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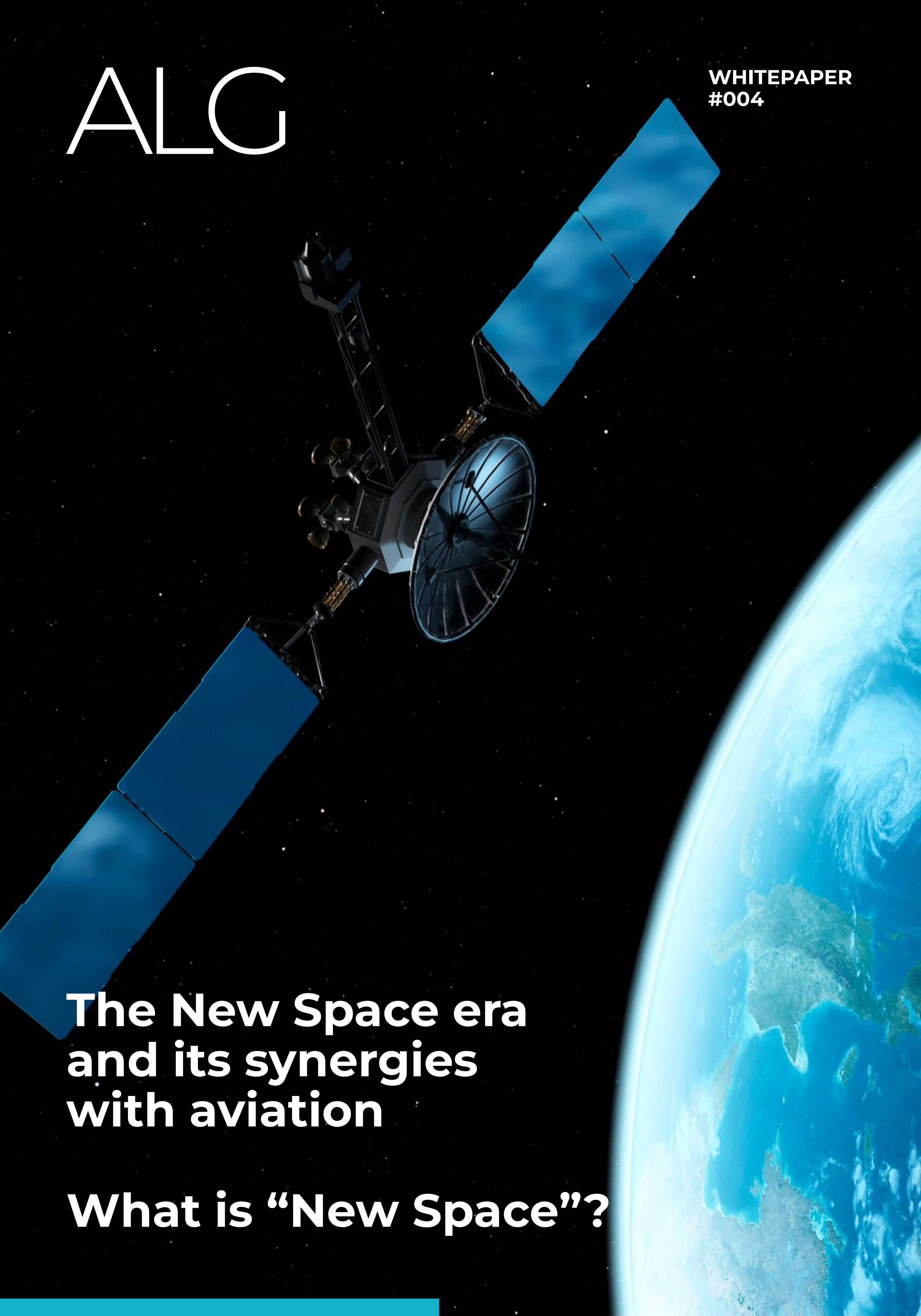

The New Space era and its synergies with aviation

What is "New Space"?

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What is “New Space”?

The space industry is undergoing a profound transformation underpinned by new digital technologies and business models often referred to “New Space”. The modern space age was initiated in the 1950s during the cold war and has been historically focusing on defence applications and dominated by institutional actors. This New Space age is populated by new aerospace companies, launching space missions at a pace never seen before with the main objective of providing commercial services at global level. This is enabled by technological progresses, making it cheaper than ever to produce and launch small satellites forming constellations at Low Earth Orbits (LEO) around the earth.

The trend revealed by numbers is scaring: LEO satellite launches in the last three years have been equivalent to the cumulative numbers of launches in the previous 2 decades, with more than 3,900 satellites since 2018, compared to the 2,100 in the period 1997-2017. And this is just the beginning of a myriad of launches from hundreds of companies around the world, led by Elon Musk’s SpaceX initiative, **Starlink**, which represents the 55% of the total payload launches in LEO and MEO for the 2021 year with more than 950 payloads.

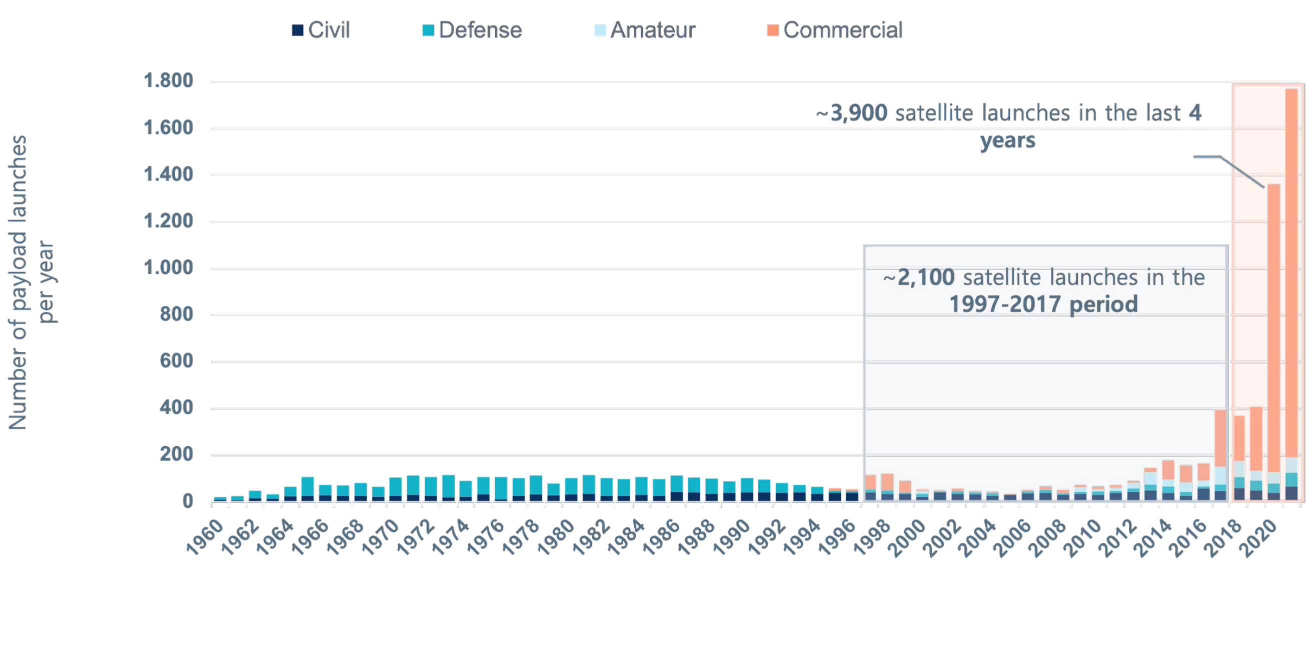


Figure 1. Number of yearly payload launches in LEO and MEO (200 ≤ hp ≤ 1750km). Source ESA.

But, what really is New Space? The concept remains quite fuzzy, because the commercialization of space activities and the use of miniaturized technology such as CubeSats as space assets has been a reality since decades. Commercial space has been present since the early 60s with missions covering a broad range of applications such as broadcast television, satellite radio, and satellite mobile communications and therefore it cannot be considered as a defining trait of the New Space concept.

It is really about the new business models, starting from funding which is mainly driven by private capital sources in contrast to the main public funding programs supporting traditional space practices. However, New Space is not only a shift regarding the privatisation aspect of the space industry but also a shift in the utilisation of new downstream services, where space assets are not the main factor in defining a mission. Rather the service delivery model and the management of the whole company structure are at the core, following new agile principles permitting constant evolution based on modular space infrastructures. Technology supports the second pillar of New Space, in particular through innovative approaches to product development and manufacturing processes, thanks to massive use of Commercial Off The Shelf (**COTS**) products, reducing upfront investment costs and the miniaturisation of components reducing the cost of launches, which in turn reduce financial risks and deployment times. Although CubeSats are not a unique feature of New Space, many initiatives are choosing them to deliver all the mission requirements while keeping the costs low. The following image summarises the main differences between Traditional Space and New Space.

	Traditional Space	New Space
Primary stakeholder needs	National security and society benefits	Profitability
Type of mission	Single-satellite	Commonly multi-satellite constellation
Product development process	V-model	Agile
Typical mission lifetime	5 to 15 years	Less than 5 years
Development time	Multiple years	Between 12 to 18 months
Typical unitary cost	>1M EUR	10,000 to 1M EUR
Make vs buy	Custom components	Preference of COTS components

Figure 2. Main differences between Traditional Space and New Space.

With the advent of the commercialisation of the space and the "space-cialisation" of applications, and closely tied to the proliferation of the New Space, multiple movements have been made oriented towards providing the customer with access to resources which they usually couldn't afford, due to the required investments and operational costs. In other words, these movements began as an instrument for companies investing in infrastructure, in sharing the related capital-intensive investments with clients, by offering them the exceeding computing and storage capacity (cloud services). This opportunity in turn resulted to be a great business that has completely changed the approach to development of applications and has become an independent business in itself. In this regard, Satellite as a Service (SaaS), Ground Segment/Stations as a Service (GSaaS) and Constellation as a Service (CaaS) are terms that are strongly emerging, presenting different aspects of this market trend and enabling interested customers to access the space industry, by different means:

- **Satellite as a Service (SaaS)** is a concept by which users focus on their own payload (platform could be shared with other user's payload) and satellite building, launch, qualification and launch is performed by external companies.
- **Ground Segment / Stations as a Service (GSaaS)** is a concept by which users are granted access to Ground Segment Networks (GSN), enabling the provision of the related essential services.

This addresses a major entry barrier for space companies, which might want to receive their data without the need for large investments and long schedules for the deployment of Ground Stations infrastructures. One clear example of GSaaS is what Amazon is offering under the name of **AWS Ground Station**, which consists on an end-to-end managed service that enables the customer to control satellite communications, process data, and scale operations without the need to develop or operate their own ground station infrastructure.

- **Constellation as a Service (CaaS)** not yet implemented, but if current trends continue, it would be the next logical step for these types of services. CaaS is founded on the creation of a specialised satellite constellation that would provide the communications network backbone for other own or third-party customers' satellites in orbit (let's call them sensors) that would implement only the minimum required payload. The CaaS satellites would behave as conventional network nodes, translating concepts and behaviours of terrestrial networks to a space network, providing capacity, quality of service, lowest possible latency, resiliency, redundancy, load balancing, monitoring, and control capabilities, etc. to this population of Sensors. A Sensor would implement a minimum specification to securely connect with the CaaS in order to transfer its own generated data and allow its configuration, monitoring, maneuvers, etc. This means that the Sensor would (ideally)

communicate in space with the CaaS showing advantages both technical and administrative. This in combination with SaaS and GSaaS services, would have the potential to further empower the Space industry.

In all cases, these services minimise and rationalise the cash flow necessary to address diverse applications, transforming previously unviable business prospects into positive business cases.

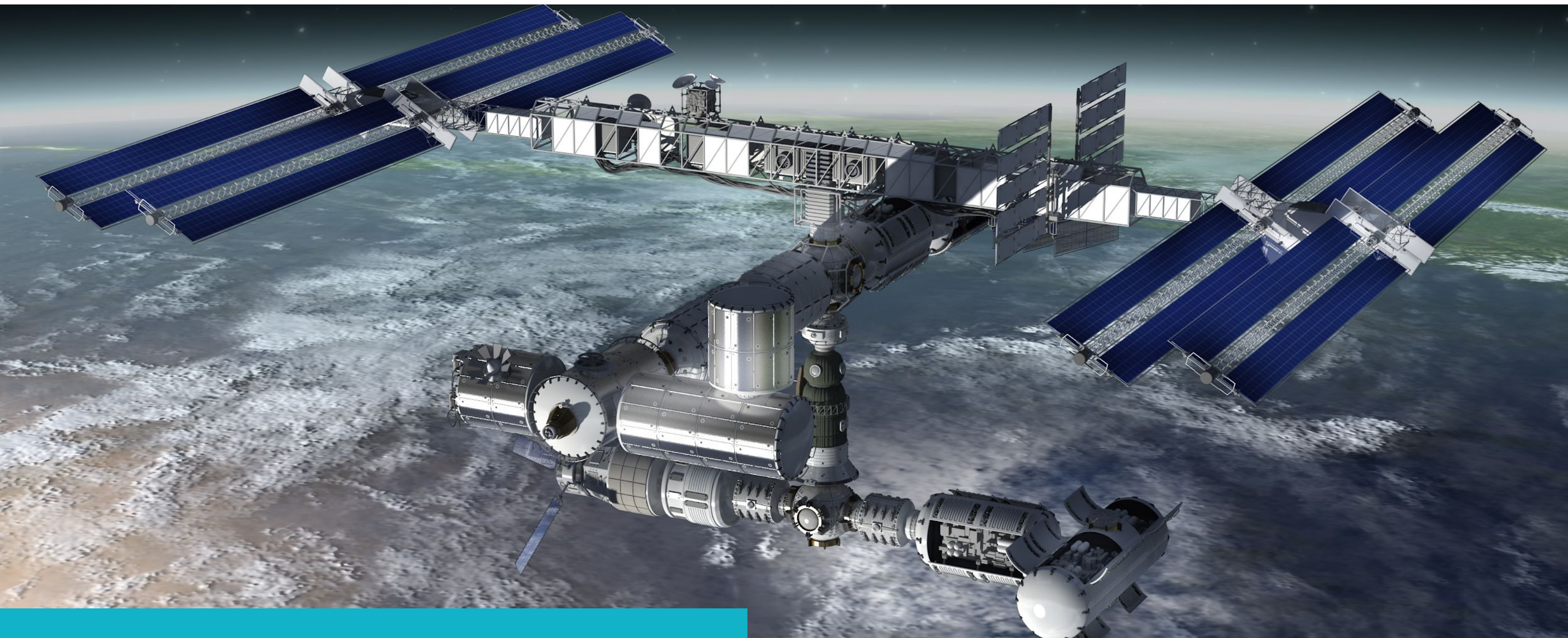
The opportunities

The type of services that the New Space concept enables is immense: the easy access to space opens the door to a myriad of projects and initiatives that are impossible to list. However they can be broadly categorised into commercial and governmental.

As of today, the most common commercial service is the provision of high-speed broadband internet access to remote areas. This type of service is being highly contested by the already working solution of **Starlink**, by SpaceX, the future project **Kuiper** by Amazon, and the **OneWeb** project by Airbus, with the common purpose of delivering high-speed internet access to any remote area at a competitive price. Another service that is expected to gain a lot of popularity is the provision of space-based 5G coverage in dead zones. The proliferation of these services will enable future effective use of the IoT which is expected to have an impact in multiple areas, like autonomous vehicles and smart cities to name a few.

As for the governmental counterpart, there are a plethora of services, which are considered crucial for both defence and public applications, based on the provision of reliable, resilient, secure, and cost-effective end-to-end communications, from the final user, up to the ground and space segments.

Currently three service families can be identified for governmental services:



- Surveillance: Involving the land and maritime border surveillance and detection of illegal activities.
- Crisis management and external actions: Includes a range of activities ranging from Search and Rescue (SAT) missions, response to humanitarian crisis, and support to police and civil protection units.
- Connecting key infrastructure: Communications for transport infrastructure (air, road, rail, and maritime traffic management, for EU Space infrastructure (EGNOS, Galileo, Copernicus).

However, governments do not limit their necessities to security purposes but also look forward to improve the quality of life of their citizens through the provision of broadband coverage for the population living in dead zones where internet access is non-existent. The European Union is very ambitious in this regard, as testified in the new flagship Space-based Global Secure Connectivity programme, launched to reinforce the **EU space programme** for the years 2021-2027 and the Commission's Action Plan (COM(2021) 70 final) with the strategic objective for Europe of becoming technologically sovereign in the Space domain.

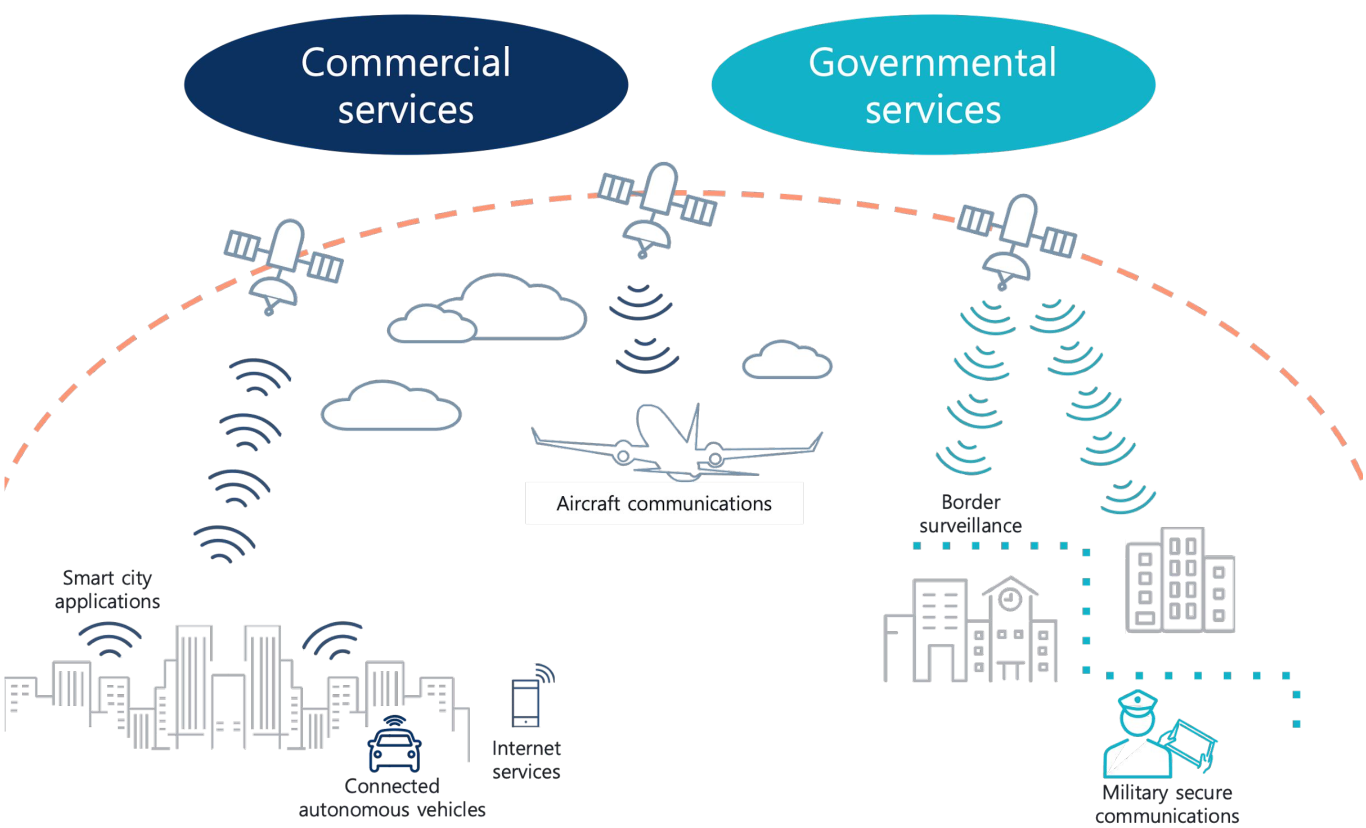
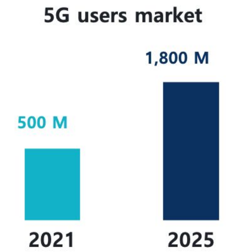


Figure 3. Illustrative representation of New Space services for Commercial and governmental applications.

The 5G use case is interesting to better understand the potential of New Space. The info card below briefly explains how this concept can contribute to improving the provision of internet data in dead zones, providing the context, some figures justifying the necessity for private companies and governments to push towards this technology, the high-level user requirements, and the affected user communities.

Use case introduction

5G has been considered as a **breakthrough technology** that will enable many new applications to emerge such as IoT, smart agriculture, self driving cars, telemedicine. As of today, 5G is rapidly growing, as new devices that can take advantage of 5G networks keep launching while coverage keeps improving. In 2021 5G for mobiles have more than **500 million subscriptions** worldwide merely a **6% of the total mobile subscriptions** (7,900 million in 2019).



The European Commission has expressed its interest in **putting into and end the dead zones** when talking about internet coverage specially in **Europe, Africa and the Arctic Regions**. Dead zones by definition not only include non-coverage or remote areas but also those areas where signal is blocked due to hilly terrain, dense foliage or physical objects (in urban areas). In Europe and according to the EU Broadband coverage study, in 2019, **89.7% of rural households** had access to one fixed broadband technology, whereas only **59.3% of the rural households** (19.7 million users) can benefit from Next Generation Access (NGA) connectivity. In the other side and according to GSMA 2019 Market report, **Africa** had in 2019 an average download speed of 7.5 Mbps with a **25% of coverage gap** which translates to a total of **270 million people without 3G nor 4G connection**.

In perspective, Germany has estimated an **investment of 1,100 M€** to install **5,000 new cell towers by 2024** to bring coverage up to 97.5% of country's surface area. With satellite based for 5G internet provision, improvements in both current internet speeds and coverage of the dead-zones will be observed, drastically reducing the investment in ground infrastructure.

High-level user requirements

- Availability
- Latency
- Compatibility
- Throughput

User communities

Institutional
- **Governments**
- **Military bodies**

Non-Institutional
- **Telecommunication operators**
- **Mass-market users**

Figure 4: Use case for the provision of 5G internet in dead zones.

How aviation will benefit from New Space

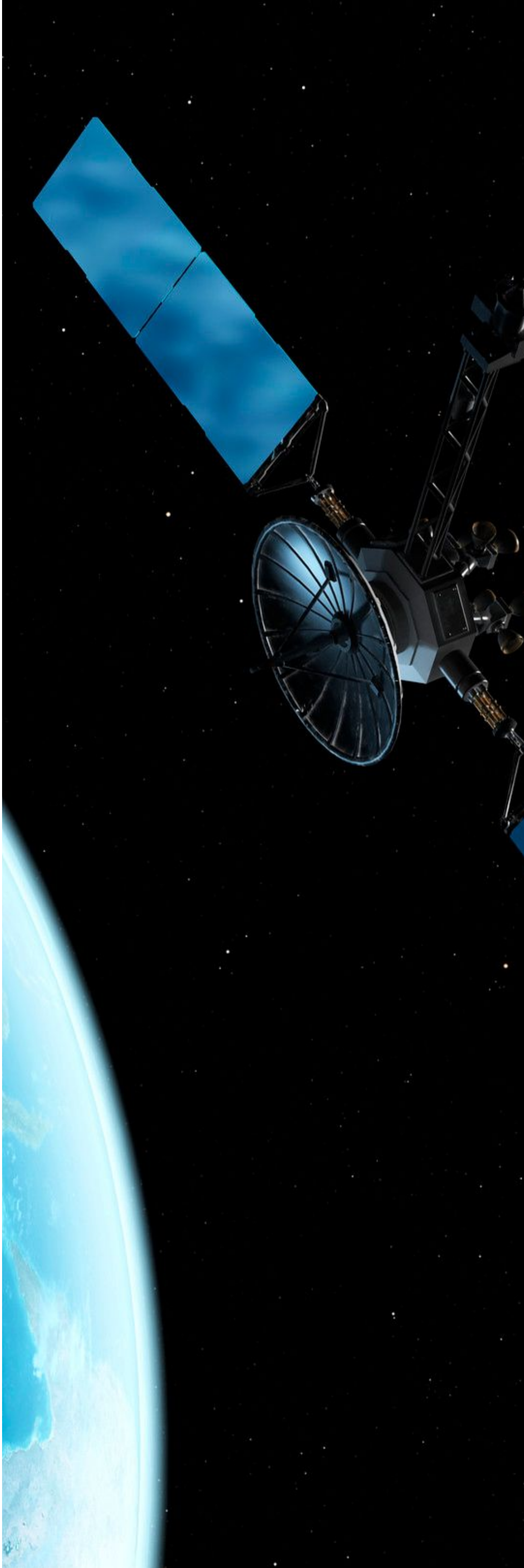
Focusing on the aviation market, the implementation of new space-based initiatives is expected to bring a series of benefits to air transport. In particular for the provision of communication, and surveillance services at global level, enhancing the safety and efficiency of air traffic. There are already a number of important initiatives ongoing devoted to provide services to aviation.

For air/ground communication, the **Iridium aviation solution**, composed from 66 satellites in LEO, already offers the provision of Air Traffic Service (ATS)/Airline Operational Communications (AOC) and passenger services with the possibility of hosting additional payload (i.e. ADS-B service, already used by Aireon). On the other side, and started in 2008 by the ESA, **Satellite Communication for Air Traffic Management (IRIS)** aims at providing a safe and secure text-based data link between pilots and air traffic controllers using satellite technology. This is part of the European Commission's Single European Sky ATM Research (SESAR) masterplan to modernise Europe's air traffic management.

For air traffic tracking, the **Aireon solution** is operational, relying on an ADS-B payload embedded on 66 Iridium Next Satellites on a LEO. Aireon's ADS-B complies with the ICAO Global Aeronautical Distress Safety System (GADSS) standard, launched after the losses of Air France 447 and Malaysia Airlines 370 flights. GADSS enables the Aircraft Tracking, Autonomous Distress Tracking, and Post Flight Localization and Recovery functions.

The Startical initiative on the other hand aims at providing integrated communication and tracking services to air traffic since its conception.
It consists of the creation of a LEO satellite constellation for innovation in the provision of air navigation services, with a collaboration between Indra and the Spanish aeronautical services provider, Enaire. Startical will provide pilot-controller voice and data communications and aeronautical surveillance ADS-B services globally through the deployment of 240 nano-satellites. With an expected launch in 2026, the implementation of this initiative will improve air traffic safety, capacity, and efficiency. The initiative will also provide global coverage, serving areas where there is currently no radar coverage. In addition and as opposed to Aireon's solution, the Startical initiative will provide an extra safety layer against malicious attacks to the ADS-B signal (jamming and spoofing) by adding multilateration techniques. This technique uses the ADS-B measurements from different sources (satellites) and triangulates the position of the object (aircraft) to ensure that signals are genuine and emitted by real aircraft.

In addition to the previously presented initiatives, whose are foreseen to impact the aviation sector in the fields of communication and surveillance we are still missing the Navigation aspect of the Communication-Navigation-Surveillance (**CNS**), the foundations for the operations of aviation. Covering this gap, we identify Global Navigation Satellite System (GNSS) as the potential infrastructure and technology from which aviation could benefit the most from the accelerating spread of New Space solutions.



GNSSs is a constellation of satellites that provide signals from space and sends location and timing data to GNSS receivers. This information is subsequently used by the receivers to calculate their position. The appearance of GNSS have changed the navigation landscape due, among other things, to the accuracy they provide in terms of positioning and time, their global coverage, and the low cost of receivers. In fact, the International Air Transport Association (IATA) refers to it as "the recommended navigation system, supporting better flight trajectory and airspace capacity."

Currently there are 4 different constellations launched or being deployed intended to deliver GNSS services:

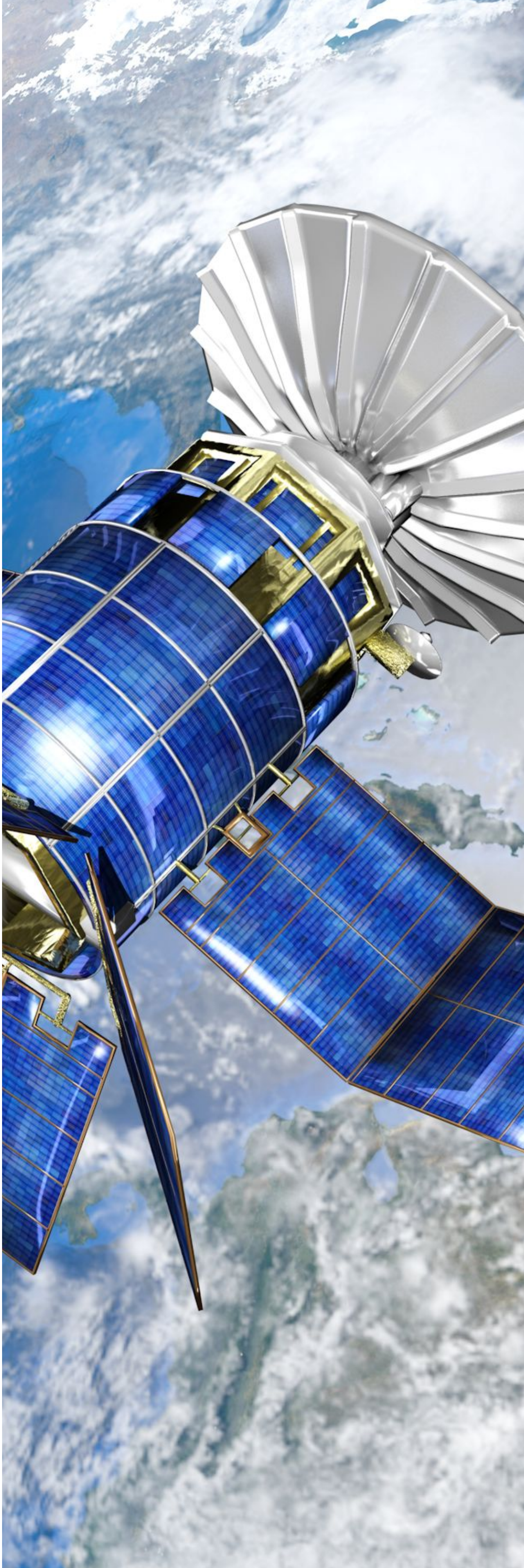
- Galileo, the European GNSS system, providing an open and free of charge service through 22 operative satellites.
- **GPS**, the US counterpart of the GNSS system which has been operative since 1995, although it was conceived for military use only, it has open and free to use signals to deliver accurate positioning and timing services. The service is provided through 31 operative satellites.
- **GLONASS**, the Russian GNSS system was initially operational in 1995 but the system decayed for many years until efforts to restore it were applied, re-enabling operational services in 2015. Still a military system, it provides open and free of charge signals to deliver accurate positioning and timing services.
- **BeiDou**, the Chinese GNSS system consisting of 35 satellites, with open and encrypted signals similar to Galileo's, it will provide open and free of charge signals to

deliver accurate positioning and timing services.

On top of GNSS services, there exists the augmentation term, from which the signals provided by these satellite systems can be further augmented by other means for the purposes of higher accuracy and reliability. Different augmentation systems are available, Satellite-Based Augmentation System (SBAS), Ground-Based Augmentation System (GBAS) and Aircraft-Based Augmentation System (ABAS) which depend on the nature of the system. For the sake of this article, we will focus on the Satellite-Based Augmentation System (SBAS) as they rely on a network of satellites for providing enhanced Positioning, Navigation and Timing (PNT) signals. As of today, the following solutions have been deployed or are in the process of being deployed:

- **EGNOS**: the European Geostationary Navigation Overlay Service, augments Galileo, GPS and Glonass by providing corrections and informing about their reliability and accuracy. It consists of more than 40 stations and 3 geostationary satellites.
- **WAAS**: the US Wide Area Augmentation System (WAAS) augments GPS by using a network of around 40 stations and 3 geostationary satellites. It provides corrections and informs about GPS reliability.
- **MSAS**: the Japanese Multi-functional Satellite Augmentation System (MSAS) augments GPS and was commissioned on September 2007. It provides corrections and informs about GPS reliability via 2 geostationary satellites.

- **QZSS**: the Japanese Quasi-Zenith Satellite System (QZSS) aims at using four satellites to complement GPS at the regional level. It is expected to be operational in 2018.
- **GAGAN**: the Indian GPS Aided Geo Augmented Navigation (GAGAN) uses 15 ground stations and 3 geostationary satellites to augment GPS signals with corrections and reliability information. The system was certified in 2013.
- **SDCM**: the Russian System for Differential Correction and Monitoring (SDCM) is foreseen to be deployed to augment the Glonass system and may use satellites with different orbits for signal dissemination.
- **StarFire**: is a commercial system to augment GPS developed by John Deere that uses 25 stations in total in several regions of the world.
- **OmniSTAR**: is a commercial system to augment GPS. Several manufacturers provide OmniSTAR capable receivers.



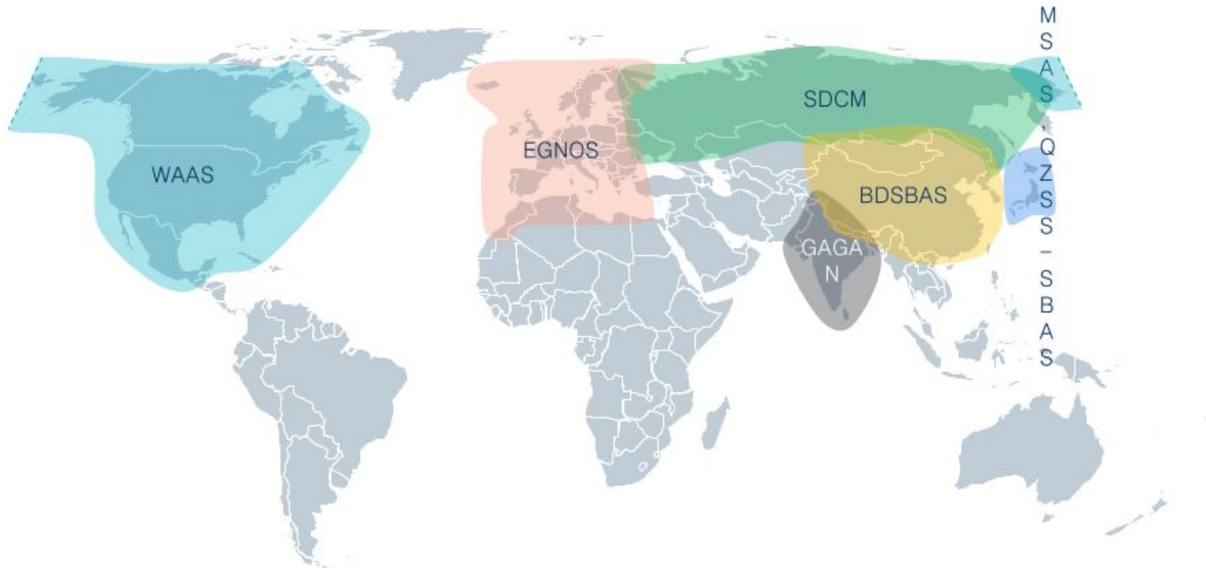


Figure 5: SBAS systems.

Despite the fact that current GNSS systems, both basic and augmented (SBAS), cannot be catalogued as New Space solutions, as the characteristics they present are incompatible with what we have defined as New Space there exist some applications that can benefit from what New Space is known for. This is the case of LEO-PNT solutions. These initiatives propose the deployment of a LEO constellation in conjunction with existing GNSS and augmentation (i.e., EGNOS) services, which are located in MEO and GEO orbits, respectively, as well as additional inputs from terrestrial PNT systems and user-based sensors, with the goal of improving overall service quality, availability, and resilience, as well as enhancing GNSS capabilities. . Because of the technical characteristics of those satellites in terms of dimensions, mass, and power, which are primarily due to the fact that they are destined for LEO, these solutions are suitable contenders for inclusion within the New Space concept.

In this regard, and to understand the interest this kind of solution is generating, the following initiatives have been identified:

- **PULSAR** from Xona Space Systems, a private US-based firm that will employ tiny satellite technology to provide consumers a safe and stable alternative to GNSS from satellites 25x closer to Earth, anticipating an economical worldwide coverage with x10 times the accuracy of present GNSS signals.
- **GeeSPACE** from Geely, a private Chinese company that has planned a constellation of 240 satellites to provide high-precision centrimetre-accurate positioning services.
- **GNSSaS** is a funded United Arab Emirates (UAE) Space Agency initiative acting as a demonstrator for the use of a constellation up to ~96 nano-satellites to improve GNSS position determination accuracy on ground.

In addition to these initiatives, the European Space Agency (ESA) has also demonstrated interest in this type of technology with its **FutureNAV**: LEO-PNT programme. The ESA issued a Request for Information (RFI) with the aim of gathering data for an In-Orbit Demonstration (IoD) of LEO-PNT services, system capabilities, and technologies that could open the door to an operational LEO-PNT system and hasten the readiness of European industry for the eventual implementation.

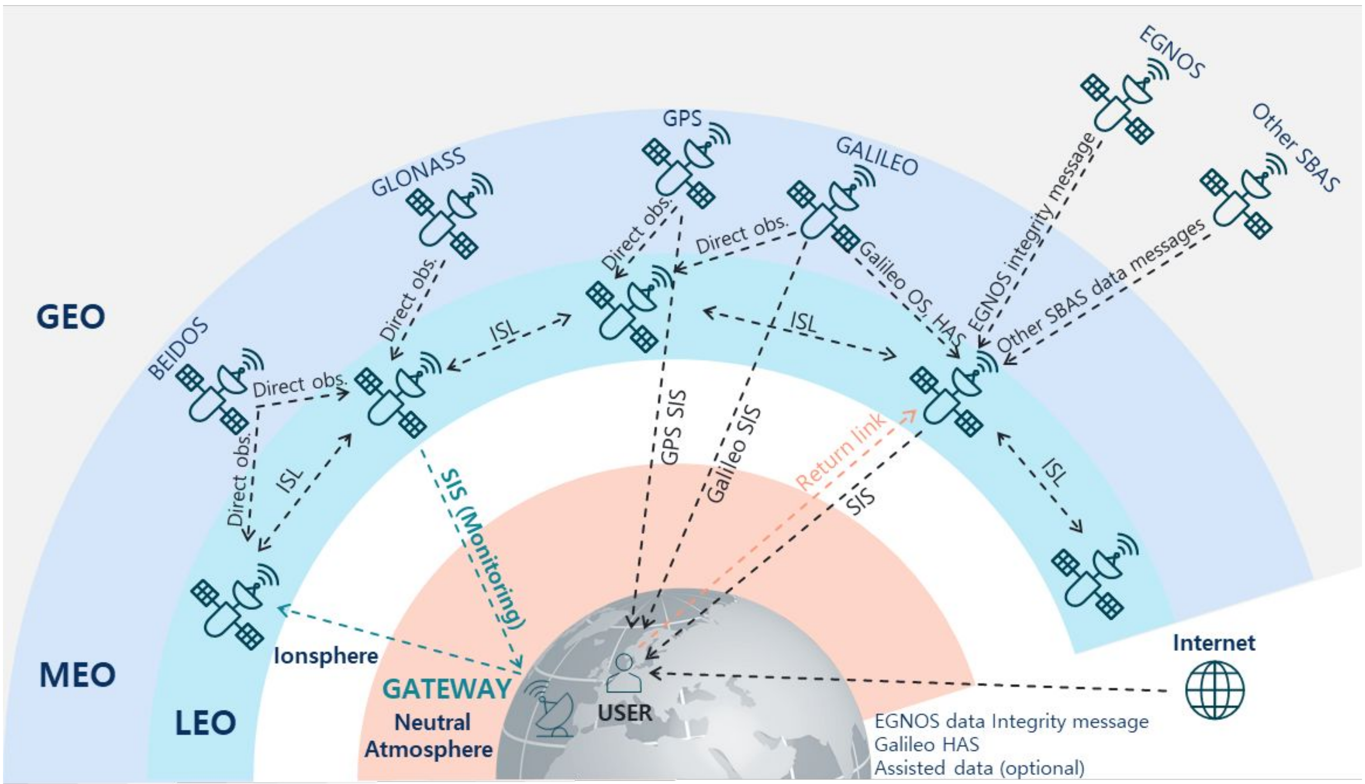


Figure 6: PNT multi-layer architecture, source: ESA FutureNAV programme for LEO-PNT.

The need for a Space traffic Management

This run to the New Space is not exempt from challenges, in particular space congestion caused by the exponential increase in space traffic. At present, over **6800** active satellites are orbiting the Earth, but, as the New Space practice becomes more popular, the population could increase exponentially, increasing the possibility of collisions with the further possibility of initiating the **Kessler effect**. This situation needs to be addressed accordingly and by consequence will raise future challenges in space traffic management and situational awareness. At EU level the Commission has recently launched two projects tackling the challenges and benefits of having a Space Traffic Management (STM) systems set up:
SPACEWAYS which will provide recommendations on STM evolution from concepts to industrialization, taking into account the evolution of legislation, and its impacts on technologies, space infrastructure and satellite operations. And **EUSTM** that will analyse the current STM support competences in Europe and define the related needs for an autonomous European STM capability.

In particular the Air Traffic Management (ATM) capabilities can provide a reliable success story, based on the track records of safety and the long evolution it underwent since its foundations. Its intertwined structure of governance at policy and operational level involve hundreds of different entities at global and local scales that work in a seamless way. Similar principles and working structures should be inherited by the STM, to guarantee that there is global coordination and cooperation on a global scale, which is a prerequisite to

ensure the maximum levels of safety, security and efficiency of the overall system.

Regional agencies such as EUROCONTROL are already providing airspace management coordination functions across several Member States at regional level in Europe when space launches occur. This requires closing an airspace to air traffic to ensure safety, an activity that needs to be planned in advance and run through well agreed procedures and systems.

The New Space run has just started and the next decade will be crucial in defining the rules for the system to be sustainable, safe and efficient, while ensuring that people can benefit from new services, enabled by a global level playing field, a necessary condition for the industry to remain competitive in such a global business, where the sky is really not the limit.

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