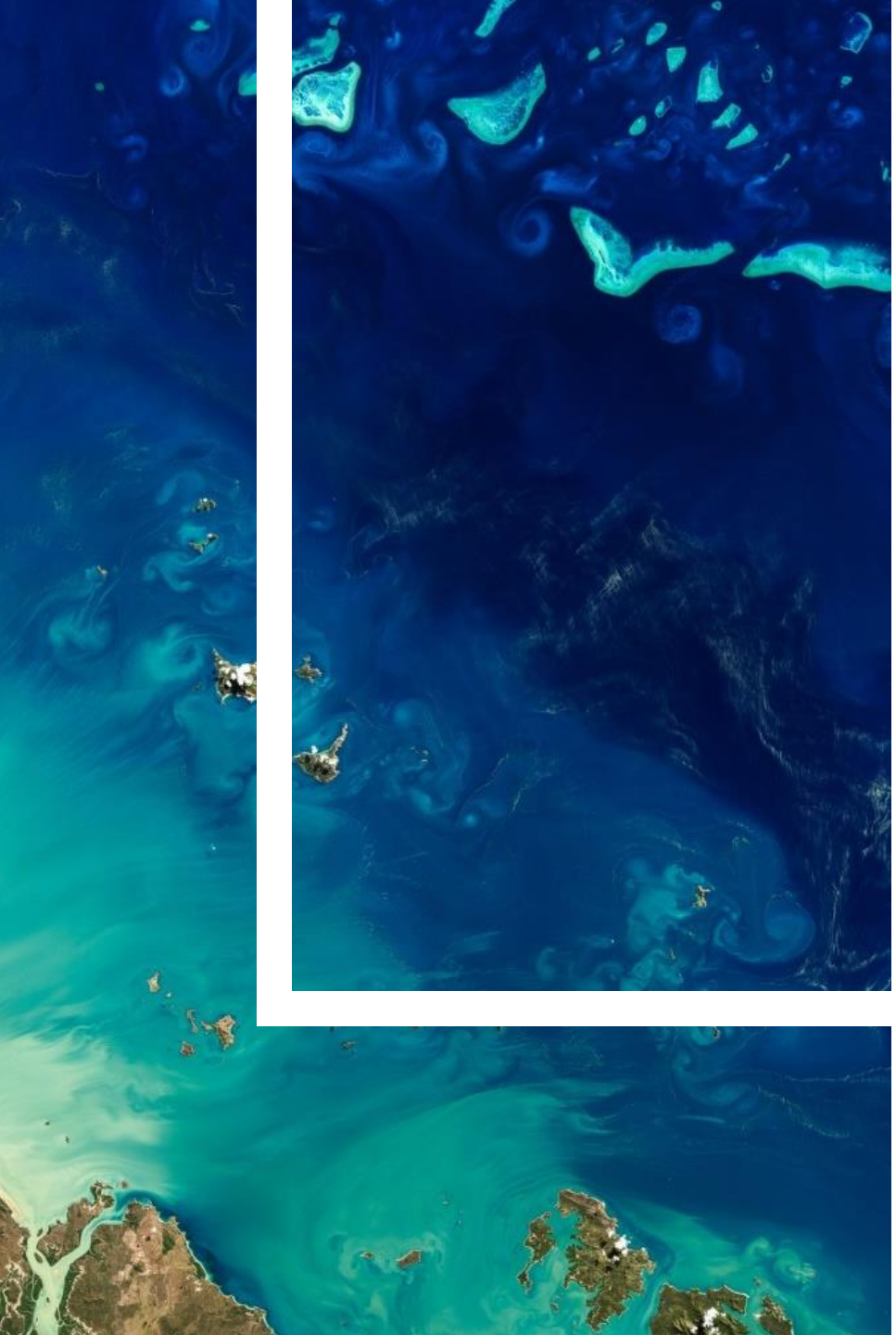
Main Trends & Challenges in the Space Sector

2nd Edition

December 2020

pwc



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The PwC/Strategy& Space Practice in 5 points

1 With a global reach, and **a dedicated strategy and policy team based in Paris and Toulouse**, the PwC Space Practice is unique among large professional services firms. It combines focused space expertise with a significant reach into the broader downstream.

2 The core space team is currently involved in assignments for public and private entities in **Europe and worldwide**.

3 Our core team notably works on **strategy assignments** (e.g. market sizing, go-to-market, business plan development, commercial due diligence, etc.), **commercial due diligences** and support to M&A**, socio-economic impact assessments** related to public investment in space, **analysis of governance & organizational structure** (at programme, company or country level) and **regulatory analysis** (e.g. impact of existing & prospective regulations, assessment of regulatory requirements in the cycle market-regulation, etc.)

4 With the PwC Data Lab – an entity from PwC France specialised in the development of innovative applications – **we provide services (PwC Insights from Space) using space data to public and private decision-makers** (often non-familiar with the space-based data derived capabilities).

5 The PwC Space Practice is **part of the wider PwC Aerospace and Defence network** which is composed of more than 2,000 consultants in the world.

Recent publications

04/11/20
Market perspectives of Ground Segment as a Service

Market perspectives of Ground Segment as a Service
November 2020
Provides a comprehensive understanding of GSaaS, its current context, market and its potential evolution in the future. It explores the market drivers that could impact the GSaaS market in the future and assesses their potential impact.

02/10/20
International space conference 2020

Trends and challenges in the space sector
October 2020
On the occasion of the Indian International Space Conference, we have published a report on the current trends and challenges in the space sector, with a specific focus of the Indian space industry.

06/05/20
Resilience of the Space Sector to the COVID-19 Crisis

Resilience of the Space Sector to the COVID-19 Crisis
April 2020
Provides an assessment of the impacts and resilience to the COVID-19 crisis of the various domains in the space sector.

05/03/20
Emerging space nations: supporting sustainable development and economic growth

Emerging Space Nations
March 2020
Provides an understanding of the role of emerging space nations in supporting sustainable development and economic growth.

The space sector is driven by complex macro-level dynamics that go beyond simple market forces, requiring an holistic view

The "Main Trends & Challenges in the Space Sector (2nd Edition)" provides PwC Space Practice views on major trends and dynamics impacting the civil and commercial space sector globally.

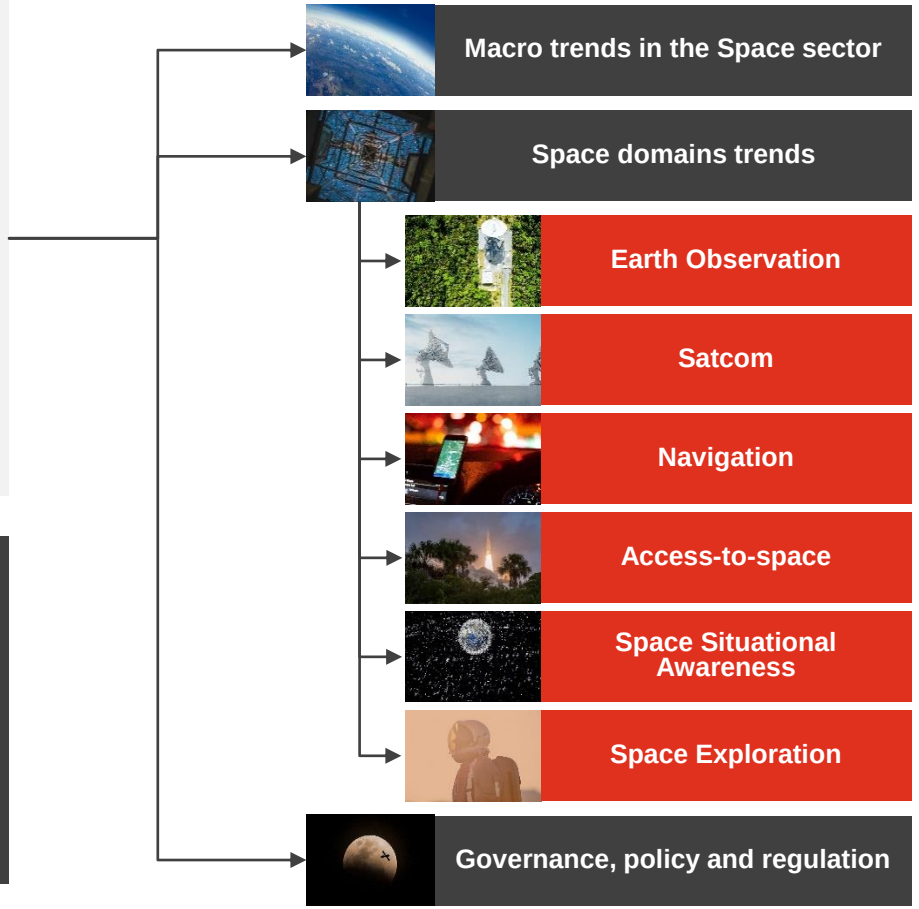
The document is organised into 8 sections: an introduction to macro trends impacting the space sector; 6 dedicated chapters per space domain; and a closing section on governance, policy and regulation.

Disclaimer on Scope

The present document focuses on ***civil and commercial space***, only providing some minor pointers touching military space.

As such, it should not be considered comprehensive or representative of trends related to military space and defence.

A separate piece of thought leadership dedicated to space and defense is currently being prepared by PwC.



A sector with multiple specificities

- Multiple domains with different trends and specificities
- An ever evolving regulatory and policy environment
- A significant reach and implications into other industrial sector, with subsequent dependency on general macro-trends
- Considerable wider societal and economic impacts, justifying the still prevalent government spending in the sector

Source: PwC analysis ; Image Credits: CNES, Arianespace, NASA

Space is experiencing significant mindshare growth, as well as increasing implications in multiple downstream industries

Upstream

Technology push – Applications

System & infrastructure → Operation

User demand pull – Services

- Launch systems and vehicles
- Satellite AIT and manufacturing
- Ground segment systems and network equipment (e.g. gateways, VSAT, etc.)
- Launch service provision, satellite and ground segment operation

Example of companies (non-exhaustive)

AIRBUS, ThalesAlenia Space, SPACEX, BLUE ORIGIN, arianespace, Raytheon, KSAT, AAC CLYDE SPACE, TELESPAZIO, gmv, NORTHROP GRUMMAN, SSC, MOMENTUS, BOEING, SPACEFLIGHT, LOCKHEED MARTIN, NSSLGlobal

Downstream

Data & Processing → Advanced products & services

- Data and satellite services (direct-to-home, broadband, navigation, etc.)
- Value-added services
- User equipment (e.g. GNSS devices and chipsets, TV dishes, radio receivers, etc.)

Example of companies (non-exhaustive)

AIRBUS, planet., INTELSAT, OneWeb, MAXAR TECHNOLOGIES, CLS, ECHOSTAR, SES, Telesat, ICEYE, eutelsat, KYMETA, SATELLOGIC, kinéis, Viasat, e-geos, septentrio, SONY, sky, orange

End users

- Consumer, industry, governments, non-profit organisations
- A variety of sectors (energy, infrastructure, agriculture, marine, defence and security, Location-Based Services, etc.)

Examples (non-exhaustive)

METEO FRANCE, YARA, Google Earth, Pokémon GO, Google Maps, Uber, Panasonic, Indufor, aramco, FarmersEdge, TESLA, FSE Center on Food Security and the Environment, AMNESTY INTERNATIONAL

Key take-aways

- The space value chain is evolving, with the traditional upstream driven technology push (upstream creates new applications for the downstream market to follow) transitioning into a market demand pull (downstream drives space systems development with needs for new services)
- Space has attracted an important number of actors in the past decades, with New Space and non-space companies entering the different streams of the value chain
- Space retains its status as a halo sector, with positive impacts and spillovers over a large pool of end users, in the global economy

Source: PwC analysis

Sizing the global space economy is a complex exercise due to the lack of a unified taxonomy and difficulties in setting up boundaries

Measuring the space economy

- Space is not recognised as a category in international standards of industrial classification. Therefore, **worldwide market sizing studies differ in definition, coverage and methodology**. This makes it difficult to compare the results in global estimates.
- The **boundaries between space and non-space activities are often blurred**, leading to different ways of assessing the overall space economy. This is specifically critical when setting the boundary between the downstream space industry and end-user economy: as the analysis moves down the value chain, the **assessment of the direct causal relationship** (called *paternity*) **between the space industry and the benefits brought to end-users become complex to isolate and accurately measured.** Indeed, benefits derived from space tend to only represent a tiny part of the value created for end-users.
- Given the above, when considering global and regional figures related to space market sizing, **it is extremely important to understand what they encompass in their perimeter**.

Sources	Market estimate	Notes on the assessed perimeter and granularity
pwc	**USD 371 Bn** *(2020)*	• **Upstream (USD 23 Bn):** launch services; satellite manufacturing • **Midstream (USD 40 Bn):** ground infrastructure & operations; fleet ops • **Downstream (USD 226 Bn):** consumer equipment, space services • **Institutional budgets (USD 82 Bn):** research & science; space exploration; military; etc. Source: PwC, 2020

SPACE FOUNDATION	**USD 423.8 Bn** *(2020)*	• **Commercial revenues (USD 336.9 Bn):**
		  • Space infrastructure (USD 119.2 Bn);
		  • Space products & services (USD 217.7 Bn);
		• **Governmental spending (USD 86.9 Bn).**
		Source: Space Foundation, 2020

BRYCE space and technology	**USD 366 Bn** *(2019)*	• **Satellite Services (USD 123 Bn):** telecommunications, remote sensing, science & national security; • **Ground Equipment (USD 130.3 Bn):** network & consumer equipment; • **Government Space Budgets & Commercial Human Spaceflight (USD 95 Bn):** non-satellite industry; • **Satellite Manufacturing (USD 12.5 Bn);** • **Launch Industry (USD 4.9 Bn).** Source: Bryce, 2019
Euroconsult	**USD 298 Bn** *(2019)*	This figure refers to **commercial satellites revenues only:** • **Upstream (USD 8 Bn):** satellite manufacturing, satellites launch, ground equipment manufacturing; • **Downstream (USD 290 Bn):** satellite operation, services. Source: Euroconsult, 2018

Cross cutting macro-trends and main trends per domain at a glance

Macro-trends impacting the space sector transversally

COVID-19

The COVID-19 crisis has mainly impacted operational and manufacturing activities during country-wide and partial lockdowns. These resulted in programme delays and financial strain on small and medium enterprises. Heavily tied to institutional budgets, the space sector is expected to be impacted by changing government priorities and agendas, with sizeable knock-on effects from other industrial sectors.

Digital Drivers

Companies that are combining multiple digital technologies such as Cloud, Artificial Intelligence, Additive Manufacturing or Blockchain tend to have a high competitive advantage in the sector. These technologies give rise to more scalable and innovative business models with more customer-oriented approaches, and push for the democratization of the access to the space sector.

Defence programmes

While defence has always been one of the primary drivers for space activities, we see new types of malicious threats and demonstration of sovereignty driving an increased militarisation and weaponization of space. This manifests itself with the launch of dedicated defence units to ensure space sovereignty and surveillance. Examples include the US Space Force and the French Commandement de l'Espace.

Broader Public Policy

Institutional actors are expected to take a leading role with the definition, update and implementation of their space policies to foster economic growth and to face upcoming challenges such as the sustainability of the space environment. In addition, the renewal of several major space programmes, towards green economy for example, is expected to create new opportunities for space-based applications and services.

Overview of trends in space domains (focus on civil and commercial space)

Earth Observation	While the EO domain remains geared towards defence and security markets, an increasing demand from a diversified pool of customers is leading the rapid evolution of Earth Observation, with more supply from new entrants, and innovative delivery models for data and analytics to support situational awareness.
Satellite communications	Demand from new market segments (mobility, IoT, M2M and ubiquitous connectivity) is transforming the satcom domain. LEO-based communication systems and new types of antennas are being deployed to address market needs.
Navigation	GNSS alternatives from GPS have come to maturity in the recent years, leading to the uptake and growth of the downstream market offering numerous PNT solutions. Space-Based Augmentation Systems (SBAS) are increasingly deployed worldwide.
Access to Space	The launch market is experiencing a drive towards reduced cost to orbit, and shows increasing competition at global level, while still retaining a significant captive nature at a regional level. Sovereign interest in launch capability is becoming widespread
SSA/STM	Increased space activities and traffic are leading to the need to conceive and implement Space Traffic Management (STM) system(s) to sustain the space environment.
Space Exploration	Numerous new actors, both institutional and commercial, show interest in manned missions to LEO (mostly in the frame of institutional missions, while the commercial sector is closely examining the business case of Space Resource Utilization (SRU). A lunar economy is under consideration.

Space domains and subsectors each show a different level of resilience to the impacts of the COVID-19 crisis

Overview of the main impacts of the COVID-19 crisis on the Space sector

Direct operational impacts delaying the supply chain

The COVID-19 crisis has provoked the slow-down of the majority of operational activities along the value chain. Manufacturing facilities have put their activities on hold and launches have been delayed due to the interdependence between actors and their global footprint. With sustained demand for satellite services, mission operations have been preserved and facilitated through remote working.

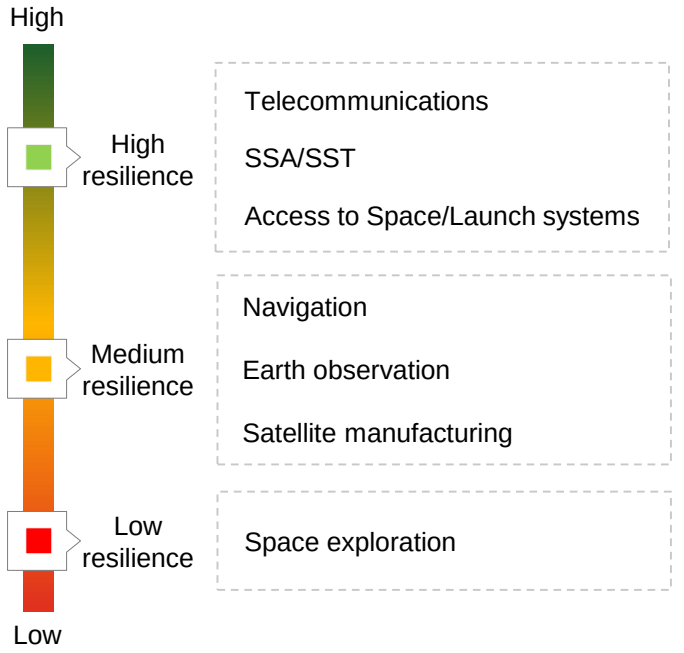
Financing issues hindering business continuity

Most prime integrators have defined measures to mitigate the financial impact of the crisis, whereas small/medium enterprises, including critical sub-component suppliers, are facing cash flow difficulties due to the delayed and cancelled orders. Start-ups are exposed to liquidity dry-ups and increased financing risks driven by a heavily impacted global economy. The business continuity of these players is jeopardised by the prospected outlook of the financial markets.

Expected to result in wider impacts at public policy and procurement level

Heavily tied to institutional budgets and overall wider public agendas, the space sector is expected to be impacted by changing government priorities and agendas. Public institutions and governments play a prominent role in shaping the space industry by placing orders and implementing large space programmes. Driven by reshuffled priorities, the revision of institutional budgets could be expected to lean towards decreased envelopes for space programmes.

Resilience of space domains to COVID-19



Learn more on PwC's insights on the impacts of COVID-19 on the Space sector

Source: PwC analysis

Digital technologies are enabling reduced costs, faster production and diversification of business models

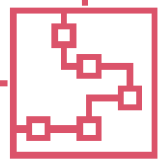
Space 4.0

Space 4.0 is similar to the concept of Industry 4.0, highlighting the impact of the so-called “fourth industrial revolution” of manufacturing and services. Companies that are combining multiple digital technologies such as Cloud, Machine Learning, and Blockchain are developing a strong competitive advantage in the sector, impacting both upstream and downstream parts of the space value-chain.

Employing cloud computing bypasses the need for hardware and software ownership, opening up the market to startups and allowing companies to provide ground stations as well as full turnkey solutions as a service.

Machine learning facilitates the extraction of actionable insights from large amounts of data, automation of repetitive processes, and extends the use of space-based applications to new markets.

Blockchain can employ token-based financing for space missions as well as start-up funding to ease the barrier of entry. It also offers transparency in supply chain management, efficient procurement processes, and secure satellite communication



These technologies give rise to more scalable and innovative business models that are democratizing access to the space sector.

Users are seeking effortless access to insightful outcomes from space data.

Diversification of business models is allowing for a more customer-oriented approach.

Digital technologies enable new manufacturing methods

Additive manufacturing (AM) methods have led to reductions in cost, weight and production time of space assets and is the stepping stone for in-space manufacturing.

The 3D printing market for space applications is forecasted to top USD 5.5 Bn in value by 2027[1] .

AM has enabled vertical integration of production in companies due to the low-volume, high-value nature of the space sector, decreasing costs and eliminating reliance on outsourcing. On the other hand, an increase in mass production and automation, and miniaturization of electronics has led to an increase in the development and use of COTS components and globalization of supply chains.

Research shows that the top 19% of companies in the aerospace and defence sector that have significant investments in digital technologies consequently achieve higher than average returns on these[2].

Source: ESA; PwC analysis, OECD, [1]SmarTech Publishing, [2]Accenture

Ground Segment as a Service (GSaaS) contributes to lowering barriers to entry in the space industry

Ground Segment as a Service (GSaaS) concept

Ground segment activities require significant investment
- Ground segment activities require expertise, infrastructure and resources, both human and financial
- Difficult for satellite operators to invest in a wholly dedicated network

Regulation aspects require time and effort
- Licensing needed to build and operate a ground station
- Complex procedures to follow (i.e. lack of clarity/transparency), fees, etc.
- Can cause delays in satellite operators business development

Ground segment services were not adapted to New Space operators
- Costly and complex premium solutions from incumbents adapted for satellite operators with demanding requirements
- New Space satellite operators have different needs (e.g. smaller satellites)

Mutualising ground infrastructure (e.g. ground stations, data storage), GSaaS enables different satellite operators access a single network of ground stations, together with benefits including:
- **Flexibility**: possibility to have on demand or reserved contacts
- **Cost-effectiveness:** pay as you use or subscribe on a monthly/yearly basis
- **Simplicity**: easy-to-use API and interfaces

Switching CAPEX to OPEX, GSaaS allows satellite operators to focus on the core of their business: data

GSaaS current supply and demand

GSaaS supply is made of half a dozen actors…

… supplying services to a variety of users

	Trends in GSaaS users
Mission type	EO, Internet of Things (IoT)
Customer type	Mostly private and some public users
Orbit type	LEO satellites mostly

astrocast, MAXAR TECHNOLOGIES, Myriota, NSLComm, ICEYE, spire, Capella Space

Non-exhaustive list

GSaaS market perspectives

The customer base could be enlarged

New satellite operators (e.g. military entities, emerging space agencies) and customers with other mission types (e.g. low latency applications, deep space and lunar missions) could contribute to enlarge the GSaaS customer base...

To answer to such customers, the **supply will have to offer adapted services** (e.g. enhanced security, data processing/ analysis, consulting services etc.), notably **leveraging on partnerships and technologies**:
- Partnerships with specialised companies in specific domains (e.g. to offer better security) or with ground suppliers (e.g. to expand ground stations coverage)
- Technologies like Artificial Intelligence, Electronically Steered Antennas, Optical communications and Inter-Satellite Links could enhance satellite communication performance on the ground and in space

Learn more on our Paper on Ground Segment as a Service

Source: PwC analysis

While always strongly tied to defence, Space sees its relevance growing as a component of defence programmes, with space sovereignty key for an increasing number of nations

The strategic dimension of space

Space assets play a key role in military activities

Space assets are an essential component of the infrastructure and backbone enabling military activities and operations. Examples include the use of satellites to allow secured communications, the collection of earth observation to perform intelligence activities, and the support from satellite navigation to conduct drones operations.

The space environment is targeted by increasing malicious threats

The development of offensive space assets designed to eavesdrop, jam or disrupt satellites capabilities is increasing. In response to these increasing threats, nations are developing capabilities to observe, prevent and counteract these attacks. These countermeasures are materialized by increased space observation capabilities and the development of more resilient space systems (e.g. quantum communication)

Space militarization is used as a sovereignty demonstration tool

In 2007, China conducted an anti-satellite test using a kinetic kill vehicle on its own satellite Fengyun-1C. More recently, in 2020, India conducted a similar test targeting a LEO satellite. So far, only few nations (USA, Russia, China and India) have demonstrated the capability to potentially neutralize a foreign spacecraft. But other nations are expected to acquire this capability to prevent such scenarios from occurring, and to establish ways to counterattack.

Evolving National Space Strategies and Governance

The US Space Force and US Space Command

The Space Force was created in 2019 as a new branch of the US armed forces dedicated specifically to orbital and space defense. The Space Force is focused on train, organization, and equipment of missions that are to executed by the US Space Command (re-established in 2019), in turn in charge of the operations (space observation activities, surveillance and tracking potential threats that could jeopardize the network of US space assets). The foreseen budget dedicated to the US Space Force in 2021 is USD 15.4 B*.

The French Space Command

Following the announcement of its space strategy for national defence, France launched its Space Command which will lead and coordinate the country's enhancement of its space surveillance and observation means and the development of self defence means. The French Space Command is expected to be supported by a budget of EUR 700 M over the 2020-2025 period.

China's Strategic Support Force

Driven by the need to protect its rapidly growing architecture of space systems, China has increased its military capabilities related to space. In 2015, China created the Strategic Support Force which aims at fostering synergies between China's military components in space, cyber and electronic warfare.

Examples, non-exhaustive - Source: PwC analysis ; * Space.com (it includes administrative costs)

The institutional civil space budget in Europe is split between the EU Space Programmes, the European Space Agency and national space budget

European Commission

Multiannual Financial Framework (MFF) (2021 – 2027) — **EUR 14.8 Bn**

EU Member States (EU MS) (27)

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden

Budget distribution among the EU Flagship Programmes

GALILEO	Copernicus	Govsatcom SSA
9.01 Bn	5.42 Bn	0.44 Bn

The EU Space budget is based on the contribution of EU Member States. Nevertheless, **each EU MS has it own national budget for space activities**, together with a possible **contribution to the European Space Agency (ESA)** in addition to the EU Space Programme.

NB: the financial envelope for the MFF 2021-2027 is based on the update performed on 18 December 2020

European Space Agency (ESA)

ESA Ministerial Space+19: Budget 2020 – 2024 *(including EUR 12.5 Bn over the period 2020 – 2022)* — **EUR 14.4 Bn**

ESA Member States (MS) (22) + 3 countries with specific agreements with ESA

Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Spain, Hungary, Ireland, Italy, Luxembourg, Netherlands, Sweden, Poland, Portugal, Romania, United Kingdom, Norway, Switzerland

Associate States: Canada, Slovenia, Latvia

: Country not part of the European Union

Budget distribution among the main space domains

Earth Observation	Space Transportation	Space Exploration	Space Science	Telecom.	Basic Activities	Others (space safety, Navigation, Technologyx,, etc.)
2.54 Bn	2.24 Bn	1.95 Bn	1.67 Bn	1.51 Bn	0.8 Bn	3.69 Bn

Main MS's contributors to ESA overall budget
(% of overall ESA budget over the period)

1	2	3	4
Germany	France	Italy	UK
22.9% (3.3 Bn)	18.8% (2.7 Bn)	15.9% (2.3 Bn)	11.8% (1.7 Bn)

Source: ESA, ASI, CNES, DLR, UKSA, European Commission

The European Green Deal initiative is expected to stimulate the demand for advanced satellite-based applications in the EU Member States for the next decade

Green deal societal impacts and associated role of the space sector

The European Green Deal sets Europe's roadmap towards a pan-European climate resilient economy, driving incentives to turn climate and environmental challenges into policy and business opportunities. This new EU's "climate action plan" will be mobilizing EUR 1,000 bn for the EU economy over the next decade.

Contribution of space data in science-based decision-making tools for policy makers

The **utilisation of satellite data & information** (e.g. satellite imagery, GNSS signal, meteorological data, etc.) fused with in-situ data and other sources of data offers a unique capability to monitor the state and change of the environment on a global scale, allowing the **creation of a digital library of Earth's evolution**. Such continuous monitoring of planet Earth is allowing to **observe and forecast the impacts of human activities on soil, air, and water quality.**

Governments and organizations can ensure compliance to environmental regulations

If the **European Climate Law** goes forward, it will be transforming EU's Member States **political commitment into a legal obligation**. Advanced satellite-based products & services, more specifically for EO-based applications, would then become **highly critical as support-evidence**, opening a major field of activities for **certification and standardization**

Offers the space industry an opportunity to re-evaluate its practices to become a more sustainable industry, both on Earth and in space

The sector is **opting for green propellants for cleaner launch**, space **debris removal** and regulation, **in-orbit servicing** missions to **extend satellite lifetime**, and implementing more sustainable models in system engineering and space system design

EO leads the way to sustainability in the space sector

Satellite data can play a critical role in the achievement of the goals of the EU Green Deal. A significant part of the budget of the Green Deal investment plans is expected to support the space industry, especially related to the development of advanced satellite-based products and services.

Machine learning applied to satellite imagery can be implemented for change detection to protect biodiversity and provide evidences to decision-makers and legislative authorities

Many products and platforms have been funded by the EU and ESA over the next decade that could support the implementation of the EU Green Deal

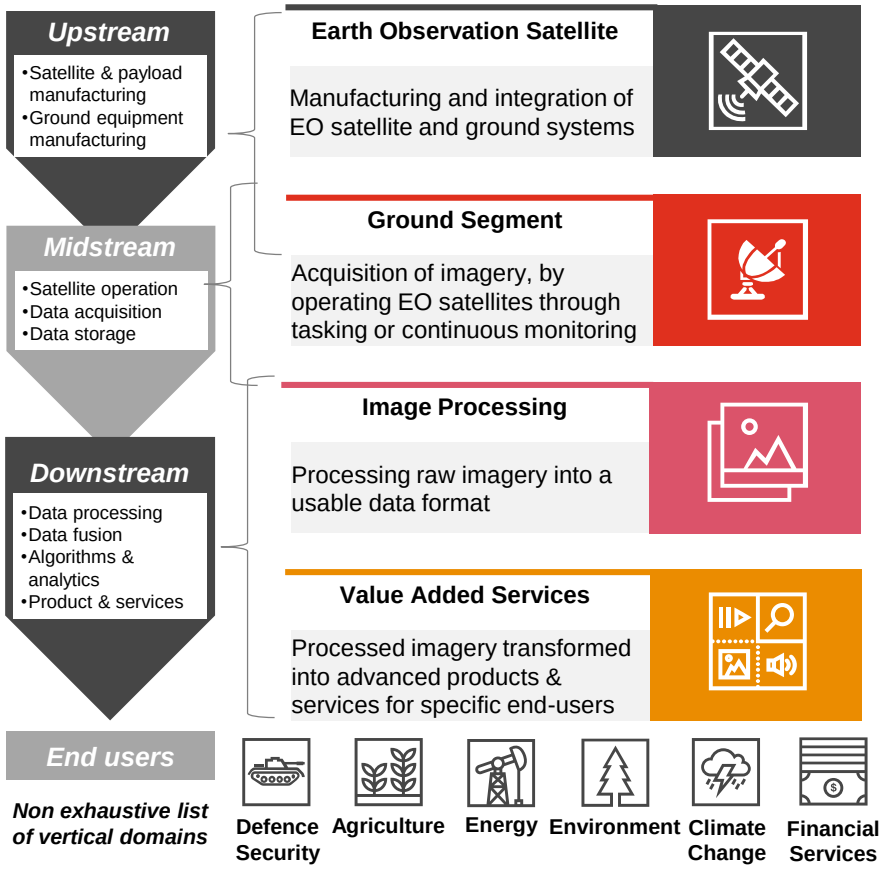
Next generation meteorological satellites (i.e. EUMETSAT EPS-SG) and EO satellites (i.e. ESA Aeolus) will improve Europe's forecasting capabilities for a more efficient use of Variable Renewable Energy.

Learn more on PwC's identification of the benefits brought by the European Green Deal to the Satellite Services Industry

Source: PwC analysis

The Earth Observation market is rapidly growing with rise in both supply of imagery through NewSpace constellations as well as in demand

Earth Observation Value Chain



Key facts and figures

The impact of EO on the space economy

The EO market has **been growing over the last year** thanks to:

- A global **growing interest** from institutional and commercial players in **buying EO satellites**
- A **democratisation of the use of satellite data** leading to an increase in demand from end-users

Strong increase in competition

- **Increasing number of new entrants with vertical integrated business model** on the commercial EO market aiming at building EO small satellite constellation
- **Strong pressure on EO data price and push for diversification**

Towards the emergence of a promising EO BDA market

Access to low cloud-storage & computing and an increasing volume of satellite imagery at low cost is allowing the **emergence of a new type of EO market** based on **Big Data analytics & services, unlocking new business cases** for the next decade

USD 5.3 Bn in 2020
Including USD 1.5 Bn for upstream and about USD 3.8 Bn for downstream EO activities

Many NewSpace players incoming
Planet, IceEye, Capella Space, Satellogic, SpaceWill or Zhuhai Orbita Aerospace, all targeting large-scale small EO satellites constellation.

>20% CAGR for BDA
Estimated CAGR of the revenues generated by EO Big Data Applications (BDA)

Source: PwC analysis, NSR

Recent trends are stimulating the demand for EO data while strongly impacting the price of such data, allowing a steady growth for EO-based products & services

DEMAND TRENDS

 **Increasing availability of EO data**	• **Vertical integration of traditional actors** (e.g. Airbus, Maxar, etc..) aiming at building synergies between upstream and downstream activities • New entrants focusing on **large-scale constellation of small satellites** or focusing on the analytics side of the activities, attracting very large private investments	• Strong pressure on EO data price • Raising interest/awareness for EO-based products & services, indirectly stimulating demand for EO data
 **Democratisation of the use of EO**	• Responding to new developments in cloud and computing power, **new delivery models, based on API (i.e. APIfication)**, are being developed by the entire market • New delivery models responding to **client needs** to facilitate **access to data, data discovery** and to offer access capacity to **very large volumes of data at low cost** (i.e. for EO BDA companies) • New models enable to switch to **subscription** and **volume-based business models**	• Strong increase in demand for large volume of data (especially for medium and high resolution optical data) • Commoditisation of basic analytics (e.g. objects counting, change detection, etc..) • Unlocking new use cases based on scalability
 **Advancements in data fusion capabilities**	• **Strong and rapid progress** in **capabilities to fuse large volume of heterogeneous data sources** (i.e. data with different format), including satellite data with other sources of data (e.g. mobile data, social media data, images, video, text, statistics, financial data, etc.) • **Explosion of large Big Data Analytics (BDA) market**, on which EO data offer an interesting additional source of data	• Stimulation of the demand in EO data • New opportunities with large BDA companies consuming large volume of data • Growing interest for insight-based analytics exploiting heterogeneous data sources

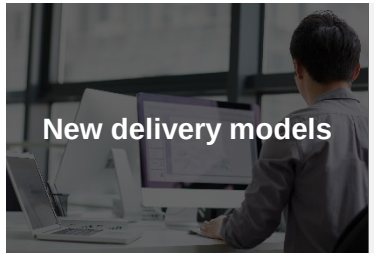
 **New emerging analytics markets**	• Low-cost imagery, cloud storage and cloud computing stimulate the emergence of a **fast growing EO Big Data Analytics (BDA) market**, attracting large private capital
	• The growth of such a market will **stimulate demand in EO data,** driving prices down, notably for:
	  • **Long archives of EO data** to perform change detection over time for very specific region, especially for Medium Resolution (MR) and High Resolution (H),
	  • Continuous monitoring of very specific AOIs.
		• Strong growth in demand for EO data, with recent important interest in high and very high temporal revisit (i.e. daily and sub-daily)
		• Strong pressure on archive prices for MR and HR EO data

The changing and growing competition and the impacts of digital trends on EO data distribution business models are reshuffling the EO supply-chain

SUPPLY TRENDS

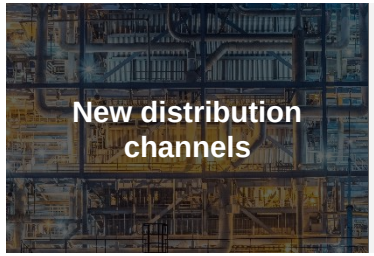
- Large **volumes of EO data freely available** from open source programmes such as **Copernicus or Landsat**
- Development of **large scale EO small satellite constellations**
- **Growing interest from governments** to build their **own EO capacities**
- **Ground Segment as a Service (GSaaS)** offers **turnkey solutions to EO satellite operators** that wish to avoid investing in dedicated infrastructure, while benefiting from fast and secure data download and processing

- Reduction of barriers to entry for new comers
- Strong pressure on EO data price
- Raising interest and awareness for EO-based products & services, indirectly stimulating demand for EO data



- Access to **low-cost cloud storage capabilities and powerful low-cost computing** power through cloud services (AWS, Microsoft Azure, Google Cloud, etc.)
- Availability of **open source tools & analytics** facilitating experimentation and utilization **by non-technical users**
- Important **public investments**, especially in Europe by the EU and ESA, to **support dissemination of EO knowledge** (e.g. online free trainings, universities classes, etc.)

- Strong increase in demand for large volume of data (especially for MR and HR optical data)
- Commoditisation of basic analytics (e.g. objects counting, change detection, etc..)
- Unlocking new use cases based on scalability

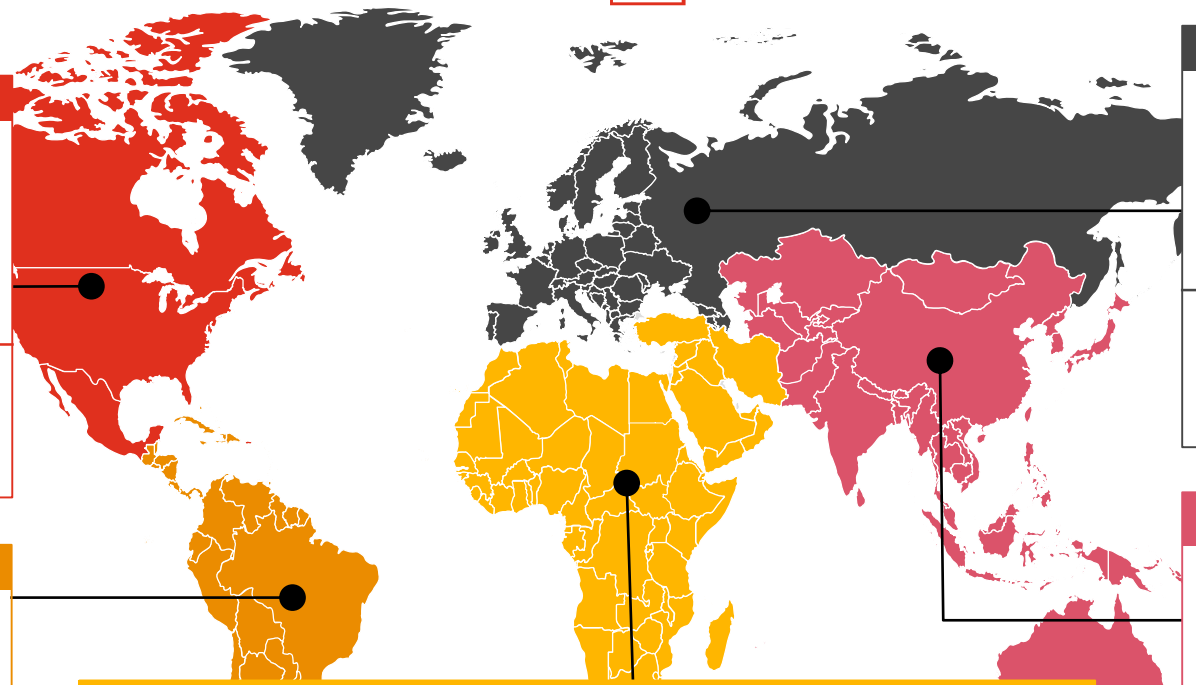


- **Switch from direct distribution channel** (i.e. selling EO data directly to end-users for expert communities/analysts and/or EO downstream actors) **to vertical specialist Value-Added Services (VAS)**
- Raising interest from end-users to **access diversified sources of data into one stop-shop digital marketplaces bringing together different datasets (EO and non-EO),** but also sometime VAS and computational capacity, under one subscription (e.g. SkyWatch, UP42, Arlula, etc.)

- Stimulate demand in EO data
- New opportunities with large BDA companies consuming large volume of data
- Growing interest for insight-based analytics exploiting heterogeneous data sources

Over the period 2015-2019, 180 institutional satellites have been launched globally, including ~30% of military assets

The figures displayed here refer to institutional satellites only (i.e. civilian & military). They do not include educational satellites (i.e. satellites owned by research centres, universities, etc.)



North American Region *(# of satellites; 2015 – 2019)*

Space agencies' satellites	Other institutional satellites (civilian)	Military satellites
4	5	10

Major large-scale open data program

Landsat Program

Joint programme between

USGS science for a changing world — NASA

South American Region *(# of satellites; 2015 – 2019)*

Space agencies' satellites	Other institutional satellites (civilian)	Military satellites
2	2	1

No large scale open data programme for this region

Middle East & Africa Region *(# of satellites; 2015 – 2019)*

Space agencies' satellites	Other institutional satellites (civilian)	Military satellites
9	5	3

No large scale open data programme for this region

European Region *(# of satellites; 2015 – 2019)*

Space agencies' satellites	Other institutional satellites (civilian)	Military satellites
13	8	11

Major large-scale open data program

Copernicus Programme

Owned & managed by — *With technical support from* esa

Asia-Pacific Region *(# of satellites; 2015 – 2019)*

Space agencies' satellites	Other institutional satellites (civilian)	Military satellites
30	45	32

Major large-scale open data program

Gaofen Program

Owned & managed by

Source: PwC Earth Observation data

The Copernicus Programme from the European Union provides various economic, social, environmental and strategic benefits (1/2)

Owned & managed by

With the technical support from

In July 2020, ESA has announced the awarding of **more than EUR 2.5 B** to the European space industry for the development of the **6 HPCMs**.

This new generation of Sentinels satellite will be developed in addition to the current Sentinels fleet.

Copernicus HPCM		Potential / Envisioned Use Cases			Budget
Copernicus Anthropogenic Carbon Dioxide Monitoring (CO2M)	CO2M will analyse anthropogenic CO2 emissions, enabling the derivation of the overall CO2 budget at national and regional/megacity levels. This will enable better assessment of carbon related COP21 decisions, which require EO support for accurate and consistent quantification of anthropogenic CO2 emissions and their trends. Auxiliary observations of NO2, cloud and aerosol distribution support the mission objective. The instrument will also provide valuable data to the scientific community, including meteorology, climatology, or atmosphere studies.	CO2 Monitoring	Science (e.g. meteo, climatology)	Auxiliary Pollutant Monitoring	**455 M EUR***
Copernicus Land Surface Temperature Monitoring (LSTM)	LSTM shall complement current visible (VIS) and near-infrared (NIR) Copernicus observations with high spatial-temporal resolution. Near real time evapotranspiration maps, generated by LSTM primarily will support agriculture, but may also aid in disaster management, ecology, ocean currents, climate change, erosion control and others. It will help implement optimized irrigation strategies, decreasing the amount of water required in agriculture and increasing yield. By extension, LSTM will support food security and decision making in cases of water shortages. The heat measurements can also be used to infer information on land degradation and on urban heat island issues.	Agriculture	Environment & Climate Monitoring	Water Management	**389 M EUR***
L-band Synthetic Aperture Radar (ROSE-L)	The ROSE-L mission is responding to the requirements expressed by both the Land Monitoring and the Emergency Management services. Unlike the Sentinel-1 radar instrument, ROSE-L leverages on L-band waves capability to penetrate through natural barriers like vegetation, dry snow and ice. This would enable improved applications in forest management, precision agriculture, land monitoring, shipping through measurements of soil moisture, biomass quantifications, and monitoring of polar phenomenon. Other emerging applications will be possible by the synergetic and complementary observations with C-band and X-band SAR systems.	Land Monitoring	Emergency Management Services	Forest Management	**500 M EUR***

Source: PwC analysis, ESA, DLR, SpaceNews

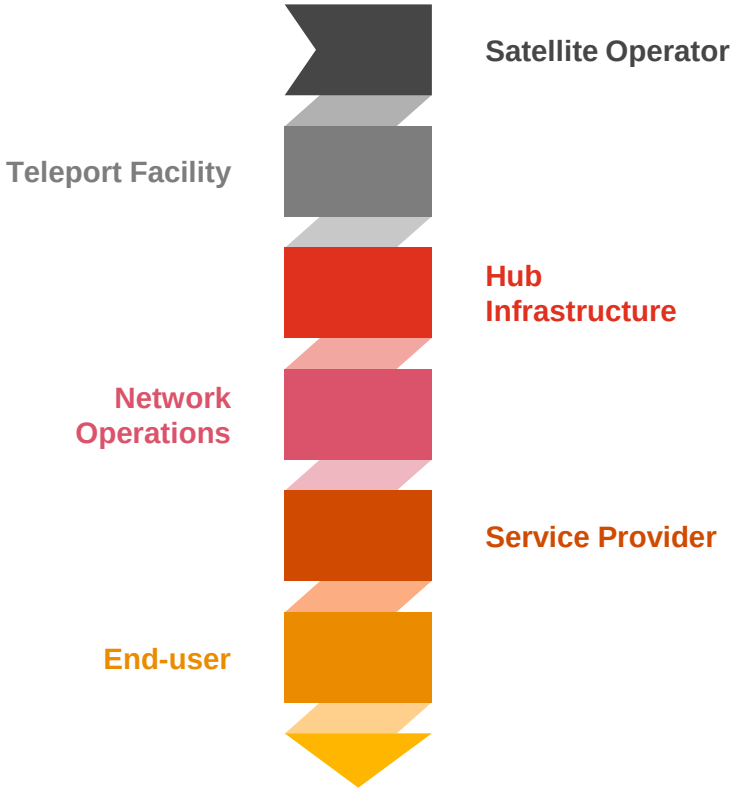
The Copernicus Programme from the European Union provides various economic, social, environmental and strategic benefits (2/2)

Copernicus HPCM		Potential / Envisioned Use Cases			Budget
Copernicus Polar Ice and Snow Topography Altimeter (CRISTAL)	Leveraging on knowledge developed from Cryosat, CRISTAL shall improve land ice elevation and sea ice thickness measurements by implementing higher spatial resolution for improved lead detection and an additional capability to determine snow loading on sea ice. CRISTAL is thus of relevance to the maritime sector as sea ice is an important component of maritime logistics, especially for future polar marine spatial planning. The mission will also be critical to measure specific variables associated with climate change. The data gathered by P-ICE will be relevant to climatologists and scientists interested in the planet's cryosphere such as glaciologists, meteorologists and oceanographers.	Maritime Logistics	Environment & Climate Monitoring	Meteorology	**300 M EUR***
Copernicus Imaging Microwave Radiometer (CIMR)	CIMR shall provide improved continuity of sea ice concentration monitoring missions, in particular in terms of spatial resolution (15 km), temporal resolution (sub-daily) and accuracy (in particular near the ice edges). The instrument will notably measure sea ice concentration, sea surface temperature and sea surface salinity, and will have implications for the maritime sector (e.g. shipping). As with CRISTAL, this mission has a high potential to monitor climate change.	Maritime Logistics	Environment & Climate Monitoring	Ocean Monitoring	**495 M EUR***
Copernicus Hyperspectral Imaging Mission (CHIME)	The CHIME mission aims to augment the Copernicus space component with precise spectroscopic measurements to derive surface characteristics in support of the monitoring, implementation and improvement of policies in the domains of raw materials, agriculture, soils, food security, biodiversity, environmental degradation and hazards, inland and coastal waters, snow, forestry and the urban environment.	Agriculture	Biodiversity Monitoring	Urban Monitoring	**455 M EUR***

Source: PwC analysis, ESA, DLR, SpaceNews; Image credits: NASA

The satellite communication domain is still by far the largest satellite services market

Satellite Communication Value Chain



Key facts

The impact of Satcom on the global economy

Satcoms are critical to a wide range of businesses, governmental and leisure activities.

Compared to terrestrial infrastructures, Satcoms provide an unmatched level of availability, coverage, confidentiality and resilience.

Highly competitive business environment

The **dot com billionaires** have heavily invested in the satcom market, and are **redefining** the satcom architecture from GEO centric to LEO centric.

There are **4-5 prominent NewSpace LEO operators** (e.g. SpaceX, Oneweb, Amazon and Telesat, etc.) that are cumulatively expected to send thousands of satellites in the coming years

Towards the emergence of potential markets

New markets such as **M2M/IoT enabled by 5G, in-flight connectivity, connected cars, and maritime security**, are expected to sustain and grow the Satcom market.

Key figures

USD 153 Bn
Estimated size of the global market for satcom services

900+
SpaceX and Oneweb satellites currently in orbit as of mid-Nov 2020

21%
Estimated CAGR of the revenues generated by Satcom based broadband internet access

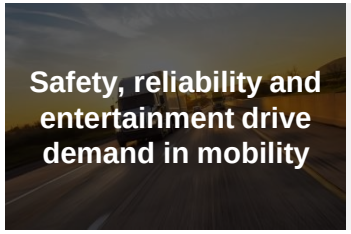
Source: NSR, PwC analysis

The demand for satcom enabled applications is on the rise especially for mobility markets and markets that shall be enabled by the advent of 5G

DEMAND TRENDS

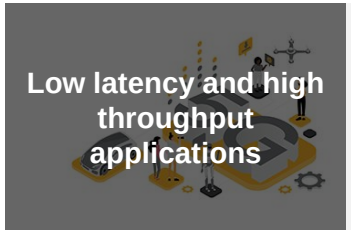
- **Moving away from traditional GEO Large satellite constellation** (10's of satellites) towards LEO small satellites constellation (100's of 1000's of satellites)
- **Leveraging economies of scale to reduce CAPEX**
- Moving towards a vertically integrated business model (example: OneWeb, Starlink, etc)

- Enabling applications that are highly demanded and require low latency
- Strengthening demand for existing applications at a lower price point



- **Safety and reliability** are the key **demand drivers** for **connectivity** within the **maritime** (offshore and merchant vessels) and **land mobility** (firetrucks, ambulances and surveillance vehicles) markets
- The **demand for aero connectivity** in broad terms is generated for **entertainment** purposes in flight. **Inmarsat's 2018** survey suggests that about **67%** of the **passengers** are likely to **rebook with an airline if inflight Wi-Fi were available.**

- Unlocking new mobility applications for safety, reliability, and entertainment purposes
- Growing demand for connectivity "*anywhere and anytime*"
- Increased interest in adopting In-Flight Connectivity (IFC) over In-Flight Entertainment (IFE)



- End-users **demand low latency and high throughput systems** for internet connectivity, especially **for 5G applications**
- IoT/M2M are expected to be the demand pillars for the satcom market.
- The **satellite IoT market** is expected to reach healthy profits and achieve growing revenues in the coming five years with a market forecast **reaching USD 5.9B in 2025**

- Transition from a video heavy market to a data heavy market
- New opportunities and applications to be addressed by the advent of satellite enabled 5G, and 5G enabled M2M/IoT

Source: PwC Analysis

LEO mega constellations are expected to drive the momentum within this market in the upcoming years, by supplying approximately 85% of the capacity by 2024

SUPPLY TRENDS

- It is expected that **between 2019 and 2024** approximately **65-70 Tbps of capacity** could be supplied to the market and **LEO mega constellations** are expected to account for **85% - 86%** of this
- **OneWeb and Starlink have cumulatively** launched more than **800 satellites**
- **Mega-constellations projects** have strong anchor customers, mainly institutional (USAF, FCC for Starlink, UK government for OneWeb, Canadian government for Telesat) or linked to GAFA business (Amazon for Kuiper, Facebook with its own constellation project)

- **GEO High Throughput Satellites (HTS)** operators are expected to contribute an additional **10-12 Tbps** of capacity, **accounting for 13-16%** of the total capacity supplied **between 2019 and 2024.**
- In 2020, **Intelsat and SES** cumulatively **ordered 13 C-band satellites** as a part of **US C-band repurposing for 5G.**

- Operators are **partnering** with **local distributors** and gaining **access** to these niche **regional markets**
- **OneWeb partners** with **Airtel in India**, **Viasat in USA**, and **Eutelsat and Avanti in Europe** for its distribution network over these regions
- **Other mega constellation** operators are expected to **follow suit**

- Strong pressure on capacity pricing across all major verticals, especially for video distribution via C-band satellites.
- The 4-5 prominent mega constellation operators, in conjunction with traditional satellites operators could potentially oversupply capacity in the mid to long terms, as both these segments are aggressively launching communication satellites.
- The evolution of the satcom market will largely depend on the success or failure of mega constellation operators
- M2M/IoT and 5G applications are the key supply drivers for both traditional and NewSpace (mega constellation) operators

- Access to niche regional markets
- Opportunity to stimulate capacity sales in developing nations

Image Credits: SpaceX

Various quantum technologies initiatives in Europe are ongoing to form the European Quantum Communication Infrastructure

What is EuroQCI

The recent developments around quantum computers threaten current cybersecurity systems and algorithms with obsolescence in the coming years. In order to guarantee the security of current and future data exchanges, disruptive strategies are envisaged, among which is the use of quantum technologies.

The vision for EuroQCI

In this context, the European Commission laid out its ambition for a European Quantum Communication Infrastructure (EuroQCI) acting as a secure communication shield across the EU. This network, based on a combination of a terrestrial infrastructure and space infrastructure, should secure sensitive communications and digital transactions both at EU scale and globally. In the longer term, EuroQCI would be a step towards the quantum internet.

What role for Space in the EuroQCI

During their transportation through optic fibre links, quantum signals are attenuated with the distance, and require relays to be re-amplified every 100 to 200 km. Such relays, also called “trusted nodes”, represent security weaknesses in the network, and greatly affect the relevance of a QCI over large distances.

Satellite-based links enable a limitation of the number of nodes when communicating at large scale, increasing the level of security for communications across Europe, or at global scale.

Present

Quantum Key Distribution (QKD)

Unconditionally secured distribution of encryption key

Other quantum services

Quantum based…
- Digital signatures
- Authentication
- Secret sharing schemes

10+ years

Quantum Internet

Interlinking quantum computers, simulators and sensors are via a quantum network.

Current status of the initiative in Europe

An initiative embraced by Member States and at EU level

Various quantum initiatives and projects exist within EU Member States, supporting the development of quantum technologies and testbeds, in particular around QKD. On top of the national initiatives, 16 EU Member States have also signed a declaration of cooperation to work jointly on the establishment of a EuroQCI.

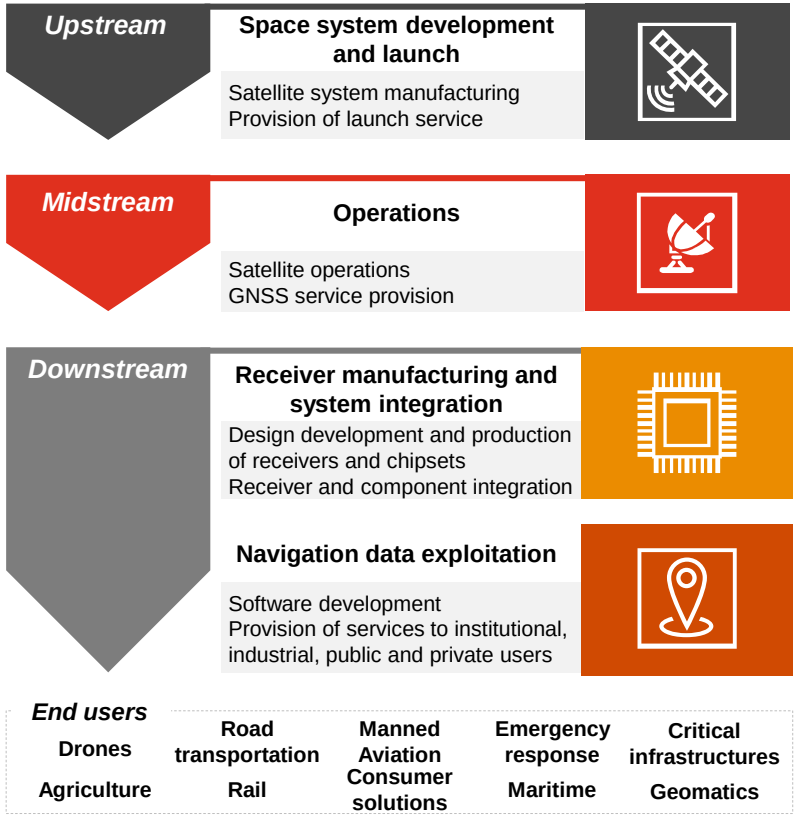
At EU level, in 2018, the EC launched the Quantum Technologies Flagship programme, with a budget of EUR 1 Bn over the next ten years. This programme targets the development of quantum technologies and will be supported through the Multiannual Financial Framework (MFF) for 2021-2027, which includes a EUR 2 Bn envelope for Cybersecurity and Trust and through the dedicated research projects in the Horizon Europe programme.

As part of the Quantum Technology Flagship, the OpenQKD pilot project launched in 2019 is supported by 38 industrial, academic and institutional partners across 13 EU countries, and aims at establishing a QKD-based experimentation platform.

The EC is also supported by the European Space Agency (ESA) for the design of the Space Segment of the EuroQCI, the « Security And cryptoGrAphic » (SAGA) mission, a GEO based QKD system. ESA is also studying LEO QKD missions, such as QUARTZ (led by SES based in Luxembourg) and QKDSAT (led by the private British company Arqit) projects.

Navigation satellites provide positioning and timing data to an ever-expanding user base

Satellite Navigation Value Chain



Trends in the Navigation Sector

A vital asset for performance, safety and leisure

Today, global navigation systems provide information about positions, routes, speed and timing, and are used by an extremely wide range of users in every economic sector.

Navigation signals are freely emitted by public entities, and their exploitation drives significant economic activity.

Pushing for greater accuracy

The development of multi-constellation receivers (compatible with multiple GNSS signals) is expected to result in greater uptake by end users and enhance performance in terms of accuracy and integrity.

In addition, navigation signals will have to resist jamming and spoofing threats.

Development of multi-frequency capabilities

The expansion of GNSS constellations and augmentation systems and the associated increase of new signals are driving the receiver market to develop multi-frequency features for their devices.

Key facts and figures

4
GNSS constellations providing global signals: GPS, Glonass, Galileo and Beidou satellites

102
Number of Global Navigation Satellites in MEO in operation in 2020

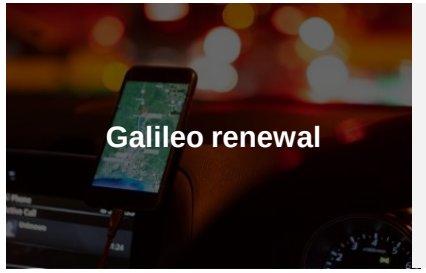
EUR 150.7 Bn
Estimated global navigation market revenues in 2019

EUR 324.4 Bn
Projected global navigation market revenues in 2029

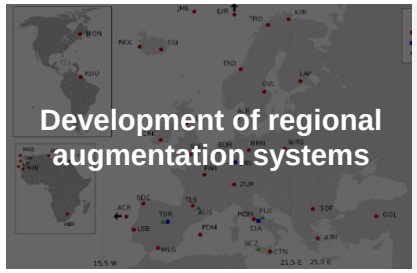
Source: PwC analysis and GSA GNSS Market Report (Issue 6)

Interests in global and regional navigation systems remains in high priority for most faring and emerging space nations, especially for augmentation systems

Infrastructure development initiatives



- In its proposal for 2021 – 2027 spending programmes, the Commission acknowledged the importance of ensuring the operational and service provision continuity of the EGNSS programme through the deployment of Galileo second generation (G2G)
- The first batch of G2G is expected to be launched around 2024 in transition with the end-of-life phase of the first Galileo generation
- ESA is examining a complement possibility to the Galileo system, dubbed GNSSEvo. Several concepts are envisaged while a LEO nanosat constellation seems the option to be favoured by ESA (TBC)

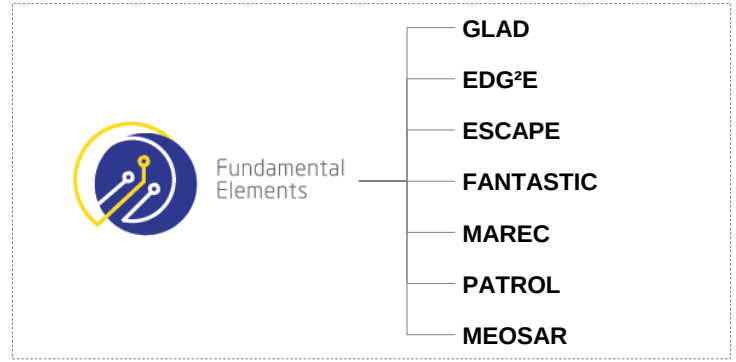


- Driven by the need to increase navigation data integrity and accuracy, several nations are developing their regional Satellite-Based Augmentation System (SBAS)
- Australia and New Zealand are jointly developing an SBAS, expected to allow the economies of both countries to generate USD 7.5 Bn across their industries
- The Agency for Air Navigation Safety in Africa and Madagascar (ASECNA) has recently validated the system architecture and geographic coverage of its future SBAS planned for 2022

- Following the implications of Brexit, the UK is examining different alternatives to replace its reliance on the Galileo system. Based on possibilities emanating from different orbits and technologies, the UK Space-Based Positioning Navigation and Timing Programme (SBPP) is exploring different satellite systems configurations
- The UK is developing its strategy towards the adoption of the OneWeb constellation, recently acquired by the UK government with India's Bharti Global Ltd, as a complement to GPS.

R&D development

The European Global Navigation Satellite Systems Agency (GSA) is responsible for the management of the Fundamental Elements programme (FE) which is a dedicated funding mechanism supporting the development of EGNSS-enabled chipsets, receivers and antennas.



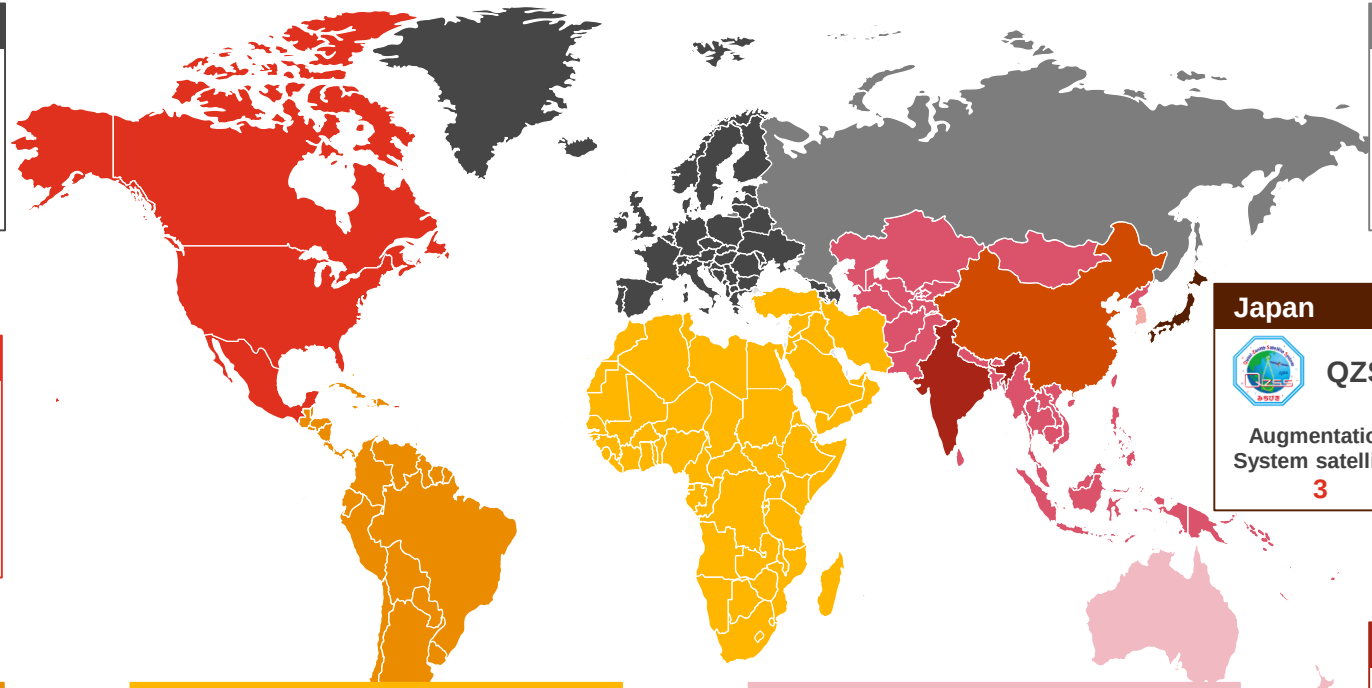
The implementation of FE projects has significantly bolstered European leadership by leveraging differentiators from the EGNSS infrastructure.

The technology developments achieved through the development of the FE projects have enhanced competitiveness of the European Union on a global scale.

Image Credits: Ikonact

Several GNSS constellations and satellite based augmentation systems provide navigation capabilities around the globe

Main GNSS and augmentation systems across the globe



Europe

Galileo
- Operational Satellites: 26

EGNOS
- Augmentation System satellites: 3

Russia

GLONASS
- Operational Satellites: 24

SDCM
- Augmentation System satellites: 3

North America

GPS
- Operational Satellites: 31

WAAS
- Augmentation System satellites: 3

Japan

QZSS
- Augmentation System satellites: 3

China

BeiDou
- Operational Satellites: 35

South Korea

KPS (Korean Positioning System)
- Planned satellites in constellation: 7

South America

SACCSA
- Augmentation System satellites: 1

Middle East & Africa Region

ASECNA
- Augmentation System satellites: 1

Oceania

Australia and New Zealand SBAS
- System under development

India

IRNSS (NavIC)
- Operational Satellites: 9

GAGAN
- Augmentation System satellites: 3

Galileo is Europe's GNSS civil programme, providing a highly accurate, guaranteed, global positioning service

The Galileo Programme

First GNSS to be under civil control

The aim of the Galileo programme is to provide the first global navigation satellite system under civil control, for the public and private use of European and global entities.

Providing a set of four high-performance services worldwide

Open Service	Free of charge to users, providing positioning and synchronization information for high-volume navigation applications
High Accuracy Service	More secured and precise service delivered through encrypted signal for applications such as safety-of-life
Public Regulated Service	Restricted to government-authorised users, for sensitive applications requiring a high level of service continuity, free of charge for European institutions and MS
Search and Rescue Service	Contributing to COSPAS-SARSAT, Galileo will offer a unique link alert informing the sender that their distress message has been received

The Galileo programme was created to answer Europe's strategic need of a reliable European satellite navigation signal, and to foster the development of economic and societal benefits

Key facts and figures

EUR 9.7 Bn — Potential budget allocation for the continuation of the Galileo and EGNOS programme over the 2021 – 2027 period

30 — Number of satellites in the final Galileo constellation. As of May 2019, 26 Galileo satellites have been deployed

1 Bn — Estimated number of Galileo-enabled smartphones in 2019

Source: PwC analysis, EC – Proposal for a regulation establishing the Space Programme of the Union and the European Union Agency for the Space Programme, GSA

Today, different classes of orbital launchers are being used around the world, almost exclusively by six spacefaring regions

Access to Space Value Chain

Launcher Development

Launch system design

Launch vehicle system architecture definition and design

Launcher Manufacturing

Manufacturing and integration

Manufacturing, integration and testing of launch system's main and sub-components

Launch operations

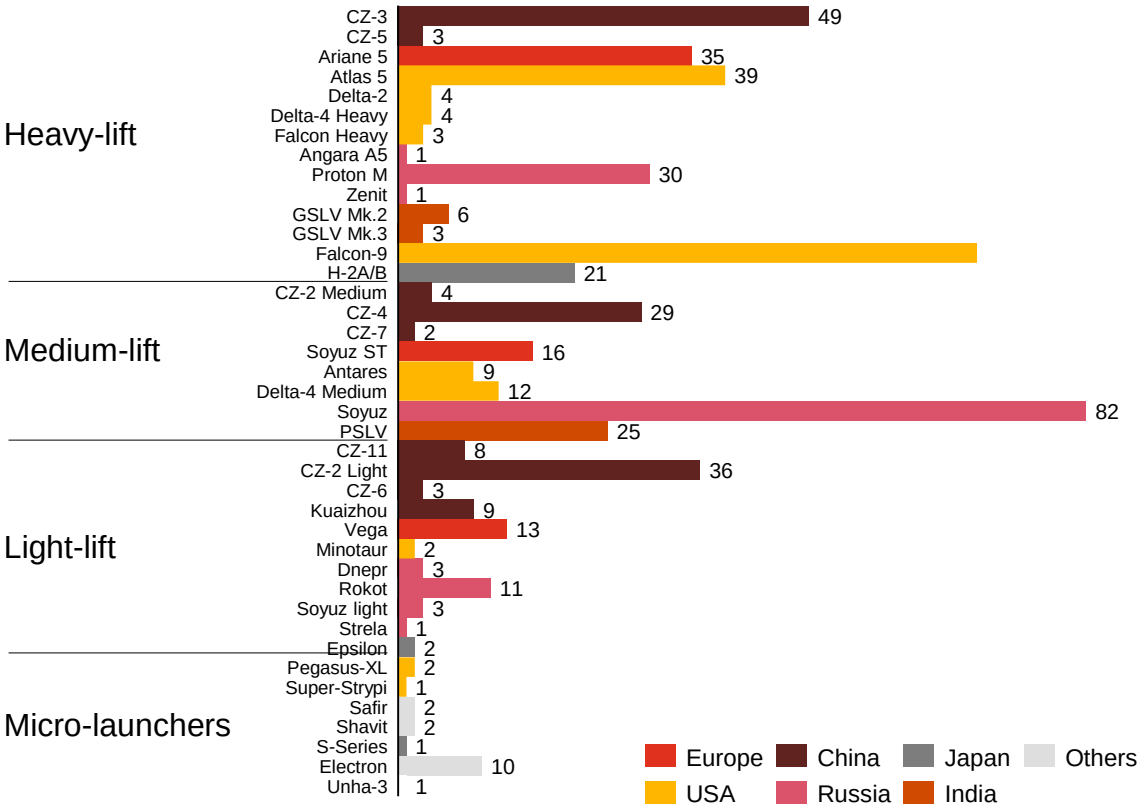
Launch service operations

Management, sequencing and monitoring of launch mission

Launch Demand

Commercial Market | **Institutional Market**

Number of orbital launches (2014 to 2019) per vehicle class, family and location



Key facts

- The launch market can be segmented into **two types of customers**: institutional and commercial.
- On the **commercial market, there is currently a duopoly between SpaceX** (Falcon 9 and Falcon Heavy) and **Arianespace** (Ariane 5, Soyuz ST, Vega)
- On the institutional market, **most of the launches are not open to competition** (use of local vehicles for local institutional customers)

Source: PwC analysis, PwC Launch Database

The launch market is experiencing a drive towards reduced cost to orbit, showing increasing competition at global level, while still retaining a large captive nature at a regional level

Market Trends

Reduction of the cost of access to space through the development of modular and reusable launchers

Pushed by a fiercer competition, launcher companies are aiming at reducing the development, manufacturing and operation costs with the objective to be price competitive.

To create economies of scale, they aim at maximizing the modularity of their vehicles through the use of components on different launcher families (e.g. Epsilon first stage as a booster of H-3, Ariane 6 and Vega-C will share the same first stage booster). The development of reusable launch systems is expected to lower costs.

Development of micro-launcher systems from new entrants

Pushed by a promising market for the delivery of small satellites, more than 200 micro launchers projects are being developed around the world by new entrants usually supported by local agencies. The commercial sustainability on the long term of these micro-launch solutions is yet to be demonstrated.

Governance Trends

Disruption of traditional institutional market with the emergence of major private players restructuring the industry

Space and government policies play a significant role in shaping the competitive landscape at regional level, with institutional markets (and in some cases even commercial markets) being still largely captive.

The increased competition from private launchers such as SpaceX and Blue Origin have added pressure on institutionally-driven launch providers, both nationally (e.g. United Launch Alliance) as well as globally.

Shift in governance and risk-taking from public to private with institutions limiting their involvement

Although governments remain involved to fund key developments, private companies increasingly lead launcher development in the USA, in Europe, and progressively in India – where ISRO notably initiated a space policy aiming at boosting the Indian private sector participation in a wide range of activities, including access to space.

Technology Trends

New generation of systems and development of super heavy launchers serving defence and exploration missions

The current families of orbital launchers are being replaced using modular designs with common core between medium and heavy-lift vehicles. Examples include Ariane 6, Angara, H-3, Vulcan and Long March 5.

In addition, super-heavy launch vehicles are being developed by the US, China and Russia for deep-space missions, the delivery of heavy payloads (e.g. space stations modules) but also to serve a wide range of defence missions. Examples include Falcon Heavy, Long March 9, New Glenn or SLS (focused on exploration missions only).

Development of engines using LOX/ Methane propellants

The use of liquid oxygen and methane as propellants would lead to significant gains such as simpler and lighter launcher design, re-ignitable engines and easier storage and handling. US, Europe and Japan are known to be currently developing methane engines.

Source: PwC analysis, Space Institute, Image Credits: NASA, SpaceX

The European institutional launch market size and openness to competition creates challenges for European launch providers

Overview of the launcher market and of European trends

European launch activities are primarily sustained by commercial launches

More than **60% of the mass delivered by Ariane 5** is currently **dedicated to the private sector.** In comparison, less than 30% of both Chinese and US launches address commercial purposes.

European launch capacity **to answer commercial operators' needs may be affected by the *2018 National Defense Authorization Act*** that prevents the DoD from using commercial satellites launched on Russian rockets. This could represent a potential constraint if Ariane 62 faces additional delays.

Acute competition has been rising from international players

US, China, Japan and Russia have issued **regulations** preventing foreign systems from launching their **institutional payloads**.

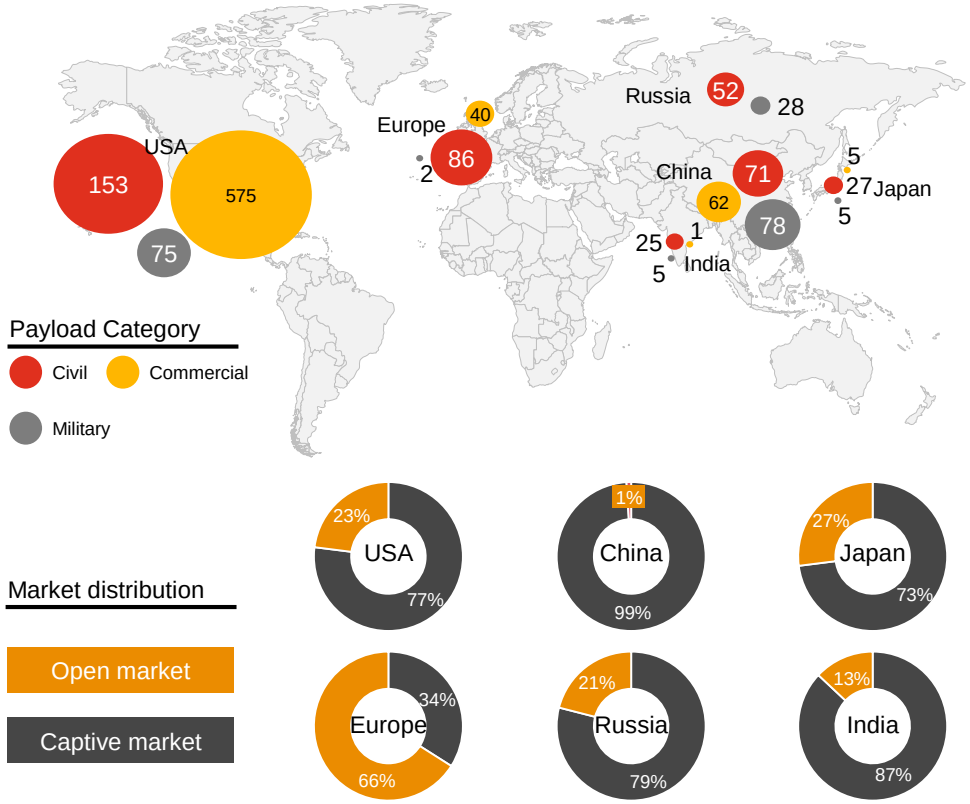
Due to the **US government's public procurement programme**, government contracts in the US are a captive market. Such policy, as well as the large budget allocated to launchers, have supported the **emergence of national champions** (e.g. SpaceX). The latter are enabled to offer attractive prices on the international commercial market.

European institutions are pursuing their efforts to support their launch service providers

The **EU has included access to space to its space strategy**, providing financial support to research and innovation.

The coronavirus pandemic delayed the testing of Ariane 6's solid-rocket-booster (P120) and the construction of the launch pad (ELA-4), and obliged decision makers to **postpone Ariane 6's maiden flight** to the **second quarter of 2022**.

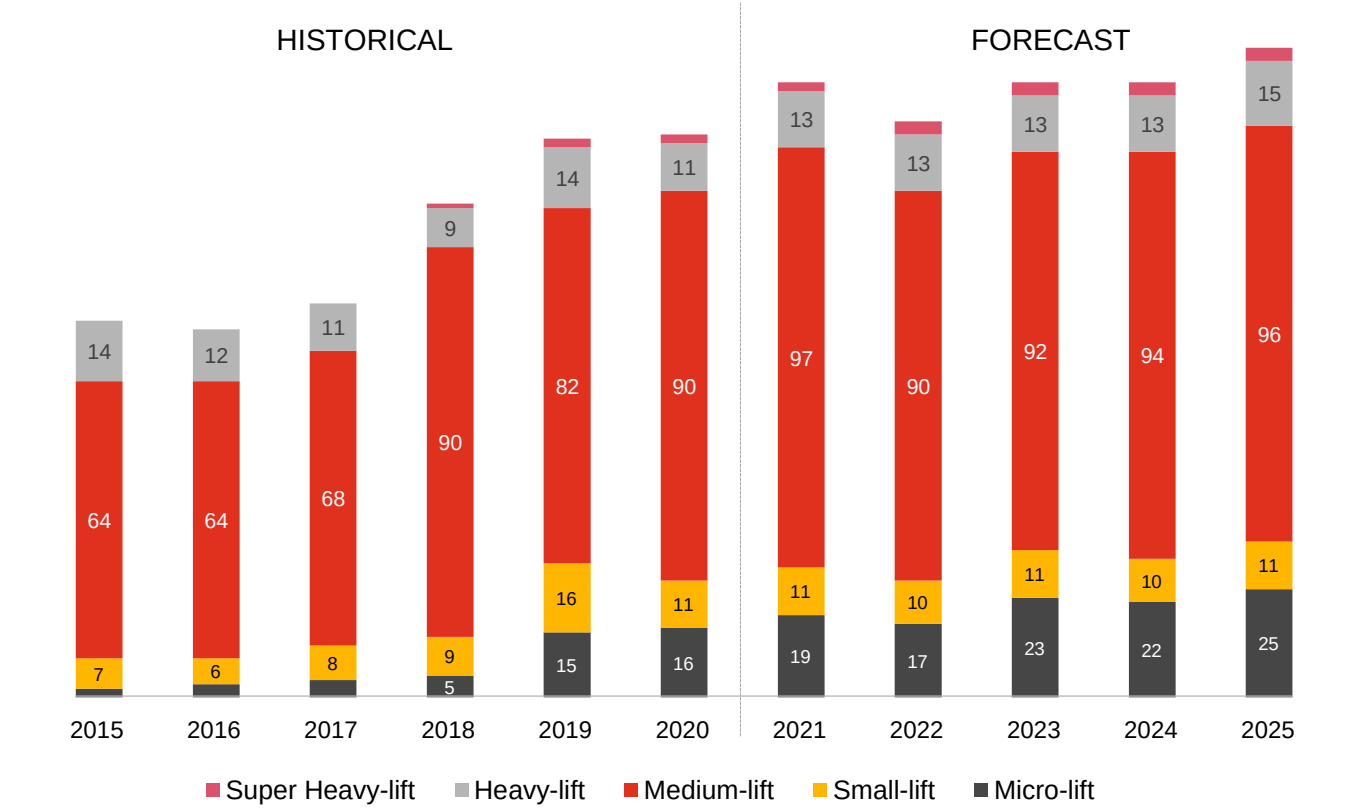
2017-2019 launch distribution



Source: PwC analysis, PwC Launch Database

Heavy and medium lift launch markets are expected to evolve steadily and activity from micro-launchers is expected to further materialize in the coming years

Historical and forecasted evolution in space launches per launcher class (2015-2025)



Key facts

Heavy lift launchers (e.g. SpaceX Falcon9, Ariane 5, Proton, etc.) are expected to represent a high share of the launch activity in the next years. Several heavy lift launcher programmes are currently under development (e.g. Ariane 6, GSLV, New Glenn, CZ-5, etc.).
Chinese exploration missions with Long March 5 are expected to ramp up heavy lift launches, and in the US, Falcon Heavy and New Glenn are expected to be the main launch vehicles used in the heavy-lift segment, followed by ULA's Vulcan Heavy.

The medium-lift segment is expected to be driven by the Russian-made Soyuz, the Indian-made PSLV and the future European-made Ariane 62. **Ariane 62 is expected to have a maiden flight in 2022**. The **Indian PSLV also plays a role** in this segment however the manufacturing shift from ISRO to HAL might have a negative impact on the launch frequency of PSLV. In China, CZ-4 is being phased out and replaced by CZ-7 and the heavier CZ-5.

With an increasing demand from small satellite operators, the micro-lift segment is expected to rise in the next years. **Several micro-launcher companies are developing micro-lift solutions with the objective to drastically reduce the costs to access space for small satellites companies**. In Europe, micro-launcher companies are also supported by European institutions, with some of them attracting significant private funding (e.g. the recent funding rounds for **Orbex (UK)** - $24M - and **Isar Aerospace (DE)** - $91M).

Source: PwC analysis, PwC Launch Database

The rapid increase in small satellites has given rise to micro and small launch activities

Among the 200+ projects of micro launchers in development across the world, very few are already operational and some are more mature (non-exhaustive sample list)

	iSpace Hyperbola-1	Rocket Lab Electron	Galactic Energy Ceres-1	Virgin Orbit LauncherOne	Orbex	Isar Aerospace Spectrum	PLD Space Miura-5	Skyrora XL Skyrora	Firefly Aero. Alpha	Relativity Terran-1
Maximum payload (SSO 500km)	150 (700km)	200	230 (700km)	300	180	700	300	315	630	900
Expected/ effective first launch	2019	2017	2020	2021	2022	2022	2024	2023	2020	2021
Comments	Operational rocket, raised USD 273M in Series A and B, developing larger rockets (Hyperbola-2)	Operational micro-launcher (14 launches as of August 2020), extended payload capacity in 2020	Developing larger rockets (Pallas-1), benefiting from transfer of military technologies access to test/ launch sites from Chinese gov.	Virgin Orbit's first orbital launch partially failed (premature shutdown of the first stage's engine)	Having raised USD 70M in investment and signed 6 launch contracts, Orbex is expected to be one of the leading companies in Europe	Isar Aerospace has raised over USD 91M will be starting its launch operations in 2022 from the European spaceport in French Guyana	PLD Space plans to launch a first rocket (Miura 1, 100kg payload capacity to 150km altitude) in 2021	Step-by-step approach starting with demonstrators (Skylark nano tested in 2020), targeting primarily UK market	Vertically integrated company developing a motorized dispenser and a larger rocket (Beta) in parallel	Highly innovative company digitizing rocket manufacturing (Stargate factory using 3D-printing, robots, etc.)

Key trends

Micro launchers have been developed to enable smallsat operators access tailored launch services as primary customers. Micro-launchers have the capacity to launch 100 to 300 kg into SSO 500km. Several companies such as RocketLab Electron, PLD Miura-5, iSpace Hyperbola-1, Orbex or ISAR Aerospace are developing micro-launcher systems. In order to expand their customer base to reach both small and medium satellite operators, companies such as Firefly Alpha or Relativity Terran 1 are developing greater launch capacities.

Traditional heavy and medium launch service providers are responding to the competitive threat emerging from micro-launcher solutions, notably decreasing the rideshare costs (down to USD 1M for 200kg with SpaceX Falcon 9) and offering enhanced precision of injection and autonomy to rideshare satellites using motorized dispensers (developed by companies like Momentus for example). Together, this could pose a threat to micro/small launchers' business.

Source: PwC analysis, El Pais, Firefly, iSpace, Rocket Lab, Galactic Energy, Virgin Orbit, PLD Space, Firefly Aerospace, Skyrora, Relativity

Ambitious plans for spaceports are moving forward globally with new levels of international cooperation

Mapping of the current spaceport projects being planned/developed across the globe (non-exhaustive list)

United Kingdom - Sutherland, Shetland and Cornwall
The UK is developing spaceports enabling vertical (Sutherland and Shetland in Scotland) and horizontal launches (Cornwall in England). In June 2020, first tests were conducted in the Shetland Space Centre (SSC) with Skyrora's Skylark Nano. Spaceport Cornwall is under development, and collaborated with Virgin Orbit to start operations in 2021-2022.

Norway – Andøya ; Sweden – Kiruna ; Portugal - Azores
Apart from the UK, various projects of commercial spaceport for smallsats are observable in Europe. In Norway, the Andøya spaceport is expected to reach full capacity in 2023-2024. In Sweden, the Esrange Space Centre is expected to host the Themis reusable rocket stage prototype starting 2023.

United States of America
An increasing number of commercial spaceports are being established in parallel to heritage launch sites such as Cape Canaveral or Vandenberg Base. As of June 2020, 12 commercial spaceports are already FAA-licensed, and another 16 have announced plans (e.g. Puerto Rico, Michigan, etc.). To coordinate this growth in the number of US spaceports, a National Spaceport Network is currently under study.

United Arab Emirates - Dubai
The UAE plans to turn the Al Ain International Airport into a "multi-mode super-port".
Also, the UAESA signed an agreement with Virgin Galactic for space tourism and technology flights using SpaceShipTwo.

China - Hainan and Shandong
In addition to the established space launch centres (Jiuquan, Taiyuan, Xichang), China recently completed construction of the Wenchang Launch Centre in Hainan, South China. In parallel, China is making progress on spaceport project for sea launches in Shandong, North-East China.

Key trends

- With a large number of micro/small launcher projects emerging, governments are aiming at developing spaceports to host operations for such vehicles
- Pushed by the incentive to eventually develop new economic activities, various spaceport projects have been announced since 2015, around the world
- To attract micro launcher companies, countries are adapting their regulation to enable launch providers to conduct leaner and more efficient operations (e.g. UK agreement with the US enabling US Virgin Orbit launch from Cornwall Spaceport, etc.)
- In parallel, some micro-launchers (e.g. PLD, RFA) are also considering launching from Kourou.

Source: PwC analysis, Global Spaceport Alliance , SpaceWatchGlobal, New York Times, Gulf News

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

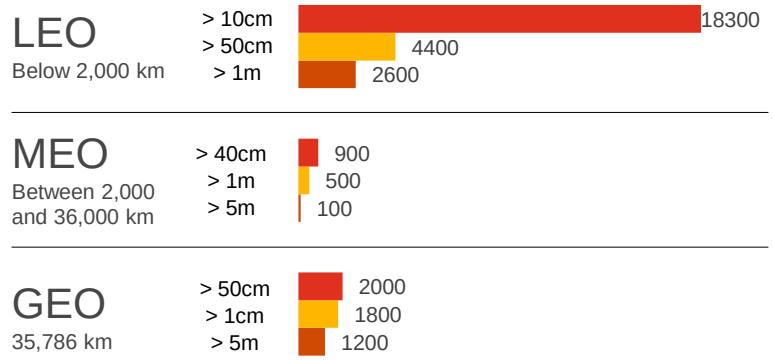
Main trends inSpace Situational Awareness and Space Traffic Management (Civil and Commercial only)

The growing issue of space debris	• The amount of space activities and launched spacecraft is rapidly increasing, especially in LEO, where the deployment of constellation projects is expected to double the number of space objects in this orbital regime. • Small satellite classes have found their audience across all major service verticals, such as Earth Observation, and Satellite Communication, and are allowing the entrances of new players into the space sector, leading to the rise of new global challenges around the sustainability of the space environment.
Measures preventing the increase of uncontrollable space objects have been designed	• The need for mitigation measures, providing the definition and application of design and operational guidelines to missions under development, have been endorsed by The UN and translated into non-legally binding guidelines. • The space surveillance and tracking (SST) of orbital debris aims to prevent debris collisions between operating satellites and other space objects, and to provide information about the trajectories of debris re-entering the Earth's atmosphere. • Active removal of orbital debris relies on innovative technologies to approach, capture and • remove existing debris, are currently under development.
Towards the development of Space Traffic Management	• Given the strategic importance of space infrastructure and considering the significant increase of space traffic expected to materialise within the next decades, the possible creation of a formal monitoring and management system for space traffic is being investigated and enforced by national institutions. • Space Traffic Management is a system of standards, requirements, guidelines, and technical programmatic and organisational activities applied to each component of the lifecycle of a space mission in order to ensure safe access and utilisation of the space environment.

Space debris threatening the sustainability of space

Space debris in the context of SST refers to man-made objects in space (as opposed to meteoroids and asteroids) that have lost their functionality.

Space debris are mostly present in regions of space closer to Earth, such as the LEO, MEO and GEO.



Nota Bene: as mentioned at the beginning of the presentation, **the focus here is on civil and commercial SSA trends and issues.**
Evolutions in Space Domain Awareness will be the subject of a separate publication

Source: PwC analysis

Increased space activities and traffic are leading to the need to conceive and implement Space Traffic Management system(s) in order to sustain the space environment

Overview of institutional initiatives in the field of STM

US Initiatives

The US are preparing a framework supporting the creation of an STM system, which aims at **reinforcing the US's strategic position** and encourages the **involvement of the private sector**.

With **strong capabilities** acquired through the development of their Space Surveillance network, the US possesses the adequate technical means to perform STM activities.

European initiatives

Even though Europe SSA means are technically far from competing with US capabilities, Europe benefits from the advantage of having a **nearly exhaustive geographic coverage of sensors**.

The **European private sector** is demonstrating capabilities to support the establishment of an STM system. The European Commission under the H2020 programme is exploring concepts for Space Traffic Management by identifying a network of opportunities, assessing available capabilities and designing a set of STM guidelines and best practices.

Russian initiatives

Russia provided the UN with a **proposal suggesting a UN-operated platform** for STM purposes. But countries such as the US were opposed to this proposal as it is not in line with their national strategies. However, should the UN adopt Russia's proposal, Russia will commit to provide its SSA catalogue at a global scale.

Chinese initiatives

The very **large population of Chinese satellites** indicates that the Chinese network for space surveillance is quite developed. The SSN (USA) and SSS (Russia) are far superior in terms of data gathering and processing when compared to national Chinese surveillance network operated by SSF.

Overview of commercial initiatives

Data Providers	• ArianeGroup • SDA • ExoAnalytic Solutions	• LeoLabs • Share My Space • Zodiac Aerospace
Database Management Software	• AGI • Applied Analytics Solutions • ArianeGroup • Omitron • Solers • Share My Space	• ExoAnalytic Solutions • Schafer • A.I. Solutions • Lockheed Martin • LeoLabs
Analysis software	• AGI • Applied Analytics Solutions • ArianeGroup • Omitron • Solers • Schafer • A.I. Solutions	• Share My Space • Lockheed Martin • North Star • ExoAnalytic Solutions • Applied Defense Solutions, Inc.
Service Providers	• AGI • ArianeGroup • Lockheed Martin • Schafer • North Star • LeoLabs	• ExoAnalytic Solutions • Applied Defense Solutions, Inc. • Share MySpace

Source: PwC analysis

Private sector companies will play a critical role in determining the evolution of the space exploration market

Space exploration markets

1 Space Tourism

- Private and commercial initiatives are encouraged through the creation of commercial space flight opportunities and development of private space stations
- NewSpace companies such as Axiom Space and Bigelow Aerospace are developing initiatives to develop commercial space stations

2 Interplanetary Transportation

- The interplanetary transportation market envisions services to the Moon, Mars, Asteroids and other celestial bodies for commercial space purposes
- Large companies such as SpaceX and BlueOrigin, as well as start-ups such as ispace and Astrobotics are developing transportation capabilities

3 Payload & Telemetry Data

- The market is dedicated to provision Moon Observation (MO) and MArs Observation (MAO) prospection data from both a payload and sub-systems (telemetry) perspective
- NewSpace start-ups and some Commercial Lunar Payload Service (CLPS) providers (e.g. ispace, etc.) are expected to lead the development of this market

4 Space Resource Utilisation (SRU)

- The SRU market is built on the concept of utilising space resources (regolith, ice, etc.) available on celestial bodies in order to facilitate the development and sustainability of in situ activities
- Start-ups such as ispace, Maana Electric are examples of companies venturing into this direction

Main trends

Challenges

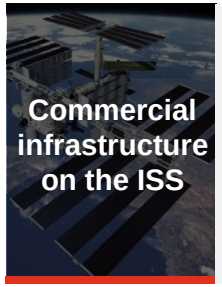
- The establishment of internationally accepted regulations and procedures for SRU, priority rights, and classification of safe zones is an important hurdle affecting the implementation of SRU activities,
- The Technology Readiness Level (TRL) of key systems must increase to enable space tourism, interplanetary transportation, and SRU activities,
- As government funding alone is not sufficient, the sustainability of a commercial space exploration market heavily relies on both terrestrial industries and investments from the private sector.

Opportunities

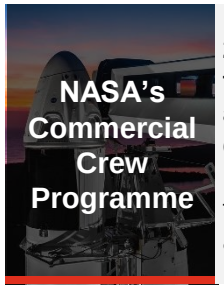
- Growing interest towards projects planning lunar activities and setting long term human presence on the Moon is gaining momentum and driving the development of the space exploration markets,
- Demand for space exploration missions, both to outer space and to LEO stems primarily from national space agencies. Recent trends of space industry privatisation (e.g. SpaceX, Astrobotic), are pushing for the development of a private space exploration economy in the coming decade
- Technological trends associated with developing cost effective launchers, orbiters, landers and rovers are enabling the commercial exploration of celestial bodies.

Numerous new actors, institutional and commercial, show interest in manned missions to Low Earth Orbit

Commercial support for the ISS



Commercial actors are getting involved in the expansion of the ISS. Examples include Airbus Bartolomeo platform featuring fully commercial space attached to ESA's Columbus module, or Axiom's project for a whole new module dedicated to space tourists, complete with 2m-high cupola

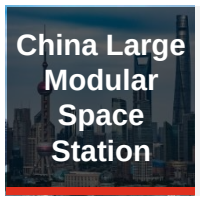


2020 is the year the US returned to space from American Soil. SpaceX's Crew Dragon and Boeing's Starliner can host up to seven crew members in their round-trip to LEO. Both companies have signed contracts for five operational flights to the ISS until 2026, and will fly astronauts from all countries.

USD 55M

The price of a seat on Crew Dragon, compared to USD 80M for the Russian Soyuz and USD 90M for Boeing Starliner

Asia-Pacific projects in LEO



China continues to develop its large space station (CSS) project *Tianhe*. Roscosmos and ESA could be interested in future partnerships, even though Chinese technology and astronauts are banned from ISS by NASA.

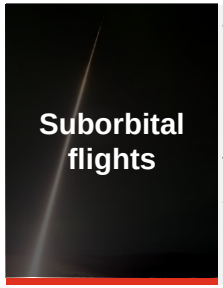
In partnership with Russia, the **UAE** had an astronaut fly aboard a Soyuz to the ISS, and **aims at expanding its astronaut corps**, with the goal to stay for longer periods of time on the station

India pursues manned spaceflight goals with the development of the Gaganyaan capsule to be launched on a GSLV Mk3. Through **partnerships with Russia** and plans for a **space station in the mid-2020s**, India is advancing quickly in the field.

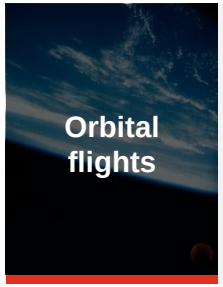
USD 2.5 Bn

The Chinese budget for human spaceflight, representing 33% of their space budget (USD 8 Bn in 2020)

LEO Tourism



The sub-orbital flight segment **attracts private companies demonstrating strong investment capabilities and POCs.** Overcoming high barriers to entry and failures, Virgin Galactic, Blue Origin and Zero-2-Infinity market themselves as dedicated space tourism companies, and will be serious players in the next decade.



Orbital space tourism segment is of **two orders of magnitude more expensive to end-customers**, and *de facto* to a private astronaut programme. Companies like Space Adventures have offered flights to space tourists, some aboard the ISS. Recently, they announced farther trips around the Moon or in high earth orbit.

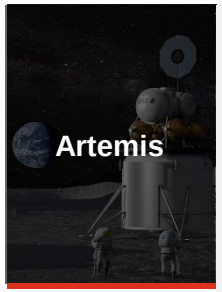
USD 250,000

The price of a ticket for a suborbital flight with Virgin Galactic onboard horizontal take-off spaceplane SpaceShipTwo

Source: PwC analysis, NextBigFuture, Planetary Society, Virgin Galactic, Space Foundation ; Image Credits: NASA,

Issues surrounding Low Earth Orbit human presence are exacerbated in Moon projects

International Moon Programmes



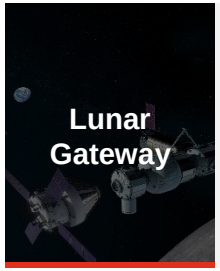
The Artemis lunar exploration program encompasses the development of the Space Launch System (SLS), the Orion Crew Capsule, and the associated spacesuits (for flight and lunar excursions) as well as the Commercial Lunar Payload Services (CLPS). The objective is to bring astronauts back to the Moon by 2024, aboard Artemis 3, the 3rd flight of the SLS. Since its inception as the *Constellation program*, Artemis has been subject to reviews by the US Congress and undergone several changes. As of 2020, Artemis 1 is planned to fly in November of 2021, with an unmanned Orion capsule. Uncertainty in the programme might arise as a result of the U.S. Elections

130 metric tones

Maximum lift capability of the SLS in its cargo version. The crew version initial lift capability will be up to 70 metric tons, twice that of any current vehicle

125 cubic meters

Maximum planned pressurized volume for the Lunar Gateway, the future space station orbiting the moon, approximately 10 times smaller than the ISS



Originally developed as part of the Artemis program, the Lunar Gateway is now an independent program. Orbiting around the Moon with a polar near-rectilinear halo orbit (NRHO) inclination, the 40-ton Gateway will be a staging location for later Artemis missions, as well as a meetup point for commercial landers and cargo missions. The station's modules will be built by the same agencies that collaborate with the ISS (e.g. NASA, ESA, CSA, JAXA). The Gateway will be composed of various modules, including the Habitation and Logistics Outpost (HALO), or the Power and Propulsion Element (PPE).

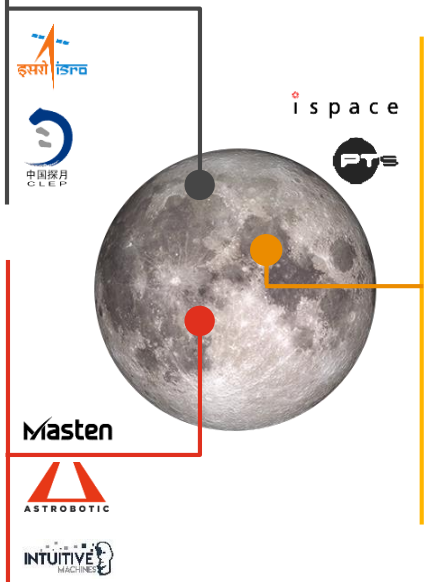
Other lunar Missions

Asian Institutional actors

After the failure of lander Vikram in late 2019, India keeps on with the goal of demonstrating capabilities of soft-landing on the Moon, with the Chandrayaan-3 probe. In the meantime, China landed the first rover on the far side of the Moon in 2019, and the Chinese Lunar Exploration Programme (CLPE) notably includes sample return with Chang'e-5 and 6.

NASA's Commercial Lunar Payload Services (CLPS)

The CLPS program aims at providing NASA with fixed-price payload contracts to the Moon, to scout for resources, test in-situ resource utilization, and prepare the Artemis missions in general. Starting in 2020, NASA's payloads will start flying on Astrobotic, Intuitive Machines and Masten Space Systems landers.



Fully commercial Moon missions

Many teams competing in Google's Xprize have spun-off start-up companies. They aim to provide regular shuttles to the Moon's surface for commercial and scientific payloads. ispace's Hakuto-R M1 mission will be the first payload flown on the new Vulcan launcher from ULA, in 2021 at the earliest.

Source: PwC analysis, NASA ; Image Credits: NASA

The main scientific and outer space exploration missions target a variety of planets and celestial objects

BepiColombo (2020)

Complete study of Mercury's magnetosphere, core, etc. featuring solar electric propulsion.

DART, HERA (2021-24)

DART is a NASA mission to study asteroid deflection, with an ESA-led follow up in 2025, HERA.

Mars 2020 (2020)

Perseverance rover is a successor to Curiosity, will look for more traces of life on Mars, and carry a helicopter drone.

Juice (2022), Europa Clipper (2024)

The Jupiter Icy Moon Orbiter and the Europa Clipper will study Jupiter moon's under-ice oceans and look for traces of life.

Dragonfly (2026)

Looking for the bricks of primitive life, Dragonfly will be a plutonium-powered drone capable of vertical take off and landing under the thick clouds of Saturn's moon.

Aditya (2025)

A 1.5-ton satellite at L1 to provide a comprehensive understanding of the Sun.

JWST

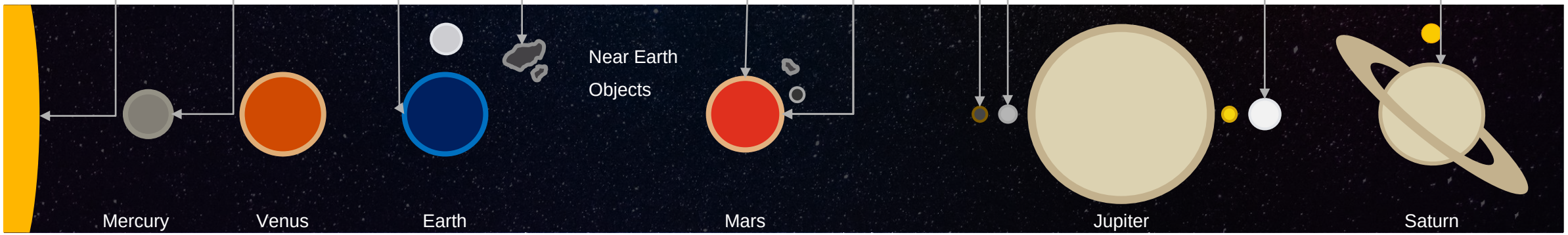
The James Webb Space Telescope will replace Hubble, and feature a 6.5-meter deployable primary mirror.

HOPE (2020)

HOPE would be the first mission of the UAE to Mars, and will study the planet's atmosphere.

Exomars (2022)

The European-Russian rover will drill 2 meters in the Martian soil to look for traces of life.



Source: PwC analysis, NASA, ISRO, CSA, ESA, JAXA, UAESA

Space regulations must comply with international laws that directly impact the domestic regulation of space activities

International Law

Outer Space Treaty (OST, 1967)	International Conventions, including	UNOOSA Guidelines
State Supervision and Liability	**1972** Convention on international liability for damages caused by space objects	**2010** Space Debris Mitigation Guidelines
Non-appropriation and freedom of exploration	**1975** Convention on the registration of objects launched in outer space	**Bilateral Agreements including**
Non-militarization of space and disallowance of weapons of mass destruction	**1979** agreement governing activities on the Moon and other bodies	**2020** Artemis Accords (9 signing parties so far)

Domestic law & regulations

Compliance with international law & guidelines	The operation of space objects
Space Debris Mitigation	Sounding rockets & sub-orbital launches
Environmental protection	Orbital launches
Liability to third-party and space insurance	Launch permit
Safety of humans and properties	Satellite operations

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

PwC is partnering with the Sirius academic Chair to develop the *Space LegalTech* platform, a platform mapping space legislations around the world in order to provide a comprehensive understanding of the global space law architecture and latest space law and space policy developments

Learn more on Space LegalTech

Source: PwC analysis

Regulatory differentiation has become an attractiveness lever for space nations

Space regulations are mostly country- specific

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

- **Some countries only have a national space law**, others have **several laws or a number of regulations** under the law,
- **States have defined their legal/regulatory framework according to the state of 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:

- Procedures 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 impacting the ease of doing business.

Elements affecting the attractiveness of a licensing / authorization process

Time duration of licensing procedures

- Duration of procedures can vary from 1 to 6+ 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-agencies process

YES / NO
- Inter-agency processes increase application delays
- Efforts in harmonization 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

- Can be tailor-made or or sometimes be fixed at more than USD 60M
- May have deterrent effects for smaller businesses

Fees

- Can be tailor-made or or sometimes be fixed at more than USD 6,000
- May have deterrent effects for smaller businesses

Source: PwC analysis

The scope and role of space agencies is evolving to better match an ever increasing downstream reach of space

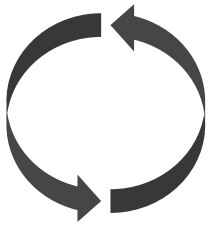
Space Agencies are required to assume new roles in relation to an evolving space environment

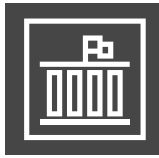
- The **space sector is increasing its reach into downstream industries** and associated value chains
- This **leads to the concept of Space Economy**, generally defined as the ensemble of core space activities and all enabled revenues, services, benefits and applications into the broader economy
- With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

New strategies of space-assets insurance are required in an era of increased in-orbit activities and STM concerns

Insurance of space assets is a new trending topic directly linked to the issue of STM

The several thousand space assets expected in orbit by 2030 (OECD, 2020) are causing **problems of orbital congestion and increased risks of in-orbit collisions**.

The development of smallsats, which are harder to track but still highly dangerous in an in-orbit collision, increases the risk of a collision event in the near future. This is **exacerbated by the development of mega-constellations**.

Multiplication of spaceports as well as launch vehicles is also becoming an issue with close-calls in rocket failures potentially leading to physical damages and deaths.

Different types of insurance are required from operators

The space insurance market is made of different types of insurances that cover different operations:

- **Property insurance** insures the value of space assets (rocket, satellite) and can be sold for the launch phase as well as years in orbit, or be bundled in "launch + 1 year" offers.
- **Third Party Liability (TPL) insurance** insures against damages dealt to third parties by the insured party's property.

Due to the increased number of assets needing to be insured, innovative insurance mechanisms could emerge in the future including "umbrella" schemes where one entity buys an insurance for a fixed value and then dispatches at its own will the amount of coverage between is different assets.

Insuring space assets is a challenge for insurers, operators as well as regulators

Insurers

The space insurance market is uncertain for insurers. **Recent market exits were registered** (SwissRe in 2019).
Decades of collected market premiums can be wiped-out in a single catastrophic event (rocket failure) or future in-orbit collision.

Operators

Insurance requirements represent an additional cost that can be substantial depending on the activity performed (launch, operation of a satellite) as well as on the financial robustness of operators (**even small insurance costs for start-ups can be impactful on activities**).
It has become increasingly costly for launch operators to insure their launchers as insurers are increasingly cautious even after launchers display positive track records.

Regulators

On one side, insurance requirements become **a component of attractiveness** for space nations. On the other side, states are liable for any damage incurred by operators they licence. **Insurance is ultimately a guarantee of responsibility from operators and proof of seriousness from regulators.**
Consequently, regulators seek a balance between the two effects.

Source: PwC analysis

Recent regulatory developments challenge the space community, notably including…

The Artemis Accords and developments around Space Resources Utilization (SRU)

Signed by 9 countries (USA, Canada, Australia, Japan, UAE, UK, Italy, Luxembourg, Ukraine), the Accords are bilateral agreements that, despite being non-binding, could set a precedent and establish practice in the area.
They cover several aspects of civilian exploration of the Moon, Mars and asteroids, but are particularly scrutinized for their treatment of extraction and utilization of space resources as an Outer Space Treaty compatible activity.

"Flags of convenience" in outer space

Current race towards loose regulations in order to attract more spacecraft and activity (regulatory competitiveness).
This creates a problem of "flag of convenience", like in maritime law, where everybody goes for the same country, creating potential safety hazards for passengers, other spacecraft and the environment.

Military space

Space military capabilities including military space forces or energy-directed weapons could violate the Outer Space Treaty or go against guidelines like the space debris mitigation guidelines (2010).

Commercial Human Spaceflight

A new legal framework is to be developed in relations to the insurance of crew members, third-parties and the registration of the space objects (orbit, trajectory…) when it comes to commercial human spaceflight.

Source: PwC analysis ; Image Credits: NASA, USAF Museum

Recent developments in Space Policy: the UAE is building a business-friendly yet responsible space policy framework

The UAE has emerged as a trusted partner to the global space community

- The UAE Space Program dates back to the 1970s and has since emerged as a proactive and innovative program that places the country among the strong contributors to the international space effort
- **Over the past couple of years, the UAE has developed a comprehensive Space Strategy as well as a complete set of legislations and regulations to attract the space economy players thanks to lean and efficient procedures**
- **The UAE is now also a credible partner in terms of space exploration with its recent Mars HOPE probe mission and its future lunar mission. In addition, the UAE has now sent its first astronaut to the ISS in the person of Hazza Al Mansouri (2019)**

Main objectives of the UAE Space Strategy & Policy

- **Becoming the Arab world leader in the space sector as well as one of the prime space nations in the world**
- **Attracting space businesses** to the UAE and take full part in the New Space revolution by **becoming a space entrepreneurs hub**
- Develop a **comprehensive set of space activities** from launch services provision, satellite manufacturing, space data innovative usages to space tourism activities
- **Inspiring new generations of space scientists** in order to secure the UAE's leading position in the space sector through a strong involvement of academic institutions

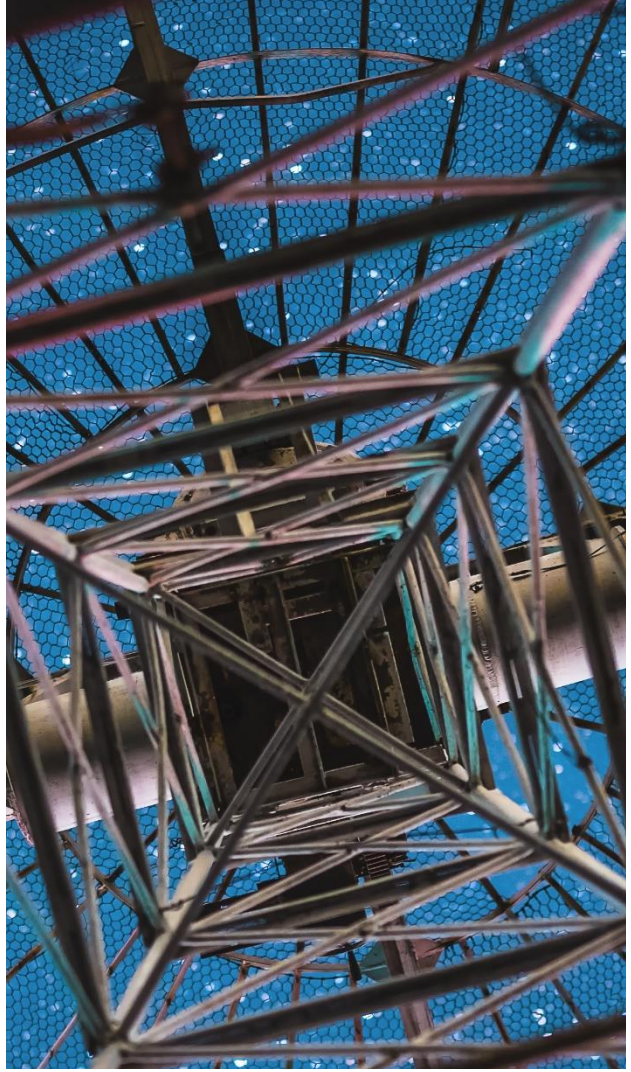
Sets of policy actions developed to attract businesses

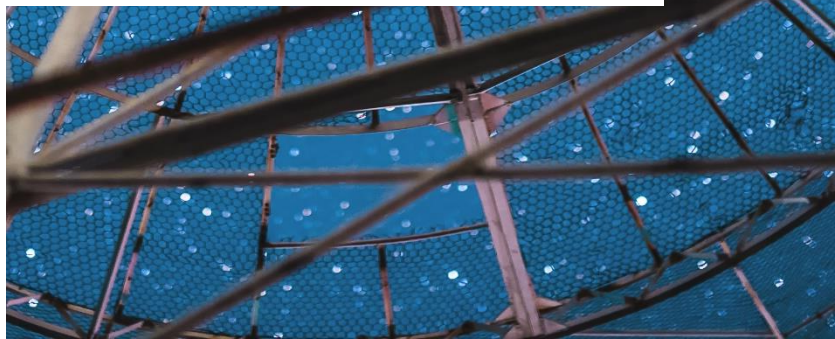
- UAE National Space Strategy
- UAE Space Policy
- The UAE Space Agency as a strong focal point for the space economy
- Strong international cooperation agreements
- Space Investment Promotion Plan including business incubation & acceleration with UAE Space Agency

The UAE is also putting forward a sustainable and responsible space sector

Space Debris Mitigation	The UAE has implemented the respect of space debris mitigation guidelines at the core of its spacecrafts licensing an authorisation process
Balanced insurance requirements	The UAE is exploring means of ensuring the development of smallsats constellations does not lead to a race to the bottom in terms of space traffic management. As such it is exploring insurance mechanisms of smallsats that are both attractive and responsible

Source: PwC analysis





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If you have questions, or wish to discuss the space sector and the challenges it faces, please contact our Space Practice leader.

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At PwC, our purpose is to build trust and society, and solve important problems. We are a network of firms based in 157 countries, with more than 237,000 people who are committed to delivering the highest quality solutions.

About the PwC Space Practice

The PwC Space Practice is part of PwC Advisory, and fully dedicated to the space sector. The core space strategy and policy team, based in Paris, is made of specialised professionals that handle space consulting across the global PwC network. Our expertise covers the entire space sector, and spans the space value chain, from upstream to downstream. We help entitire, public and private, face their business, technological, and governance challenges in constantly changing environments.