowering personnel at all levels to make nimble decisions. Furthermore, space agencies are actively **promoting commercialisation within the sector** and embracing cutting-edge **digital tools** and **processes** to modernise **project management** and **communication practices.** Leveraging technologies like cloud-based **collaboration platforms, virtual reality simulations** and artificial intelligence-powered **analytics,** agencies **enhance collaboration,** information sharing and decision-making across geographically dispersed teams.

Climate change and ESG

As **humanity confronts the crisis of climate change, space agencies are vital** in addressing these topics. **Advanced satellites** are deployed to **monitor the Earth's climate, empowering scientists** to better understand and **prepare** for future changes. Additionally, they **develop innovative technologies** for **climate mitigation,** collaborate on **evidence-based policies** and prioritise **internal sustainability practices** to reduce environmental impact.

Space agencies are also increasingly prioritising **ESG principles in their operations.** Integrating ESG considerations into their **ethos** and **decision-making** processes promotes responsible resource stewardship, **inclusivity** and **equity** within the workforce, laying the foundation for a **more robust and socially responsible space industry.**

An increased decentralisation at the country level takes place with space agencies being complemented by other entities in space governance

Space agencies are required to assume new roles in relation to an evolving space environment

- The **space sector is increasing its outreach into downstream industries** and associated value chains.
- This **leads to the concept of Space Economy,** generally defined as the ensemble of core space activities and all enabled revenues, services, benefits and applications into the broader economy.
- With an increasing number of industries concerned and potential users, there is an increasing need to **structure country-level governance in a way that maximises the growth of the Space Economy.**

Transitioning of the space agency concept

From mainly technology and space assets development and procurement agencies…

…to entities looking at market development, market needs and economics as well

Transition towards a more distributed governance

Other ministries and agencies with broader scope, or with non-space sectorial scope, taking up some role in the Space Economy

Need for tighter coordination at the country level

A movement for the decentralisation of space agencies

There is an increased movement for the 'decentralisation' of space agencies that is progressively creating ad hoc entities, including business accelerators that focus on specific domains and activities.

Examples include the ESA Business in Space Growth Network (BSGN) that includes accelerators in Life Sciences, Advanced Materials, Food & Agriculture and a Space Resources accelerator as its most recent addition. The BSGN accelerators model has also been expanded to other domains.

This organisational structure adds flexibility to the operational way of working of space agencies, a feature that is more suitable to the new dynamics of the space sector.

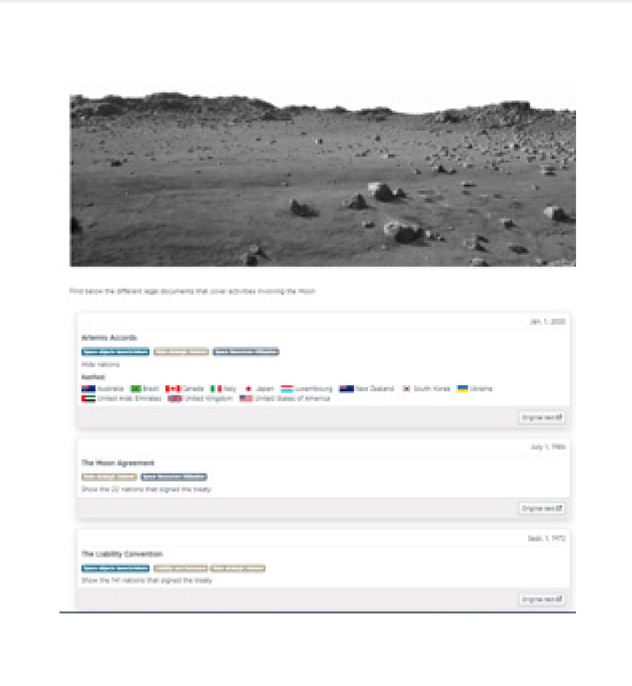
Through our Space LegalTech platform, we display a unique understanding of the space regulatory landscape

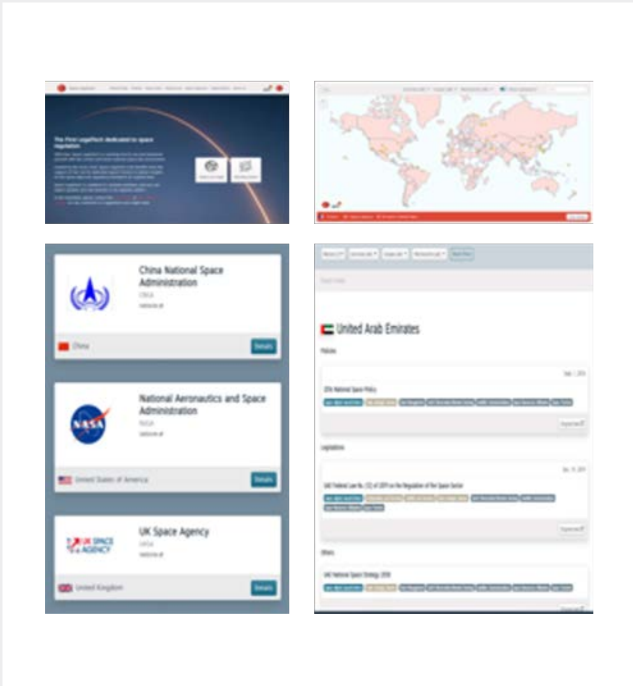
Policy/Regulatory insights

- **Space LegalTech's objective is to map global space policies and regulations,** offering an interactive user interface that allows users to pick a country of their choice and discover all its enacted space laws and regulations as well as the treaties it ratified.
- **Policies and regulations are classified based on the type** of legal/regulatory document, the activities they regulate, or the type of legal mechanisms used.
- The platform **also adds international treaties and the regulation of lunar activities.**
- Space LegalTech is a **partnership with the well-established Sirius Academic Chair in Space Law from the University of Toulouse-1 Capitole.**

Non-regulatory insights

We've also added information about spaceports including their location and type of activities covered. In addition, major space agencies and their licensing procedures are mentioned, along with major international space organisations (incl. their member countries).





The Space LegalTech is a constantly evolving platform, and you can expect new features to be included in the future: https://spacelegaltech.com

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This document includes the following images:

- Berlin (Pag 17): Copernicus Sentinel data (2015), ESA
- Planet Earth (Pag 19): EUMETSAT/ESA
- Namib Desert (Pag 24): KARI/ESA
- NGC 5468 (Pag 39): NASA, ESA, CSA, STScl, A.Riess (JHU/STScl)
- Sahara Desert (Pag 43): JAXA, ESA
- Galileo Satellite (Pag 55): ESA, P. Carril
- SSA-NEO (Pag 67): ESA, P. Carril
- NGC 604 (Pag 69): ESA, NASA, CSA, STLcl
- GAIA (Pag 70): ESA/GAIA/DPAC
- Kathmandu (Pag 83): Copernicus Sentinel data (2015), ESA

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