

# Our service offering for the space sector

PwC dedicated space expertise for public  
and private organizations

January 2022





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# Foreword

Space is a complex sector driven by macro-level dynamics that go beyond simple market forces, requiring a holistic view. It comprises multiple domains/segments with different specificities, it is characterised by an ever evolving regulatory and policy environment which can heavily dictate the evolutions of the sector, and it has significant reach and implications into other industrial sectors thanks to the services and applications it enables, with subsequent dependency on general macro-trends. Finally, it has considerable wider societal and economic impacts, justifying the still prevalent government spending in the sector. Indeed, Space is key to address growing challenges and needs for global connectivity, environmental monitoring and security.

Space is widely recognised as a highly strategic sector for governments, businesses and citizens on account of the vital role it plays as an enabler for a wide array of services and applications across a great number of sectors.

The space sector is experiencing significant growth and profound transformation: historically driven by institutional agendas and demand (with the possible exception of Communication) heralded by a few space faring nations, in the past two decades, the sector has experienced major changes with new entrants from both the institutional and private sectors. More private capital flowing into the industry and major evolutions and disruptions driven by the New Space paradigm in the upstream, and by digital drivers in the downstream have led to a marked reduction in barriers to entry. This has led to a variety of new nations getting into space, and to a variety of new companies (from start-ups to non-space companies exploiting adjacencies) entering the market.

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

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

With its dedicated Space Practice, PwC offers tailored

support to public and private entities in strategy, policy, technology road-mapping, market assessment, financial, technical and commercial due diligences, and economic impact assessment, to assist in their situational awareness and decision-making processes to develop space-related activities. The practice builds on a heritage and internal intellectual property assets from the PwC network of companies dating back over 30 years and leverages cross-domain sectoral expertise - paramount when operating in a sector like Space, characterized by unique market and institutional dynamics.

We target the community of institutional and private stakeholders directly involved in the sector, as well as the large existing and potential base of intermediate and end-users of space applications (from sectors like Energy, Agriculture, Insurance and Financial Services, defense and security).

With a genuine enthusiasm for Space, PwC is committed to providing effective support to organisations and companies across the entire space value chain, by working closely with our clients to define and implement appropriate and profitable strategies that enable them to thrive in such a stimulating and rapidly evolving sector.



**Dr. Luigi Scatteia**

Partner, PwC Space Practice Leader  
PwC France

Please note that the figures presented in this document are based on available data as of December 2021, and are subject to change over time. The monetary values are shown in euros and, when necessary, were converted based on the average annual exchange rate.

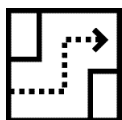


# Our service offering





# The six pillars of our offer



## STRATEGY

With a 100-year legacy in strategy consulting, PwC and its strategy consulting team Strategy& offers a unique “capabilities-driven strategy” approach to maximise its clients’ chances of success.

- Market characterisation, gap analyses and evaluation of market opportunities and barriers
- Assessment of policy options and institutional actions for market development
- Evaluation of business cases, revenue projections, business plan review
- Formulation of end-to-end business strategy, including capabilities assessment, market assessment, identification of potential ways-to-play, M&A and partnerships option, operating models and financial plan
- Support to M&A: commercial due diligence, market screening & targets identification, equity story, post-acquisition growth strategy



## SOCIO-ECONOMIC IMPACT ASSESSMENT

PwC has developed a comprehensive and commonly accepted suite of methodologies to cover the whole spectrum of socio-economic impact assessments. The approach, which has been used and validated on numerous occasions, can be applied to large-scale public or private investments.

- GDP impact assessments
- Technology & knowledge spillovers assessment
- Non-monetary impact assessments (e.g. Value of Information)
- Cost-Benefit Analyses (CBA)



## GOVERNANCE AND OPERATIONS

We support institutional bodies and private customers involved in space programmes in the analysis of governance and organisational structure to target operational excellence.

- Governance at country, programme and entity level
- Identification of funding schemes to support the development of space capabilities
- Audit of programmes and agencies governance structures to maximise economic development
- Digital transformation



## REGULATORY

We have supported public bodies to analyse regulations impacting the space sector from upstream to downstream. Our team includes legally trained consultants, supported for in-depth assessments.

- Assessment of the warranty and liability safeguards of Earth Observation and Navigation data
- Analysis of IPR, Personal Data Protection and export regulation

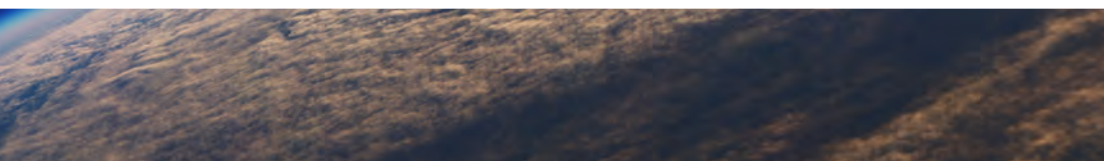
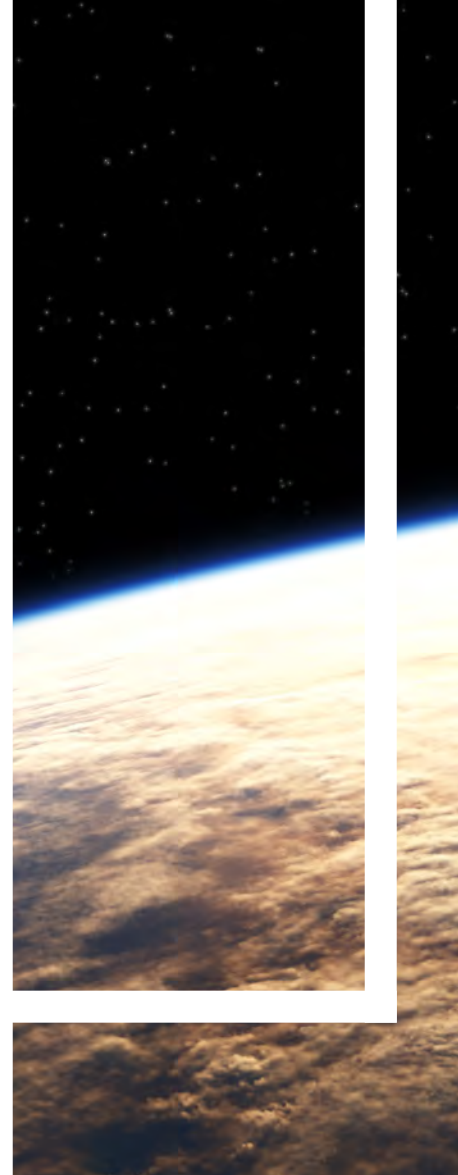


## DATA ANALYTICS: PWC INSIGHTS FROM SPACE

Thanks to our understanding of the applications of satellite data and its potential in the overall big data analytics market, we have supported commercial and institutional actors in unlocking the potential of satellite data and deriving unique analytics and insights

- Feasibility studies by identifying relevant internal use cases and developing strategic roadmaps
- Development of Proof of Concept using open sources tools and cloud-based solutions
- Support in developing internal capacity of organisations to integrate insights from satellite data

The PwC Space Practice has a set of databases covering several programmatic, technological and market aspects of the space sector. With regular updates, our database capabilities allow us to provide our customers with tailored quantitative insights on specific segments and portions of their domain of interest.



# Overview of the space sector: from infrastructure to services



# Overview of the space sector

## The Space ecosystem

The space sector value chain encompasses a variety of activities, starting with continuous, innovative research and development to manufacturing of orbital and ground infrastructure to the operation of spacecraft and finally to the delivery of products and services to end users. These activities support different space domains, traditionally divided between Communications (Satcom), Earth observation (EO), navigation (Satnav), access to space, space safety, science, and space exploration & human space-flight. Each domain has its own specificities in terms of infrastructure, business models, role of military, public civilian and private actors. The development of the space ecosystem is also more intertwined with the dynamics of adjacent industrial ecosystems such as the ICT sector, the R&I community, financing actors and cybersecurity.

## Space as a growth driver for national economies

Among the different space domains, a number of space activities are oriented towards the space sector itself such as access to space, space safety, science, exploration and in-orbit servicing. However, space remains a halo sector with wide reaching impacts beyond the space community. Communications, Earth observation and navigation sustain a myriad of services for businesses and citizens through support to climate monitoring, meteorology, transport, Location Based Services (LBS), search and rescue services, agriculture, security and defence, banking & finance, or insurance, to name a few. Space is critical for these sectors, enabling them to gain in effectiveness or even enabling their existence. As such, space infrastructure is an indispensable tool for our economy, our understanding and monitoring of environmental changes and the well-being or security of our citizen.

The data and signals received from satellites are, for most of the final users, not exploitable and applicable to their business. In order to transform space data into valuable information and actionable insights, many ecosystems of intermediate actors have emerged at the frontier between the space sector and the rest of the industries. These downstream actors, largely made of innovative start-ups and SMEs, create value through their algorithms, data fusion, leverage of artificial intelligence and other added-value services for the end users. The strong dynamics of these ecosystems over the past years reflect the vast

variety of applications that space can enable, and how space directly stimulates the economy growth.

## Space activity today

This increasing demand for space-enabled products and services drives a continuously increasing pace of deployment of space assets, reaching close to 5,000 active satellites in orbit by 2022. The increase in the number of launched and active satellites over the past 5 years is not only driven by the demand for space data, but also by the shift in the approach taken by satellite operators, deploying more and more constellations of smallsats to nanosats.

As a result, in 2021 more than 1,800 satellite have been launched, largely dominated by telecommunications, representing nearly 80% of the total launches. When excluding SpaceX's Starlink constellation from the figures (nearly 1,000 satellites), Satcom still constitutes more than half of the total spacecraft launched. Earth observation and technology demonstration are the 2 other domains driving the number of satellites launched, representing each over 150 satellites per year. Satcoms are now the main segment also in terms of mass launched, with around 550 tons launched over the year. It is followed by the human spaceflight and space stations missions which represent around 2% of number of spacecraft but total nearly 350 tons of spacecraft launched.

Globally, the launch market is dominated by China and the USA. China's Long March rockets accounted for a third of satellites launched in 2021 whereas SpaceX approximately one fifth.

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# \$ 371 bn

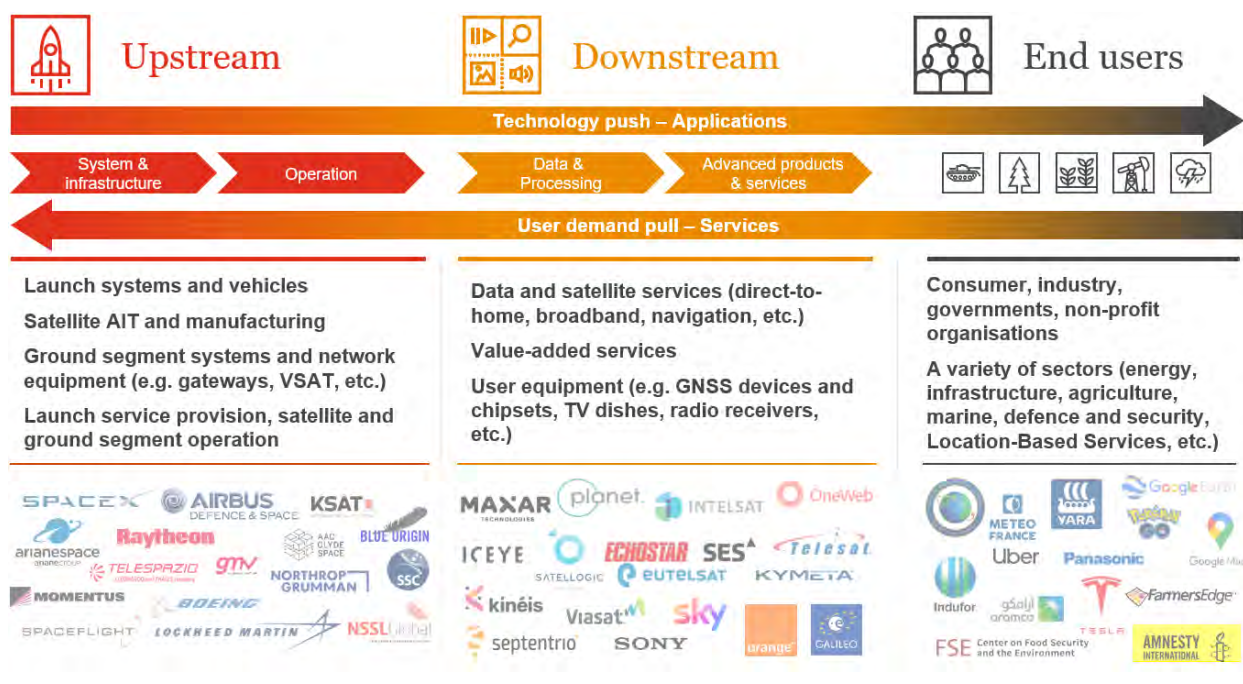
Estimated value of the global space economy in 2020 (€309bn), +9% compared to 2016



# The space value chain

The space value chain is increasingly oriented towards downstream activities. Since the emergence of NewSpace players, more and more vertically integrated actors are developing and operating their space infrastructure with a demand-oriented mindset rather than following the traditional technology push from the upstream. The incumbent large players from the upstream sector remain however the leaders for large infrastructures and satellites, in particular on the institutional and military markets.

Figure 1: Space Economy Value Chain



## The structure of the space value chain

The space value chain englobes different types of activities. The “upstream” includes the development (design and manufacturing) of the satellites and other orbital infrastructures, launch vehicles, and their associated ground segment. The upstream also includes research activities, project management and other space agencies projects. The “Midstream” includes activities related to the operation and management of the space infrastructure: ground station operation, ground segment capacity and network management, lease or sale of satellite capacity, data storage, processing and dissemination. The “Downstream” includes activities related to the end users, through the provision of space-based products

and services: broadcasting services, broadband services, geospatial products, geolocation apps, manufacturing of user equipment (antennas, satellite phones, GNSS chipsets, etc.). At the end of the space value chain are a wide variety of end users that benefit from diverse downstream applications.

## The complementary role of public and private actors

Today the space sector remains, as since its early stages in the 1950s, predominantly driven by public spending, from space agencies and governmental agencies. While the presence of private actors as customers of space





Photo: NASA

infrastructures has increased on some space domains, many domains are still quasi-exclusively funded through public procurement, combining military budgets and civilian programmes: navigation, human spaceflight, space exploration, scientific missions or space safety. The private sector is largely involved in the value chain of these domains, developing and supplying satellite equipment, orbital structures or launch services to public customers, but it remains bound the evolution of the institutional budgets.

In addition to the procurement of space infrastructures and services, governments play a central role through international and national space policies. The regulations and strategic orientations stimulate the space sector by providing national visions on space strategies, by including space data in the monitoring and policy enforcement tools, by supporting the market uptake by private space companies or by implementing cooperation frameworks between nations or regions. This stimulation is illustrated for instance in the formalisation of a national space strategy by the UAE Space Agency, the exploitation of space assets to support the UN Sustainable Development Goals

(SDGs), or the collaboration programmes between the EU and emerging countries on knowledge transfer and support to the development of a local downstream and upstream ecosystem.

The private procurement of space infrastructures has remained, historically, limited to few applications. The main business case is found in satellite communications, where large commercial satellite operators have driven, since the 1990s, the development of large GEO satellites, mostly for satellite TV and broadband services. Other examples of private operators driving the demand for space assets existed for instance in Earth observation, however the private sector has remained, for decades, closely tied to public spending, acting as the supply chain for institutional programmes. While the public sector is still by far the main source of funding for the space sector with more than 80% of the overall spending on the upstream, the dynamics observed over the past years show a progressive evolution in the landscape of the space sector and in the positioning of the private sector.



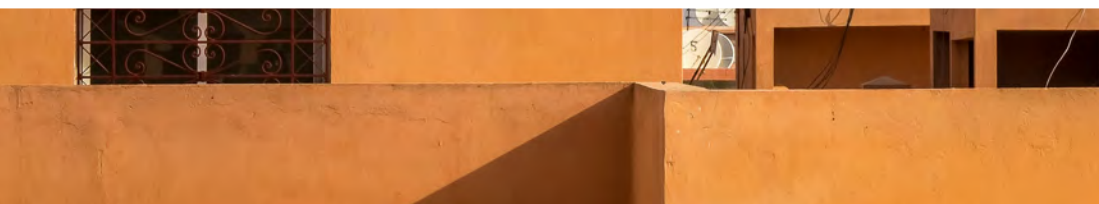
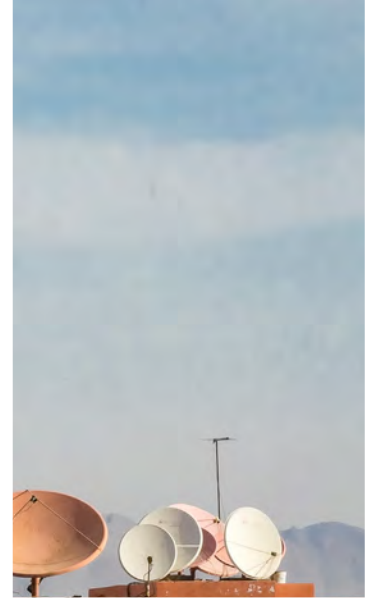


Our expertise in each space sector domain and selected recent credentials



James Webb Space Telescope  
Photo: NASA





# Satellite communication

The satcom industry and its value-chain is well-established, with over five decades of commercial existence. However, this industry is being disrupted by ventures established by dot-com Billionaires. These are rapidly changing the traditional norms of the industry from GEO to LEO architecture, and from 10s of large satellites to 100s or even 1000s of small satellites.

## Decline in mature satcom market segment

The video market has been the cornerstone application for satcom operators for decades. Today too more than half of the revenues generated within this market arrive from video. However, this market is gradually declining, especially in the developed world where the consumer habits are changing, with more preference given to Over-The-Top (OTT) platforms such as Netflix, Amazon prime etc. While in the developing world the penetration rate of OTT platforms is considerably low, but this is rapidly changing too, with regional localised platforms gaining momentum in markets such as India for instance.

## Constellations getting closer to becoming a reality

A few years ago, mega-constellation were merely a concept and were being designed on the drawing board. Today there are more than two thousand satellites that have been launched with almost 80% of them registered to one entity (Starlink). However, this is not the 1st LEO constellations wave to hit the satcom market, in the 90s too there was a commercially driven LEO wave, examples of these are Globalstar, ICO Global Communications,

and Iridium. These LEO ventures moved away from the tradition video/ DTH markets and focused their efforts on voice/mobile telephony services. Likewise, this new wave is also making efforts of moving away from the traditional video/DTH market and being more inclined towards developing a data-driven market.

## 5G becoming a real opportunity for SatCom

The fifth generation (5G) of mobile communications aims to increase connectivity by provisioning ultra-high transmission speed at ultra-low latencies with ultra-high reliability. The 5G system not only aims to connect people but also aims to provide a viable and cost effective path for applications such as IoT/M2M to take-off. While it is true that a vast majority of the 5G revenues will be directed towards MNOs, it is also true that these MNOs alone won't be able to everywhere, especially in rural regions. This opens up an opportunity for satellites, and especially LEO satellites as they could extend 5G networks remote regions, and mobility segments (air and sea).

## Antennas of the future



While the market for VSATs, TV dishes and hand-held devices is mature, the market for FPAs is largely underdeveloped. Moreover, the development of FPAs is deemed critical for mobility markets, and this is more true for the aeronautical-satcom segment. As the aviation industry requires antenna that are low profile, aerodynamic, and light weight to keep the aircraft fuel efficient and not add an additional cost burden of using extra fuel. However, the challenge here is that the technology that facilitates FPAs requires a lot of R&D spending and consumes a lot

of time when it comes to certifying such products.

#### Secure communications remain a critical need

Safety and confidentiality of communications remain a central concern, in particular for institutional users. Governments who have the capabilities keep developing secure Satcoms satellites and constellations to achieve as much as possible non-dependence, while experimenting disruptive concepts such as Quantum Key Distribution (QKD) to anticipate the future cyber threats raised by quantum computers.

2,000

Number of LEO satellites already launched for Satcom constellations Starlink and OneWeb (Source: PwC analysis)

79%

Revenues (globally) generated by Satcom services out of the Satcom value chain (Source: BryceTech)

96%

Share of the global Satcom services revenues generated by the fixed services, TV & radio (Source: BryceTech)

#### Our specialised service offering

##### Strategy

- Evaluation of business cases for innovative satellite operator go-to-market strategies
- Evaluation of business cases for satellite constellations
- Analyses of Satcom operator after-market segment potential
- Assessment of the external growth potential of satellite players resulting from diversification strategies
- Market-driven financial modelling and scenario-based forecasting

##### io-based forecasting

##### Socio-economic impact assessments

- Impact assessments of governmental Satcom programmes

##### Governance and operations

- Definition of levers to foster collaboration between satellite buyers and capacity buyers
- Technical and economic product portfolio performance evaluation and optimisation

#### Selected credentials

- Assessment of the user needs and requirements for the development of a hybrid (terrestrial and space) architecture to deliver Quantum Key Distribution (QKD) to European stakeholders
- Assessment of the EU supply chain strengths and gaps for critical components of future quantum communications satellites
- Assessment of the satellite communication requirements of governmental users and evaluation of governance scheme options for the GOVSATCOM initiative
- Business case and strategy evaluation for OEM
- vertical integration to SATCOM services
- Support to a Tier-1 space systems supplier for entry on the India market
- Green field business case development for a new SATCOM operator in Middle East / North Africa



# Earth Observation

The Earth Observation (EO) domain has raised a lot of interest from investors over the past years with 4 EO companies going public in 2021 through Special Purpose Acquisition Company (SPAC), for a cumulative valuation of US\$ 6.6 billion. In parallel, the user uptake and dissemination of EO data is progressing across the globe, with an interesting penetration in emerging space nations, notably thanks to the availability of free and open Sentinel imagery from the European Copernicus programme.

## The EO industry in a nutshell

The EO industry is growing quickly with more than 150 EO satellites launched just in 2021, raising interest from both commercial and institutional players. Over the period 2015 – 2021, US\$ 10.8 B has been invested through equity in EO companies across the globe, with the US and China capturing the lion share with respectively 43% and 32% of the global equity over the period. Over the past few years, tens of constellations have been announced with only few managing to reach a significant number of satellites in orbit, generally leading to major investment rounds and even a few IPOs announcements through SPACs (Planet, BlackSky, Satellogic, Spire).

## Supply drivers

Miniaturisation has drastically impacted the upstream part of the EO value-chain, with the vast majority of the industry turning toward smaller satellites constellation targeting very high temporal resolution (i.e. improved revisit time) at the expense of satellites' lifetime and often spatial resolution and overall imagery quality (e.g. orthorectification). Miniaturisation has notably led to

disruptive innovation for SAR satellites (i.e. which are energy intensive requiring large battery and antennas), opening interesting prospects for new commercial SAR data suppliers such as IceEye and Capella.

Most new players and incumbents are pushing toward vertical integration and trying to go down the value-chain to capture higher margin in the EO applications and services market, notably the fast-growing EO Big Data Analytics (BDA) market. The EO BDA market refers to processing and applications-specific analysis of multiple images and a wide variety of data sets in order to extract statistical information (i.e. analysis of an area of interest (AOI) over a set of period of time permitting the extrapolation of trends, automated change detection and/or abnormal behaviour identification).

## Demand drivers

The recent years have stimulated the use of satellite imagery-based applications and services across different domains and industries. In that sense, the European Copernicus programme, following the US Landsat

programme, has played a major role in the strong democratisation of the use of EO data by offering very large volume of free & open satellite data (Sentinels), basic information products based on satellite imagery but also freely available trainings stimulating user uptake and data dissemination. This availability of un-precedent scale of open satellite imagery has drastically contributed to raising awareness outside of expert communities (e.g.

Earth scientists, Defence analysts, etc.) therefore facilitating the R&D exploration and experimentation at low cost by end-users. Recent developments have notably seen a rising interest in the use of satellite imagery for parametric insurance (i.e. index-based risk insurance, notably related to climate risks), smart municipalities and for the growing concern of Environment Social and Corporate Governance (ESG) for industries and financial services.

**\$6.02 B**

Global EO industry in 2021  
(downstream + manufacturing)  
(Source: PwC)

**18.4%**

CAGR for EO BDA over the period  
2021 - 2024 (Source: NSR, PwC  
analysis)

**\$6.6 B**

Cumulative valuation for EO  
companies announcing SPAC  
merger in 2021 (Source: PwC)

### Our specialised service offering

#### Strategy

- Analyses of EO downstream market technology governance, business and demand trends
- Benchmarking of existing platforms' cloud computing capabilities and user interfaces
- Market dynamics analysis for both downstream and upstream EO market
- User requirements identification for specialised offering (e.g. large-scale event monitoring, parametric insurance, ESG reporting for finance, retail,

etc.)

- Benchmark of commercial solutions for end-users

#### Socio-economic impact assessments

- GDP impact assessments of EO programmes
- Assessments of socio-economic benefits on the EO downstream and end-user markets
- Knowledge spillovers assessment (downstream)
- Technology spillovers assessment derived from public investments

#### Regulatory

- Benchmark of main EO regulations at global level
- Drafting business friendly EO data regulations

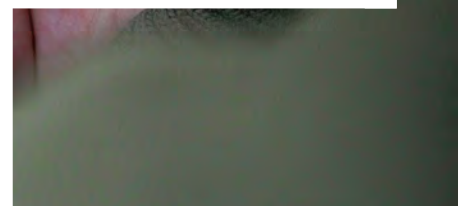
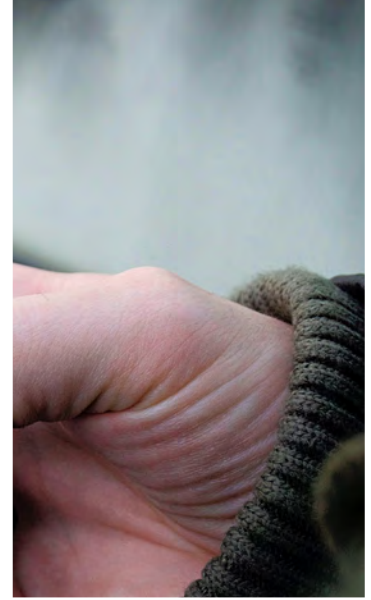
### Selected credentials

- Business strategy definition for a geospatial leader in the Gulf region, including current capabilities assessment, business model & financial plan development, and strategy implementation
- Strategic market assessment of the satellite-based geospatial data and analytics market for a growing US-based EO start-up
- Strategic commercial due diligence (buyer side) of a major player in the global EO sector with an in-depth analysis of the market dynamics, competitive landscape, market sizing and competitive positioning, product and service portfolio, technical capabilities, regulatory considerations
- Strategic commercial due diligence of a EO sector player (buyer side) of a EO company

serving the defence and intelligence market

- Business plan review of a leader in geo-information and satellite manufacturing in Europe
- Strategic market assessment and go-to-market for the introduction of new innovative EO offering, for a leader in Europe
- Strategic market assessment and go-to-market for the introduction of new innovative EO offer (hyperspectral) for a start-up in North America
- Review of an on-going programme related to the development of an Earth Observation capacity for defence and intelligence application in a European country





# Navigation

Satellites provide positioning and timing services to a global user base. With the increasing penetration of connected devices in industries, GNSS is more widely used than ever, integrated into consumer electronics, military hardware, connected vehicles, safety of life beacons, and more, representing an immense and ever-growing market.

**Diverse players enter the market, increasing resilience, bringing new technology and improving overall service**

Multiple nations currently possess fully operational satellite navigation constellations while other governments are expressing interest in developing their own capabilities.

Existing systems are launching next generation satellites like GPS III, Galileo 2nd Gen, BeiDou-2 and future GLONASS K2 that offer multi-frequency services on interoperable bands, therefore facilitating multi frequency & multi constellation capabilities and opening up new applications

This exclusive dependence on public systems has led to some resiliency concerns. The recent formation of the Open PNT Industry Alliance shows the interest in developing alternate back up systems to legacy GNSS, and includes firms proposing GNSS LEO constellations, who have received funding from investors.

Also addressing emerging concerns, Galileo adds critical capabilities such as OS-NMA (which enables verification that a signal was sent by a Galileo satellite and not a potentially malicious entity), and the RLS (a response signal emitted by Galileo to a distress beacon that assures the person in distress that their signal has been received).

**Safety and liability critical use cases demand reliability**

Improved navigation capabilities have led to more demanding and safety/liability critical use cases such as search and rescue beacons, air navigation and advanced driver assistance. For example, during the early stages of the COVID-19 pandemic, high precision GNSS signals guided medical UAV, in disinfection missions in hard to reach areas of China.

Commercial downstream ventures are capitalising on this need with augmentation services such as RTK and PPP for highly precise positioning. Others develop improved receivers that leverage inertial measurement units on vehicles or RAIM on aircraft for additional improvement to the signal beyond SBAS. These receivers further enable emerging applications such as autonomous vehicles, 4D trajectory operations and LPV200 approaches in aviation, drone activity, etc.

Similarly, development of new GNSS augmentation systems for uncovered regions such as Africa-Indian Ocean, Russia, Australia-New Zealand, China and others should further increase GNSS precision and reliability, further increasing uptake for safety/liability critical use cases.

**Consumer solutions and road remain the largest GNSS**



### market segments

The road and consumer solutions markets together account for 93.3% of the cumulative revenues of GNSS industry (2019 to 2029). Due to the increasing ubiquity of smart devices, GNSS terminals are increasingly used in daily life in smartphones, fitness trackers, wearables and health devices for an aging population. Similarly, the development of increasingly intelligent driving assistance

systems demands more precise and reliable positioning from satellite navigation.

By playing a pivotal role in timing, mobility and transport, GNSS also optimises logistics, reducing fuel consumption and supporting smart mobility solutions like rideshare. GNSS also supports aircraft precise positioning, ship routing, rail logistics, and time synchronisation in energy, supporting resource efficiency in these sectors.

€ 151bn

Estimated revenues of the entirety of the downstream sector in 2019  
(Source: GNSS Market Report)

102

Estimated number of navigation satellites in MEO as of 2020  
(Source: PwC)

7.9%

Estimated CAGR (2019 to 2029)  
(Source: GNSS Market Report, PwC Analysis)

### Our specialised service offering

#### Strategy

- Market assessments of GNSS components, programmes and services
- Assessments of market opportunities for regional augmentation systems deployment
- Assessments of high-precision signal exploitation business models
- Characterisation of excellence centres developing GNSS solutions and services

#### Socio-economic impact assessments

- GDP impact assessments of GNSS programmes,

including funding instruments

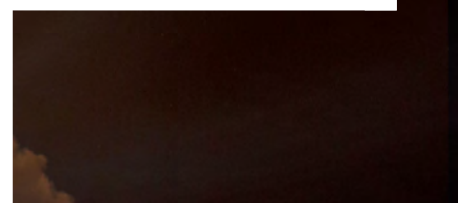
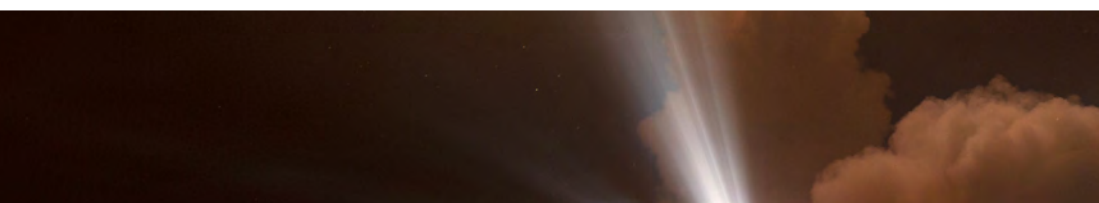
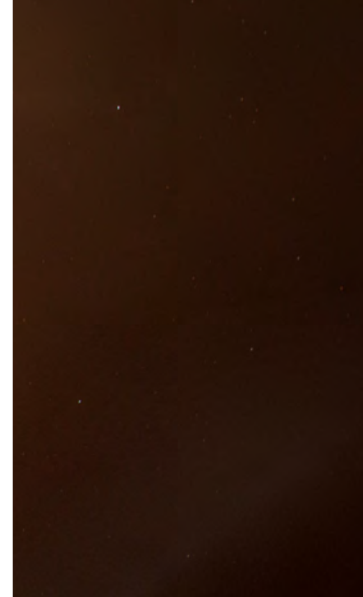
- Socio-economic impact assessment of GNSS programmes including funding instruments
- Impact assessment of risks associated with signal spamming and spoofing
- Environmental impact and benefits assessment of GNSS activity

#### Regulatory

- Analysis of warranty and liability safeguards embedded in EGNSS programmes
- Assessment of liabilities in specific sectors associated with the use of GNSS products

### Selected credentials

- Impact assessment of Fundamental Elements and H2020 GNSS funding tools and associated GNSS market and technology gap assessment
- Identification of potential prime management options for the development and procurement phases of the second generation Galileo satellites
- Evaluation of future disruption potential for navigation technologies for a US terminal/system manufacturer
- Market assessment and technology analysis for the Galileo atomic clock supply chain, leading to policy action recommendations
- Characterisation of the financial and technical tools to support EGNSS downstream business and R&D, analysing the synergies between the Fundamental Elements programme and other Horizon 2020 EGNSS calls
- Critical review of business plans for projects funded under the EU Fundamental Elements programme



# Launchers

Commercial access to space has become increasingly competitive on the global market, pushing for innovations and an adaptation of the economic model of the launcher industry. For spacefaring nations, this is particularly important for the protection of a domestic and independent access to space.

## Strategic assets for spacefaring nations

Independent access to space not only depends on being autonomous in terms of technology and infrastructure (i.e., the industrial base and spaceports). With new market entrants increasing competition on launch costs, independent access to space is now also relying on the economic sustainability of the launch sector. New industrial set-ups and practices, as well as modularity or innovative technologies, such as micro-launchers and reusable rockets, will drive the competitiveness of the launch sector.

## Growing competition on the open launch market

Competition in the launch sector has traditionally been between fully or partially state-owned industries. As the delivery of certain payloads is important to the national security of launching countries, a significant part of launch services used to be denied to private companies. However with increases in reliability being observed we

see more and more military/governmental demand being addressed to private players. On the open market, newly created private companies and non-historical spacefaring nations have been disrupting the established norms. As a result of the increasing competition, spacefaring nations have promoted their domestic launch systems through dedicated policies and measures, and also pushed their national companies to improve or develop new launch vehicles.

## Innovation as a strategic advantage

Launcher integrators and launch service providers are aiming at expanding their scope of activities through innovation and vertical and horizontal integration. Technological innovations, such as partial or full launcher reusability, methane propulsion or additive layer manufacturing, are expected to bring a strategic advantage on the launch market while also tackling growing concerns on the environmental impact of access to space.

### Launch companies need to increase their customer base

Despite being subsidised by governments due to its strategic importance, the launch sector is expected to face stable or declining government financing for flagship space programmes. As a consequence, launch companies will have to evolve and examine new markets. Historical launcher manufacturers and their associated service providers are considering new kinds of services,

such as using micro-launchers for the flexible delivery of small satellites deployed as part of large satellite constellation programmes. In addition, new business models emerge that integrate the latest innovations for a greater flexibility like the development of piggyback and rideshare solutions via satellite dispensers.

# 113

Average number of yearly orbital launches on average over 2017-2021 period

# 146

Orbital launches performed in 2021 alone

# 3 out of 4

launches in 2021 were conducted by China and the US, with China leading the way

## Our specialised service offering

### Strategy

- Revenue projections of global competitors
- Customer surveys
- Analysis of the market potential for new entrants
- Analysis of diversification strategies for launch vehicle manufacturers

### Socio-economic impact assessments

- GDP impact assessments of launcher programmes
- Scenario analyses of the impact of partial to full

reusable vehicles

### Governance and operations

- Analysis of the governance between public and private actors to maximize competitiveness of launcher operations
- Support in the modernisation of launch facilities

### Regulatory

- Analysis of regulations associated with launcher programmes (e.g. export control, IPR)

## Selected credentials

- Benchmarking of the major space nations' launch capabilities
- Critical analysis of a business plan and added-value of the launcher system of a European micro launcher company
- Benchmarking of the major European space nations' launch capabilities and policies for the European Commission
- Socio-economic impact assessment of the Ariane 6 and Vega-C programmes
- Market assessment of the European micro-launcher market for a space agency
- Support in the analysis of business and operating models for a spaceport operating

micro-launchers

- Global launch market forecast for a large rocket propellant provider and space hardware manufacturer
- Support to the definition and implementation of Data strategy in the context of the development of a future launcher



# Space Safety

The use of space has helped enhance the global economy, provide social benefits, support environmental protection activities, and ensure strategic sovereignty. Therefore, many sectors and activities rely on the protection of space assets against threats such as man-made space objects, space weather events and near-Earth objects. The increased usage of the space environment highlights the importance of Space Safety activities.

## The application of Space Safety measures appears as unavoidable for space sustainability

Current debris mitigation measures alone cannot represent a long-term solution to guarantee a safe and sustainable usage of the space environment. Indeed, given the strategic importance of space infrastructure and considering the significant increase of space traffic expected to materialise within the next decades, the need to define, implement and operate a Space Traffic Management system has been identified. The debris population is expected to increase due to an upsurge of space activities in the coming years with the potential deployment of mega-constellations primarily instigated by commercial players who benefit from cheaper and simplified access to space solutions. Therefore, current Space Situational Awareness activities are expected to evolve in the more complex concept of Space Traffic Management.

## The implementation of effective Space Safety measures faces multiple challenges

Efficient space safety measures protecting the space environment and activities require efficient and timely surveillance and tracking means. Even though some major space faring nations such as the US dispose of advanced SST technology, ways to acquire an exhaustive a fully catalogue of objects that can be constantly tracked are still being developed. In addition, difficulties in reaching an international consensus can be observed. New issues raised by the development of New Space activities call for legal and regulatory activities. Even though early ideas about the need to develop “traffic rules for outer space” were already put forth in the 1980s, as to now, the legal and regulatory framework does not conceptualize a fully-fledged traffic management system. Furthermore, it is difficult to enforce existing guidelines, even if they are transformed into (binding) national laws. With current global observation capabilities, it is difficult to collect proof that satellite owners and operators have intentionally tried to circumvent space debris mitigation measures.



### Space Safety has a strategic dimension

Space Safety components such as Space Traffic Management are expected to play a political and strategic role. European decision makers must carefully consider the legal perspectives of Space Traffic Management, and closely examine the legal and regulatory framework that is being developed by the by other institutions in order to prevent future European Space activities to be imposed by standards that would diminish Europe' strategic position in space. National legal and regulatory

initiatives are, in the view of some States, more and more at the forefront of the progressive development of space law. While the US is supporting the development of a commercial ecosystem for the provision of STM services, the European ecosystem is still to be consolidated. However, the creation of a market involving the provision of STM services and their underlying business cases are subject to many examinations.

30,630

Number of debris actively tracked and catalogued by SST capabilities

36,500

Estimated number of objects greater than 10 cm as of Jan 2022 based on breakup modelling (source: ESA)

1M

Estimated number of objects between 1 and 10 cm as of Jan 2022 based on breakup modelling (source: ESA)

#### Our specialised service offering

##### Strategy

- Assessments of market opportunities for the deployment of Surveillance and Tracking solutions
- Forecast of changes in space traffic
- Revenue projection for surveillance and tracking radar systems

##### Socio-economic impact assessments

- Identification and assessment of impacts resulting from the evolution of the SSA landscape
- Cost Benefit Analysis (CBA) for the implementation of a Space Situational Awareness-related pro-

##### grammes

##### Governance and operations

- Support to the design and characterisation of potential programme governance structures
- Evaluation of organisational and operational efficiency

##### Regulatory

- Support to the definition of data policy for space surveillance information

#### Selected credentials

- Socio-economic Impact Assessment of ESA's Space safety programme
- Impact Assessment of European Space Traffic Management Activities
- Understanding of Space safety for the needs of future projects and activities of a national Space Programme
- Support in the definition of the strategy toward the rise of Space Traffic Management for a national government
- Study on the impacts of the EU space surveillance and tracking actions in the Space Strategy for Europe In line with the focus of the Space Strategy for Europe
- Assessment of the dependence of the European Economy on Space Infrastructure
- Ex-ante cost benefit analysis of the ESA SSA programmes, covering space weather, Near Earth Objects and Space Surveillance tracking



# Exploration and in-orbit economy

Exploratory activities have enabled humankind to achieve remarkable technological, scientific, and societal milestones. It has been a sector that heavily relied on political will and government funding. This is gradually changing with the advent of private sector investment aiming to commercialise space exploration activities.

## Development of a commercial LEO economy

Privatisation and commercialisation of LEO assets to develop new use-cases and applications is a major trend. Both in terms of commercialising existing assets (ISS) and development new assets in LEO. For instance, companies such as Kayser Italia, Space Applications Services, and Airbus D&S have already deployed commercially accessible platforms on the ISS. While organisations such as the Axiom Space are developing an entire space station to support activities such as space tourism, and to conduct R&D activities in micro-gravity environment.

## Terrestrial industries playing a role towards developing a sustainable Lunar economy

The idea of developing a sustainable Lunar economy by deploying In-Situ Resource Utilisation (ISRU) technologies on the Moon is building traction not only within the space industry but is also finding a sizeable audience within terrestrial industries such as the telecommunica-

tions sector, automobile sector, O&G and mining sector. For instance, automotive companies are pouring in their decades of experience aimed at developing Lunar rovers, prime examples of such companies are Toyota, and Audi (VW group).

## Space exploration moving from “only science & technology” to “commerce, science & technology”

Exploration of Celestial bodies has always been one of the pioneering objectives of space activities, mainly driven by the scientific value of discovering new environments and have a better understanding of the origin of the Solar system and deep space environment. However, today the scenario has starkly changed, especially after countries such as the USA and the Grand Duchy of Luxembourg provided legal certainty and regulatory framework that ensures private space operators' rights, regarding the future ownership of minerals extracted in space from asteroids.

### A globalised effort aimed towards exploring the moon

While it is evident that big space powers with sizeable budgets such as USA and the European Union are avid advocates of space exploration to the moon, mars and beyond. More recently this momentum has transferred to new space fairing nations such as the UAE, for instance, UAE's hope mission to Mars and the upcoming Lunar rover mission to the moon. Likewise, Canada too is showing

a significant amount of interest in developing prospects to support a lunar economy, this is evidenced by their investment of USD 150M to fund the Lunar Exploration Acceleration Programme (LEAP) by 2025.

# \$63 bn

Estimated cumulative market for in-situ resources utilisation on the Moon between 2020 and 2040 (Source: PwC)

# \$9.7 bn

Total cost (development and operations) of the James Webb space telescope launched in December 2021 (Source: US GAO)

# 2025

Updated earliest horizon for the return of humans on the Moon as part of the Artemis programme (Source: NASA)

## Our specialised service offering

### Strategy

- Market opportunities sizing for exploration markets
- Business case assessment and revenue projection
- Gap analysis and identification of market barriers
- Definition of technology roadmaps for future space exploration programmes

### Socio-economic impact assessments

- Assessment of market spillovers and technology spin-offs
- Impact assessment for Moon exploration activities

and other space exploration activities

### Governance and operations

- Analyses of investor satisfaction
- Requirements and configuration management

### Regulatory

- Analysis of the legal framework for space mining

## Selected credentials

- Market characterisation, sizing and forecast for lunar transportation, lunar data (environment, telemetry) and lunar resources utilisation up to 2030
- Study on potential future markets of Space Resource Utilisation (SRU), including socio-economic benefits and a technological roadmap covering each stage of the value chain
- Socio-economic impact assessment of ESA's participation in the ISS programme, including GDP impact, catalytic benefits and wider benefits
- Ex-ante socio-economic assessment of ESA's new partnership proposals for the use of the

ISS, LEO exploitation and lunar exploration

- Provision of recommendations for the establishment of a Space Resources Utilisation regulatory framework for a space agency in the Middle East
- Ex-post and ex-ante socio-economic impact assessment of ESA's Science Programme missions, covering 4 past missions and 4 future missions





# Ground segment services

Satellite communication has been made possible thanks to ground segment for decades, and as the satellite industry has evolved, ground segment has also been going through profound mutations, supported by the development of technologies like Artificial Intelligence or Inter Satellite Links

## What is Ground Segment

Ground segment is the sine qua non condition to operate satellites and ensure mission success for satellite operators (e.g. provision of EO images, telecommunication and navigation signals, etc.). Ground stations are necessary to communicate with satellites, send telecommands and downlink telemetries (e.g. mission data, satellite status). This communication is performed throughout the satellite life cycle, from Launch and Early Orbit Phase (LEOP), through commissioning, routine and critical operations, up to satellite end-of-life and decommissioning.

## Outsourcing of ground segment activities

Ground segment is a costly infrastructure requiring significant investment and time. Developing ground segment indeed requires investment to build and maintain a ground station network or to hire specific workforce, but to deal with regulatory aspects (e.g. licensing procedures are demanding). For these reasons, GS activities have been outsourced for years by satellite operators.

## Ground Segment as a Service (GSaaS)

With New Space, new satellite operators entered the market, that have different needs compared to large

satellite operators. To answer these needs, GSaaS was created, making access to space easier, enabling satellite operators switch their CAPEX to OPEX. Outsourcing ground segment activities is nothing new, but GSaaS is characterized by increased simplicity, flexibility and cost-effectiveness. While today, most GSaaS users are commercial satellite operators with EO, IoT or technology satellites, we expect more public entities (including military) and new applications to be covered by GSaaS (e.g. Lunar and Deep Space applications).

## Regulation

Licensing schemes (i.e. procedures, fees, etc.) can make it hard for satellite operators to predict the date of completion and activation of their ground stations, especially because they are not harmonized on a global scale. Attempts to streamline and provide various paths for licensing performed by entities like the FCC is expected to alleviate these pain points.

## Drivers

Large LEO constellations will require adaptation of the ground equipment and user equipment. Indeed, a large number of ground stations and gateways will be neces-



sary to operate constellations of hundreds or thousands of satellites. For example, in a configuration of 4425 satellites, it was estimated that SpaceX would need to install 123 ground stations and 3500 gateways to operate at full power their satellite constellation.

#### Technologies

Ground Segment service providers are expected to rely on various advancements and emerging technologies. Intersatellite links (ISLs) can reduce ground segment challenges, especially for large constellations that require an important number of stations. Optical communications are particularly interesting for ISLs as they offer increased

security, higher data rates, less interferences, and not affected by weather conditions, contrary to ground links.

AI is expected to be used in space and on ground to save time and money (i.e. reduced staffing) while improving performance (e.g. more efficient satellite operation), through onboard processing and assisting operators in massive deployment and management of constellations.

Finally, Electronically Steered Antennas (ESAs) could enable more automatized satellite management and control, especially for large constellations, although their cost remains a strong barrier today.

# 3500

Gateways necessary to operate at full power SpaceX's 4425 satellites constellation

# 10-15%

Weight of the OPEX in satellite operations

# \$130 B

Satellite ground equipment market in 2019

#### Our specialised service offering

##### Strategy

- Market characterization, value chain analysis
- Go-to-market strategy, support in "make or buy" decision-making
- Assessment of demand
- Identification of technologies influencing the ground segment market

##### Socio-economic impact assessments

- Identification and assessment of impacts resulting from the evolution of the ground segment landscape
- Cost Benefit Analysis (CBA) for the engineering

and operation of ground systems

##### Governance and operations

- Support to the design and characterisation of potential programme governance structures
- Evaluation of organisational and operational efficiency

##### Regulatory

- Support to the identification of regulations that could favour/unfavour the development of ground segment activities

#### Selected credentials

- Socio economic impact assessment of ESA's ground systems engineering and operations activities & related foresight study
- Overview of current Ground Segment as a Service (GSaaS) market trends and dynamics to support telecommunication company strategic positioning options
- Technical consultancy support to the ISS Columbus control centre and Ground segment communications architecture



## Featured initiative: the Space Legal Tech





# The Space Legal Tech

To illustrate our understanding of the Space regulatory environment and our service offering in space policies and regulations, we have teamed up with the SIRIUS Space Law academic chair to develop the Space LegalTech ([www.spacelegaltech.com](http://www.spacelegaltech.com)), the most advanced and free online platform for Space Laws & Regulations.

Via the Space LegalTech, we are able to channel the expertise we develop by supporting space agencies in developing space policies and regulations that are tailored to their individual needs, or by helping private space actors understand the regulatory environment in which they navigate.

## Description of the initiative

Through the Space LegalTech we are happy to share high level insights on space laws and regulations at the global level. By navigating our free online portal, you can read through the different pieces of Space legislation of each country, filtering through activities, scopes and legal mechanisms to identify specific legal documents you are looking for. And this is made even easier via an interactive map we have integrated, for a more visual experience.

We've also added all relevant international treaties that relate to space and anticipated incoming enthusiasm for Moon exploration by adding a dedicated page on laws that govern activities on the Moon.

But we are not stopping there ! On the Space LegalTech portal, you'll be able to access information on Space Agencies around the globe, including the regulatory procedures of major agencies, but also locate on the map

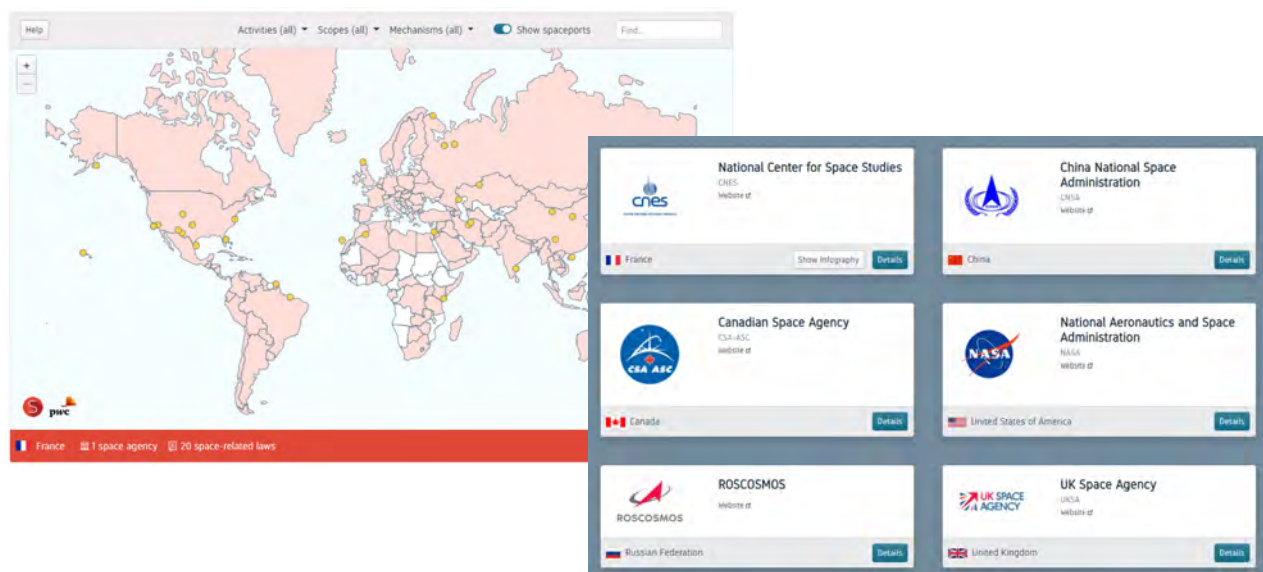
the different operating spaceports that provide access to space or space tourism activities.

## Data used

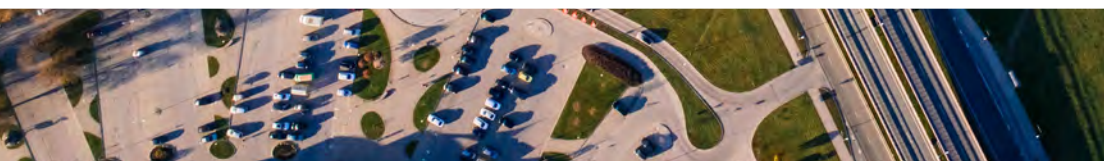
The Space LegalTech uses information collected on global space regulations by the Sirius Space Business & Law academic chair of the University of Toulouse-1 Capitole and by hands-on practical experience of space laws from PwC's Space Practice activities in the space sector, as long as this data is publicly disclosed..

## Current progress

The Space LegalTech platform is live and available at [www.spacelegaltech.com](http://www.spacelegaltech.com) ! We are constantly updating our database to provide the latest and most reliable information on space legislations at the global level. We will also be adding new features in the future, including insights on Frequencies regulation and in-orbit satellites.







# PwC Insights from Space



# Space data for business insights

Satellite data coupled with advancements in cloud computing has opened avenues to unprecedented levels of analysis. The ever-lowering barriers to entry for utilisation of satellite data brings forth new use cases and possibilities for business insights in various sectors, but also for strategy and policy consulting.

Over the past decade, the PwC Space Practice has gathered a deep expertise on the applications of satellite data for commercial use cases and policy monitoring. Due to extensive work with data & analytics providers, policymakers and end-user communities, the team has a unique understanding of the potential of satellite data in generating insights for both commercial and institutional actors across applications' domains. The raising interest and concern related to sustainability, environmental protection and climate change mitigation & adaptation makes the use of satellite data more critical than ever.

## The benefits of satellite data

Satellite data is unique in that it offers worldwide coverage over long periods of time, allowing a user to both monitor changes as they unfold or look years back in time at how a variable of interest has changed. Due to satellites being in orbit, they are resilient to terrestrial conditions (extreme weather, remoteness, etc.) and image vast amounts of the Earth constantly. The consistent, reliable, macroscopic view they provide, however, often makes them complementary to in-situ and aerial data, with the most valuable insights stemming from data fusion.

## Satellite data for business

With vast amounts of free open data available (such as Copernicus data & information) and increasing competition in the commercial data landscape, the accessibility

of this data to both expert and non-expert user communities is greatly increasing. Fusion between satellite data and other business relevant data can lead to new insights, especially powered by recent advancements in cloud computing and artificial intelligence. Such insights support business leaders in strategic, data-driven decision-making. The exploitation of satellite-based analytics is becoming crucial in a context of growing awareness and consciousness about sustainability and environmental issues, notably by better contributing to an improvement of Environmental, Social, and Governance (ESG) reporting.

Nevertheless, there exist some barriers to adoption stemming both from the supply side and the demand side.

### Supply side barriers (from satellite data & analytics providers):

- Lack of specific sectoral expertise or knowledge of sectoral trends and precise user needs
- Lack of access to the customers across industries along with diverse procurement habits

### Demand side barriers (from end-users):

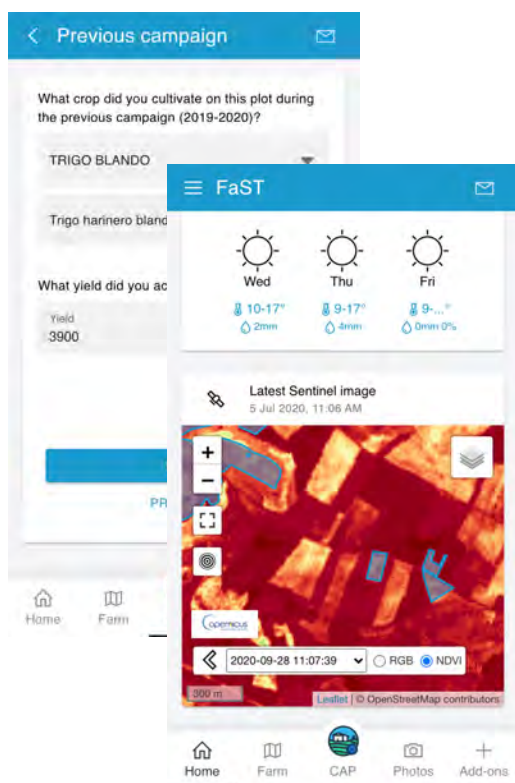
- Lack of understanding of the value added from the use of satellite data
- Lack of time, resources and/or knowledge & expertise to efficiently absorb and exploit satellite capacities

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Data collected from satellites offers huge commercial opportunities in various industries but its potential has remained largely untapped.

PwC's Insights from Space applies advanced analytics derived from integrating and analysing satellite data combined with other sources to generate deep business intelligence.





## Screenshots and description of a Crop Nutrient Management application developed by PwC

### Tool Description

FaST (Farm Sustainability Tool) is a mobile application developed for enhancing farm management by supporting farmers in the development of an accurate Nutrient Management Plan (NMP) for their crops, in accordance with the Common Agricultural Policy of the European Union.

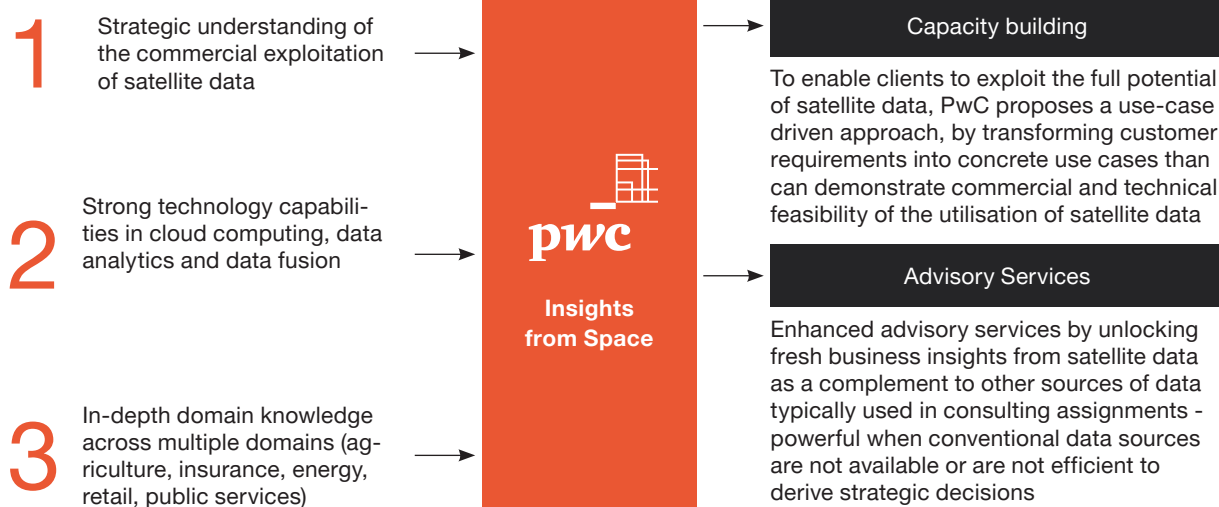
### Data used

Satellite data (Sentinel), in-situ farm data, other sources of data.

### Value

Improved decision support for farmers incorporating environmental considerations and thus facilitating large-scale digitalisation.

Based on our internal capabilities in geospatial analytics, cloud computing and data fusion along with our in-depth expertise in Earth observation, “Insights from Space” supports businesses in exploiting the full potential of satellite data for deriving fresh insights.







## Our specialised service offering

### PwC Insights from Space: Capacity Building

- Feasibility studies to identify use cases for commercial and technical demonstration based on organisational needs
- Development of Proofs of Concept(s) (POC) to demonstrate value of satellite data when combined with other sources of data
- Development of strategic road-maps for organisations to facilitate efficient scaling up of internal capacities to exploit satellite data
- Design of scalable architecture on which clients

will be able to leverage on to build their internal capacities

### PwC Insights from Space: Advisory Services

- Market assessment & demand analysis
- Competitive landscape analysis
- Support in diversification strategies
- Support in decision-taking related to infrastructure and asset management
- Policy monitoring and advisory on institutional actions

## Customer segments and selected credentials



Energy



Financial sector



Public services



Retail



Insurance



Agriculture



Others

### Policy monitoring & sustainable farming (capacity building)

Feasibility study and end-to-end development & implementation of mobile-based & desktop applications providing recommendations on the use of fertilizers. The project was notably including the development of the platform architecture and training of the local authority's staff.

### Advisory services for Retail & Energy

Feasibility study related to the development of tool supporting decision making by visualizing a network of gas stations, assessing potential demand for each station and offering recommendations on possible diversification of offering (e.g. food & beverage, maintenance services, hotel, etc.).

### ESG reporting for an investment fund

Development of a proof-of-concept (POC) of a visualisation tool to support ESG reporting for an investment fund leveraging satellite data, Copernicus data & information and additional geo-referenced data sets. The POC aimed at facilitating visualisation of investments portfolio by geo-referencing assets and protected areas (e.g. nitrate vulnerable zones, Natura2000, water-stress areas, etc.) to report potential risks on biodiversity for ESG reporting purpose.

### Conformity, tax compliance & fraud

Mapping and analysis of current use cases & opportunities, benchmark of commercial solutions & existing initiatives leveraging satellite data for this type of applications

Feasibility study related to the development of satellite-based monitoring capacity related to several use cases: tax declaration compliance & conformity; assessment of potential pool of tax-payers.

### Insurance (capacity building)

Feasibility study related to capacity building for a major insurance player related to flash flooding use case based on satellite imagery with development of a proof-of-concept (POC) and platform architecture. The analysis was notably including a specific cost benefit analysis (CBA).

### Agricultural Finance (capacity building)

Design and implementation of a platform for data-driven agricultural finance focused on Agri-SMEs located in the Eastern Europe and Central Asia ("ECA") regions, leveraging precise input data (e.g., data from official data bases, satellite imagery, ground sensors, etc.) as well as reliable models for crop production, and optimally automated services to approve loans.



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## About PwC and the space sector

### Data

The information presented in this document are based on available data as of December 2021, and are subject to change over time.

### About the PwC network

At PwC, our purpose is to build trust in society and solve important problems. We're a network of firms in 157 countries with more than 208,000 people who are committed to delivering the highest quality solutions in advisory, assurance and tax services.

### About the PwC Space Practice

The PwC Space Practice is part of the PwC Advisory practice, which includes strategy and consulting. The PwC Space Practice is fully dedicated to the space sector. Our team includes specialists from all space sectors who are supported by consultants from the global PwC network. Our expertise covers the entire space sector and spans the value chain, from upstream to downstream. We help entities, public and private, to face their business, technological and governance challenges in a constantly changing environment.

Photo front cover: ULA Atlas V Liftoff, NASA

Photo back cover: SpaceX



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