

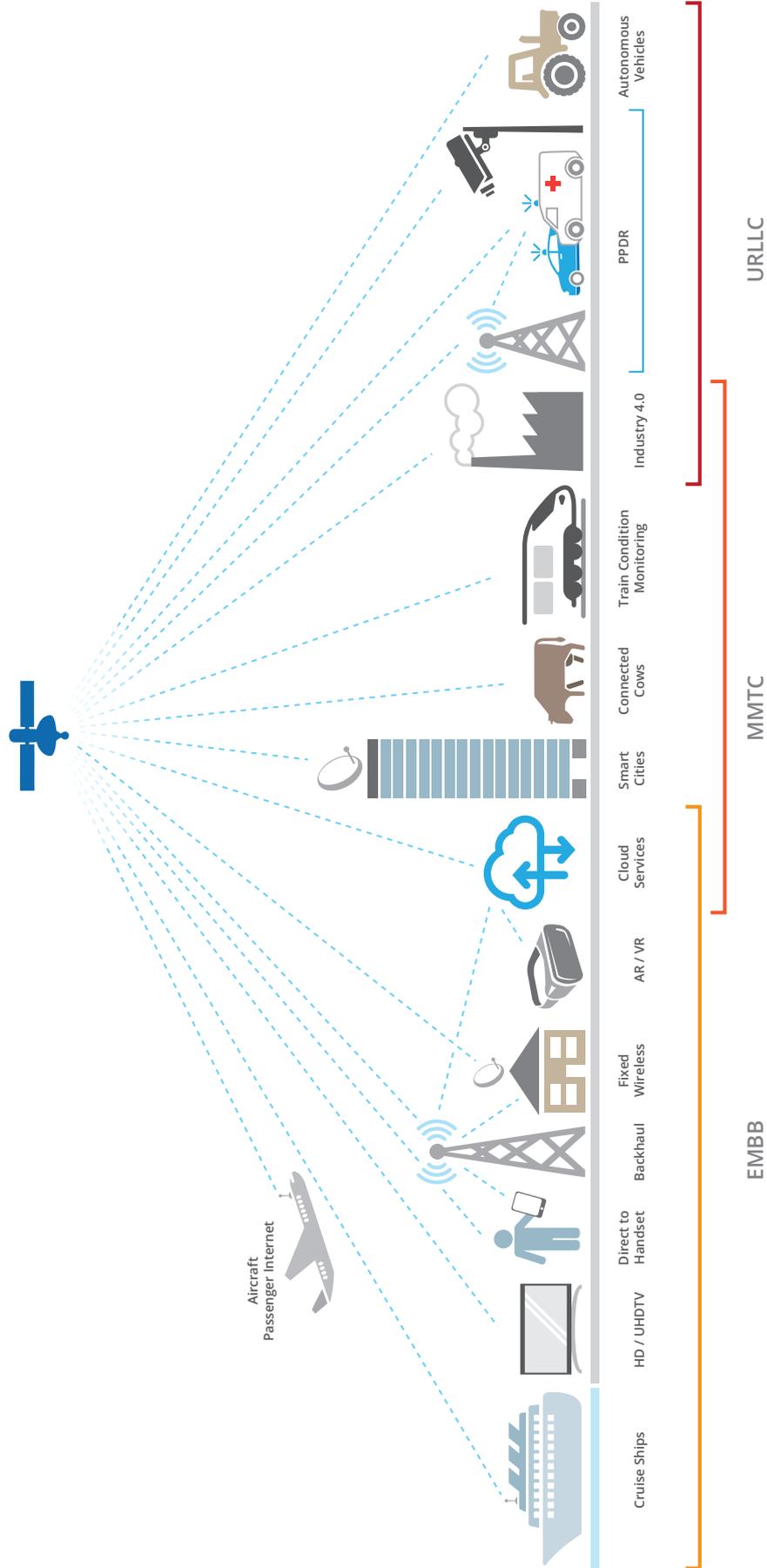
Updated July 2020



WHITE PAPER

SATELLITE COMMUNICATION SERVICES: An integral part of the 5G Ecosystem

Satellites supporting the 5G Differentiators



Contents

Executive Summary	Page 4
Role of Satellites in the 5G Ecosystem	Page 5
<ul style="list-style-type: none">▶ Enhanced Mobile Broadband (“eMBB”)▶ Massive Machine-Type Communications (“MMTC”)▶ Ultra-reliable and Low Latency Communications (“URLLC”)	
Preventing a 5G Divide	Page 6
Enabling the Integration of Satellites into the 5G Ecosystem	Page 7
Satellite Use Cases in the 5G Ecosystem	Page 7
<ul style="list-style-type: none">▶ Communications on the Move▶ Direct-to-Premises Connectivity (“hybrid multiplay”)▶ Direct Connectivity to End Devices▶ Backhauling & Tower Feed (Cell Site Backhaul & Content Distribution)▶ Trunking & Head-end Feed (Aggregated Mobile Backhaul & Content Distribution)	
5G as a Network of Networks	Page 14
Ensuring Satellites are an Integral and Effective Part of 5G	Page 14
<ul style="list-style-type: none">▶ Technology Neutrality▶ Cost-Efficiency▶ Regulatory Considerations▶ Access to Spectrum Resources	
Conclusion	Page 16
Glossary of terms	Page 16
Footnotes & References	Page 17

Executive summary

Satellite communications are ready to play a key role in the 5G ecosystem and beyond and ESOA members are taking important steps to make this a reality. In some cases, they will provide these services directly and, in others, they will partner with third parties such as MNOs, to maximise the benefit to end users from 5G services and capabilities. Either way, the benefits of 5G will be felt by much larger communities and faster than if mobile operators seek to do so alone.

5G promises hyper-connectivity for modern societies but without satellite communications it also risks increasing the digital divide. Satellite networks can be leveraged to bring the latest technology on an accelerated basis to everyone, everywhere, including areas that are not covered by 3G and 4G. This was demonstrated during the COVID-19 pandemic where satellite communications were called upon for a range of uses including the rapid set-up of direct broadband connectivity to new medical facilities and to support tele-education and tele-work to part of the population. These global connectivity services were available to all citizens, regardless of country, population density, or economic status and highlight the non-discriminatory nature of satellite services.

The success of many 5G service deployments depends on unique characteristics made possible by satellite networks such as wide area coverage that is vital to extend networks to low density populated areas, one-to-many distribution and reliable and resilient operations. Specifically, satellite networks can:

▶ Extend the reach of limited terrestrial 5G networks to underserved areas and places that terrestrial networks cannot cover (e.g. on land, in the air, at sea);

▶ Ensure service continuity for M2M/IoT devices and connected/autonomous vehicles by providing reliable communications and supporting software updates on moving platforms (e.g. passenger vehicles, aircraft, ships, trains, buses);

▶ Ensure robust and secure 5G services for critical and mobile communications (incident response, public safety);

▶ Optimise the efficiency of 5G networks by multicasting / broadcasting data;

▶ Enhance existing fixed network links with hybrid connections.

The satellite industry has successfully demonstrated that satellites can already support key features of the 5G ecosystem. In parallel, significant work is ongoing to contribute to 5G standards and develop the necessary features to ensure integration of satellite into the 5G ecosystem and also vice-versa, the 5G eco-system into satellite networks

Fixed and mobile operators stand before an important opportunity where they can choose whether to embed satellite into their networks now. By doing so, they can ensure extensive and reliable 5G services from the start and make their own networks more resilient.

The satellite industry is committed to continuously improving its technology and solutions to contribute to the worldwide deployment of 5G.



Role of Satellites in the 5G Ecosystem

The next generation of communications technology, 5G, foresees a world in which “anyone and anything will be connected at anytime and anywhere” and characterises 5G with the following 3 main use cases:



► Enhanced Mobile Broadband (“eMBB”)

This will deliver Gigabits per second (Gbps) of end user connectivity. Satellites already deliver direct broadband connectivity at 100mbps to citizens beyond the reach of other technologies; also enabling services for businesses and governments. Ongoing work in 3GPP will also enable direct integration of satellite into 5G to allow the same UE to access both terrestrial and non-terrestrial technologies. In addition video is still foreseen as a major driver for eMBB. Satellites can support high bandwidth applications as they already carry high definition (HD) and Ultra HD content and data, which can be pre-positioned close to the edge for more efficient delivery to users, thus offloading terrestrial networks and ensuring minimal delays for users. Satellites already help mobile network operators across the globe expand their 3G and 4G coverage and the same can be done for 5G.



► Massive Machine-Type Communications (“MMTC”)

Satellites support machine-to-machine (M2M) and Internet-of-Things (IoT) applications in many countries, such as supervisory control and data acquisition (SCADA), real-time global asset tracking, and weather sensor networks. New, flexible satellite technologies as well as hybrid terrestrial - satellite modems will enable IoT connectivity, and IoT backhauling from remote locations and from connected cars, aircraft, ships and trains. Investments in new ground-based technologies, such as smaller, lower cost, electronically steerable, and/or phased-array satellite transceivers, are making ubiquitous deployment of IoT via satellite cost-effective, quick and easy. As MMTC advances, satellite is integrally involved as demonstrated by, for example, the major cloud computing providers partnering with satellite operators to carry IoT data directly to their clouds.²



► Ultra-reliable and Low Latency Communications (“URLLC”)

Satellite systems and their radio links are typically engineered to ensure low packet error rate performance and inherently reliable communications. Powerful coding and modulation schemes, and channel propagation adaptation mechanisms (e.g. Adaptive Coding and Modulation – ACM) ensure low packet/frame loss contributing to highly reliable communications links. To achieve low latency, as the GSMA has acknowledged¹, “content must be served from a physical location very close to a user’s device”. Satellites’ strength in multicasting across wide areas can be leveraged to distribute common content to the network edge to achieve this low latency.²

► Regarding latency

5G emphasises targets as low as 1 millisecond (or 10 milliseconds, in more recent reports).³ Even though satellites inherently feature longer propagation delays, technical enhancements can help to efficiently pre-distribute common content to nodes at the edge of 5G networks, efficiently reducing or eliminating overall network and end-user latency. Note that terrestrial links also require these enhancements. These techniques will greatly contribute to making perceived zero-latency a reality.⁴ As the GSMA has acknowledged, “services requiring a delay time of less than 1 millisecond must have all their content served from a physical position very close to the user’s device. ... possibly at the base of every cell, including the many small cells that are predicted to be fundamental to meeting densification requirements.”⁵ Satellites’ strength in multicasting content across wide areas can thus be leveraged to distribute common content to the network edge to achieve low latency.⁶

► Regarding resilience

Unlike terrestrial technologies, satellites are largely immune to natural and manmade disasters and therefore inherently more robust. During the 2020 Covid-19 pandemic and in 2019 after Cyclone Idai, public safety and incident response vehicles relied on satellites for secure and guaranteed connectivity while illustrating the resilience of satellite communication. Satellites also helped to quickly restore communications where submarine cables were cut, most recently seen in the Democratic Republic of Congo, which relies on miles and miles of fibre for connectivity.⁷ Incorporating satellites into the overall 5G network is therefore critical to ensure that communications capabilities are available even after the worst disasters.

Preventing a 5G Divide

The political and regulatory momentum behind 5G underpins the expectation of policymakers that 5G will improve the lives of citizens who are increasingly reliant on connectivity no matter where they are. As highlighted by the COVID-19 pandemic, connectivity is a fundamental need for all, necessary to ensure both socio-economic inclusion and the functioning of economies, educational and healthcare systems, and civil society as a whole.



5G must not be reserved for the urban elite, even if the reality is that telecoms operators’ business models focus on the most densely populated areas and transport corridors. Most countries still face a Digital Divide, not just emerging economies. In the United States for instance, 39% of rural residents do not have access to terrestrial broadband.⁸ Neither 2G, 3G nor 4G managed to achieve ubiquitous coverage, and there is no rational reason to expect that 5G will do so unless 5G policymaking is balanced, holistic and technology neutral. Only by insisting on and incentivising a multi-technology approach, will policymakers

ensure the best connectivity for all areas, many of which today have would little or no connectivity at all without the use of satellite communications.

The integration of several heterogeneous networks to reach extremely ambitious goals in terms of range of services, performance, availability and programmability will also allow viable business plans for different vertical industries by allowing their services to be provided ubiquitously across a stable network. The 3GPP consortium and its members have clearly recognized this as satellite networks are included in 3GPP standards.



Enabling the Integration of Satellites into the 5G Ecosystem

The 5G ecosystem provides a broad range of design flexibilities and capabilities to support wide ranging scenarios. The development of open 5G standards allow satellite companies to reduce the development, deployment and operational costs of including satellite network solutions.⁹

Multiple successful demonstrations have shown that satellites can support key technological features in 5G networks, such as software-defined networking (SDN), network function virtualisation (NFV), and multi-access edge computing (MEC).¹⁰ They also include integrated network management and orchestration,¹¹ multi-link and heterogeneous transport,¹² harmonized control planes, common security framework, end-to-end network slicing and caching and multicast capabilities for content.

The satellite industry actively contributes to 5G standardisation bodies such as 3GPP and ETSI whose activities have been supported by a wide range of organizations from both satellite and mobile industries as well as professional and governmental stakeholders. Within 3GPP Radio Access Network (RAN), work is on-going towards incorporating Non-Terrestrial Networks (NTN), which includes satellite, into the 5G radio access standards for both broadband access and IoT.¹³ This has been taking place in a phased approach, spanning Releases 15, 16, 17 and beyond. A new work item document has recently been approved to begin the normative work to address specifications for 5G satellite access solutions based on 5G NR. In addition, 3GPP RAN also approved a study item for satellite to be supported by 3GPP Narrow Band Internet of Things (NB-IoT) as well as LTE-M standards.

These technical developments and efforts to establish global standards will enable cost effective deployment and integration of satellite solutions into the end-to-end 5G system for improved and expanded service delivery and network operations. This will ensure that the benefits of 5G networks are fully realized and broadly distributed.

Satellite Use Cases in the 5G Ecosystem¹⁴

Several use cases have been identified and are recognized as satellite's core strengths in the 5G ecosystem:

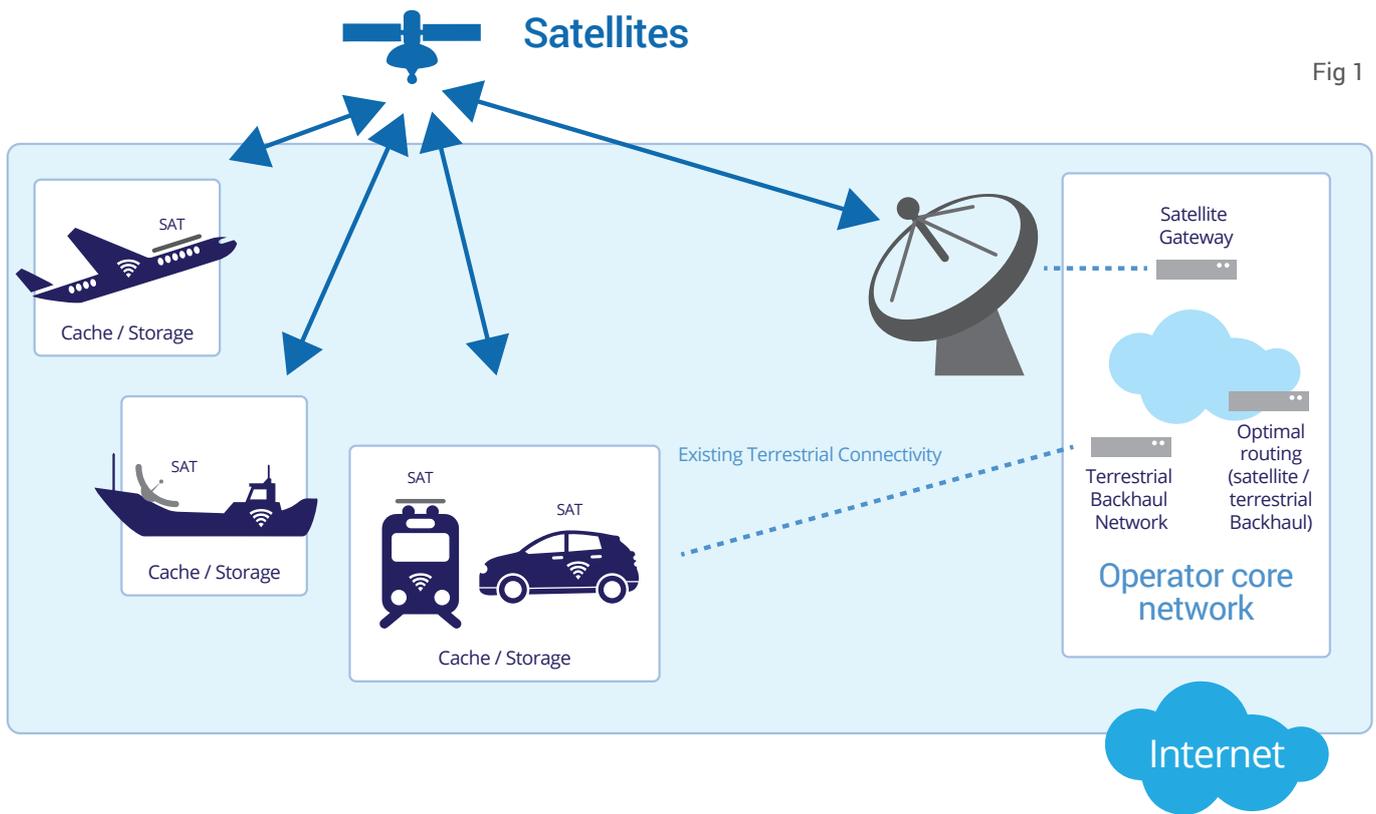
- ▶ Communications on the move;
- ▶ Direct-to-premises connectivity;
- ▶ Direct connectivity to end-user devices;
- ▶ Backhaul and tower feed (cell-site backhaul and content distribution); and
- ▶ Trunking and head-end feed (aggregated mobile backhaul and content distribution).

Each of these are explored in more detail below.

▶ Communications on the Move

This use case is about providing high-speed eMBB backhaul connectivity to individual satellite terminals in-motion on planes, road vehicles, trains and vessels (including cruise ships and other passenger vessels). Satellite terminals have the ability to pre-position content in an on-board cache (e.g. video, HD / UHD TV, FOTA, as well as other non-video data for local storage and use) across a large coverage area, as shown in the figure below. The same capability also allows for the efficient backhauling of aggregated IoT traffic from moving platforms.

This service is delivered by high-speed, multicast-enabled, satellite links direct to the plane, vehicle, train or vessel, from GEO or non-GEO satellites complementing existing terrestrial wireless connectivity where service is not available. This work builds on the successful deployment and operation of pre-5G services such as wi-fi on aircraft.



Examples of this Use Case include:

- ▶ Connectivity complementing terrestrial networks, such as broadband and content multicast connectivity to platforms on the move, in conjunction with a terrestrial-based connectivity link to base stations or relay-on-board moving platforms, to ensure service reliability;
- ▶ Connectivity for remotely deployed battery activated (M2M/IoT) sensors, or handsets with messaging/voice capabilities via satellite (e.g. fleet management, asset tracking, livestock management, farms, substations, gas pipelines, digital signage, remote road alerts, emergency calls, and mission critical / public safety communications.);
- ▶ Two-way telematics capability enabling automotive diagnostic reporting on connected cars, user base insurance information, safety reporting (e.g. air-bag deployment reporting), advertising-based revenue and remote access functions (e.g. remote door unlocking);
- ▶ IoT devices on containers (e.g. for tracking and tracing) connected via a Relay user equipment (UE) on a transport vehicle such as a ship, train or truck;
- ▶ Broadband connectivity for Unmanned Aerial Vehicles, e.g. for remote monitoring, delivery services or providing emergency service communications in remote locations.



Direct-to-Premises Connectivity (“hybrid multiplay”)

This use case extends 5G network service orchestration and management into the home or business. Satellite is being utilized to successfully deliver high-speed broadband to over 2 million homes globally, and satellite television to hundreds of millions of households. In the 5G context, such capabilities can be combined into hybrid double-, triple- or quadruple-play bundles – using a 5G “nano-cell” or even Wi-Fi inside the home as a means of re-distributing high-capacity satellite bandwidth, cloud access, and satellite-delivered content among multiple home devices – with all of it managed by the 5G core network.

While these solutions may be able to connect those that would not otherwise be connected, they can also be deployed in conjunction with available terrestrial connectivity for, example, to reduce terrestrial bandwidth consumption for video content. The satellite industry’s experience is that demand for satellite-delivered broadband and/or television can be higher in places that have some (but perhaps inadequate) terrestrial connectivity.

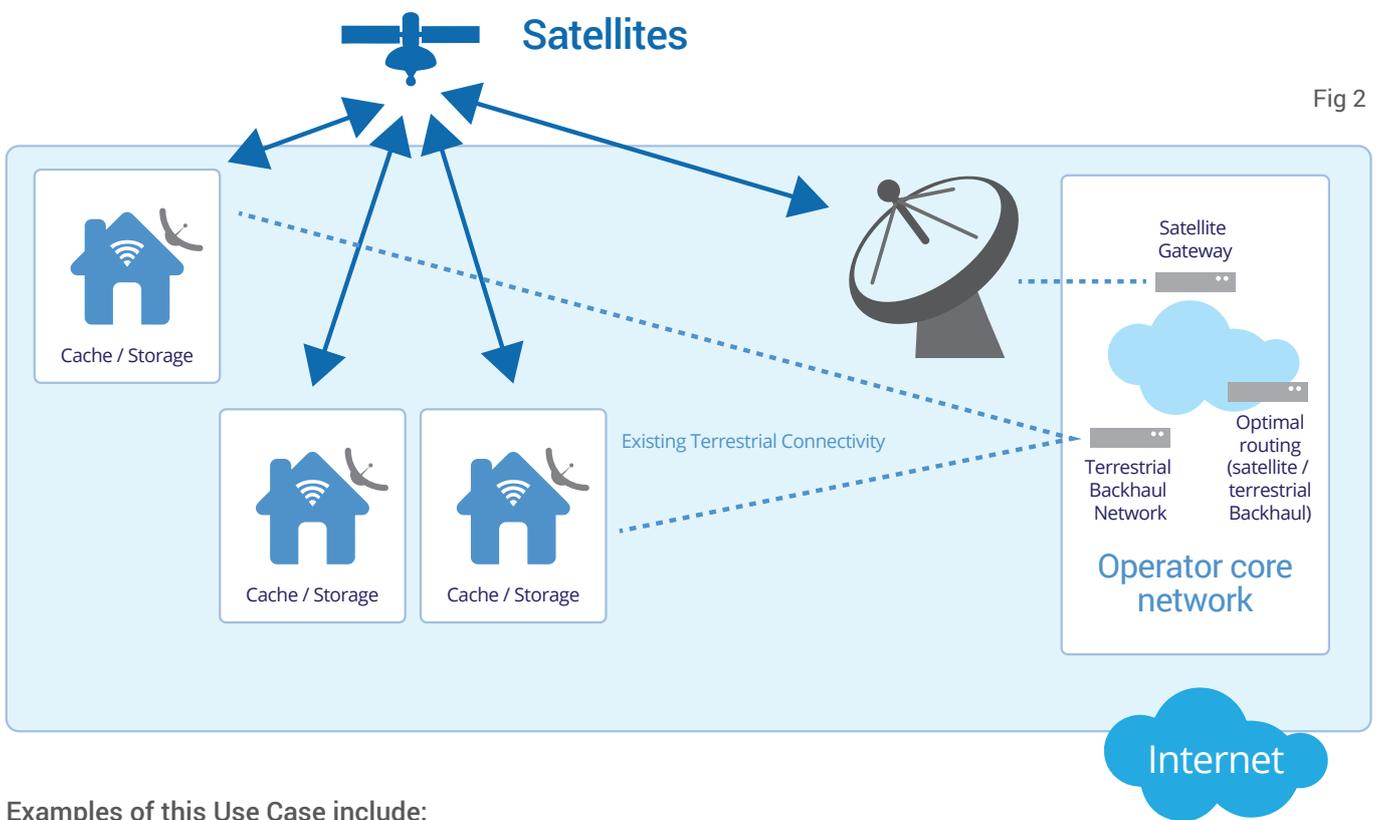


Fig 2

Examples of this Use Case include:

- ▶ 5G connectivity to the home, business or government
- ▶ Complementing terrestrial networks, such as with broadband and content multicast connectivity to fixed locations
- ▶ Distributing IP streaming services to all devices in the same premises
- ▶ Extending the reach of cloud services to unserved or underserved areas

Direct Connectivity to End Devices

Satellites already provide direct connectivity to end user devices. This includes to those in hard-to-reach areas such as mountainous regions where terrestrial networks are unable or unwilling to offer service due to challenging geography and/or prohibitive infrastructure deployment costs as well as for mobility purposes (e.g. on ships).

This builds on solutions that use standard chipsets and enhanced antennas to operate via satellite such as IoT devices, as well as end user devices that can roam between mobile terrestrial wireless and satellite operation. IoT-type services over satellite are not new and this is presently an area seeing significant new investment and innovation.

The industry is also working to ensure that the same UE will be able to access both terrestrial and non-terrestrial access technologies so that end-users can benefit from extended service reachability, reliability and resiliency. Ongoing 3GPP 5G NTN standards work enables direct integration of satellite into 5G to allow this adopting 5G NR as appropriate over the satellite link. Moreover, integration of satellite access into 5G allows for seamless service continuity through hand-over between the coverage areas of non-terrestrial and cellular networks as well as improved performance through multi-connectivity procedures.

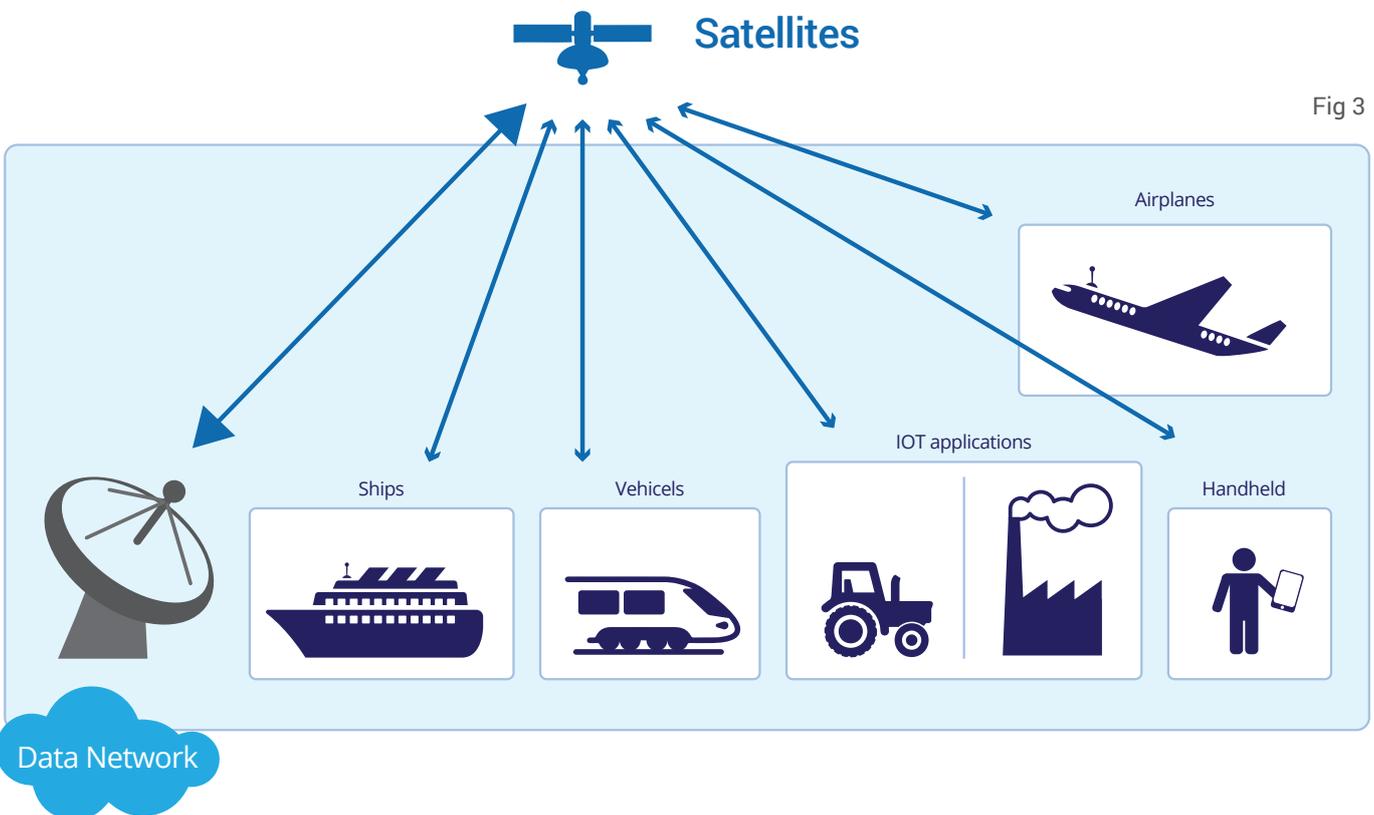


Fig 3

Examples of this Use Case include:

- ▶ Direct satellite access to 5G smartphones providing ubiquitous coverage to users in rural areas without having to deploy terrestrial base stations.
- ▶ Expanded use of machine type communication via satellite for applications ranging from smart agriculture to environmental protection and transportation.

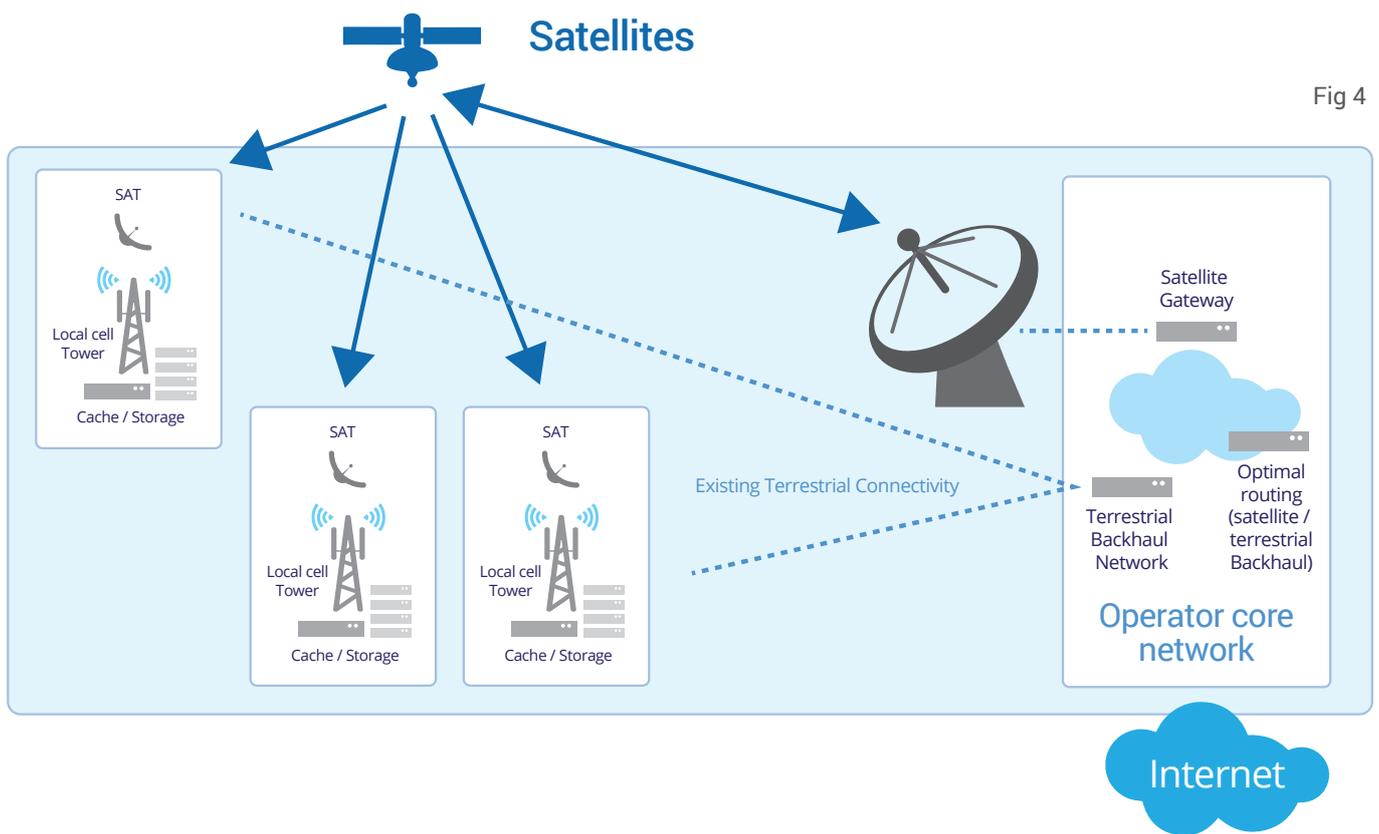


▶ Backhauling & Tower Feed (Cell Site Backhaul & Content Distribution)

This satellite use case provides high-capacity backhaul connectivity for individual 5G cell sites, and enabling efficient content distribution directly to these sites. Instead of providing middle mile connectivity to a 5G aggregation point (as in the Trunking and headend use case that follows), satellites can directly connect individual cell sites and base stations.

This is a natural extension of a role that satellites already play in 2G, 3G and 4G mobile networks. MNOs today use various combinations of individual cell site backhaul and aggregated backhaul (“trunking”) via satellite to cost-effectively upgrade and expand the coverage of mobile networks. Today’s HTS and tomorrow’s VHTS systems provide the high-capacity connections needed to perform the same function for emerging 5G networks.

Similarly, “tower feed” extends satellite’s capabilities as an efficient multi-cast distributor of common content by moving such content even closer to the network edge (i.e. to the cell site, rather than an aggregation point), in much the same way that satellite direct-to-home television is an extension of video distribution to cable head-ends. CDNs in 5G networks can thus be deployed all the way out to network edge at individual cell sites and still be efficiently fed via satellite multi-cast over a wide area.



Examples of this Use Case include:

- ▶ 5G coverage in areas requiring new, standalone cell sites that cannot be connected to each other via terrestrial means due to geography or economics;

▶ Temporary and short-term uses such as:

- ▶ Disaster relief: During natural disasters or other unforeseen events that entirely disable the terrestrial network, satellites are often the only option for rapid recovery and restoration. A good example of this is how satellites helped restore mobile broadband connectivity in the Democratic Republic of Congo within 4 days of a major submarine cable cut;
- ▶ Emergency response: specific emergencies in areas where there is no terrestrial coverage;
- ▶ Provision of service to locations (typically green field) under construction in advance of permanent terrestrial links;

▶ Additional capacity for mobile networks in locations with widely varying demand such as those serving regions heavily utilized for tourism;

▶ Backup connections for cells carrying network slices requiring a reliable connection with a service level agreement, for example where it is possible to install a single terrestrial backhaul connection but extremely hard to install a second diverse one;

▶ Backup broadband connectivity to tactical cells for mission critical communications, such as emergency calling.

▶ Trunking & Head-end Feed (Aggregated Mobile Backhaul & Content Distribution)

This use case is similar to the previous, except that it expands 5G connectivity by providing high-throughput and efficient multi-cast “middle mile” satellite connectivity to aggregation nodes near the edge of 5G networks not to the cell sites themselves.

For “trunking” (or “aggregated backhaul”), a satellite link is used for high capacity backhaul of data (whether video, eMBB, IoT or other data) at one or more points in the network that aggregate the traffic of multiple 5G cell sites. In a typical deployment, mobile traffic from multiple base stations is aggregated (e.g., via fixed microwave) to a satellite terminal which then carries the traffic to and from the network core. This can be paired with “head-end feed” (or “content delivery” or “content pre-positioning” or “content caching”), which uses the same satellite link to multi-cast commonly accessed content to these aggregation points where it can be cached and/or re-transmitted to the 5G user requesting that content. 5G networks will need efficient multi-cast distribution of commonly accessed content to the network edge to achieve the required perceived lower latency.

▶ Trunking

Trunking is a natural extension of a role that satellites already play in mobile networks today. Using the high-capacity of today’s HTS systems, MNOs from countries as diverse as the United Kingdom, Brazil, Chile, Peru, the United States, Chad and Papua New Guinea use aggregated satellite backhaul solutions to provide 3G and 4G-LTE to previously unserved or underserved populations. 5G backhaul has also been demonstrated and can ensure that the benefits of 5G are widely available.

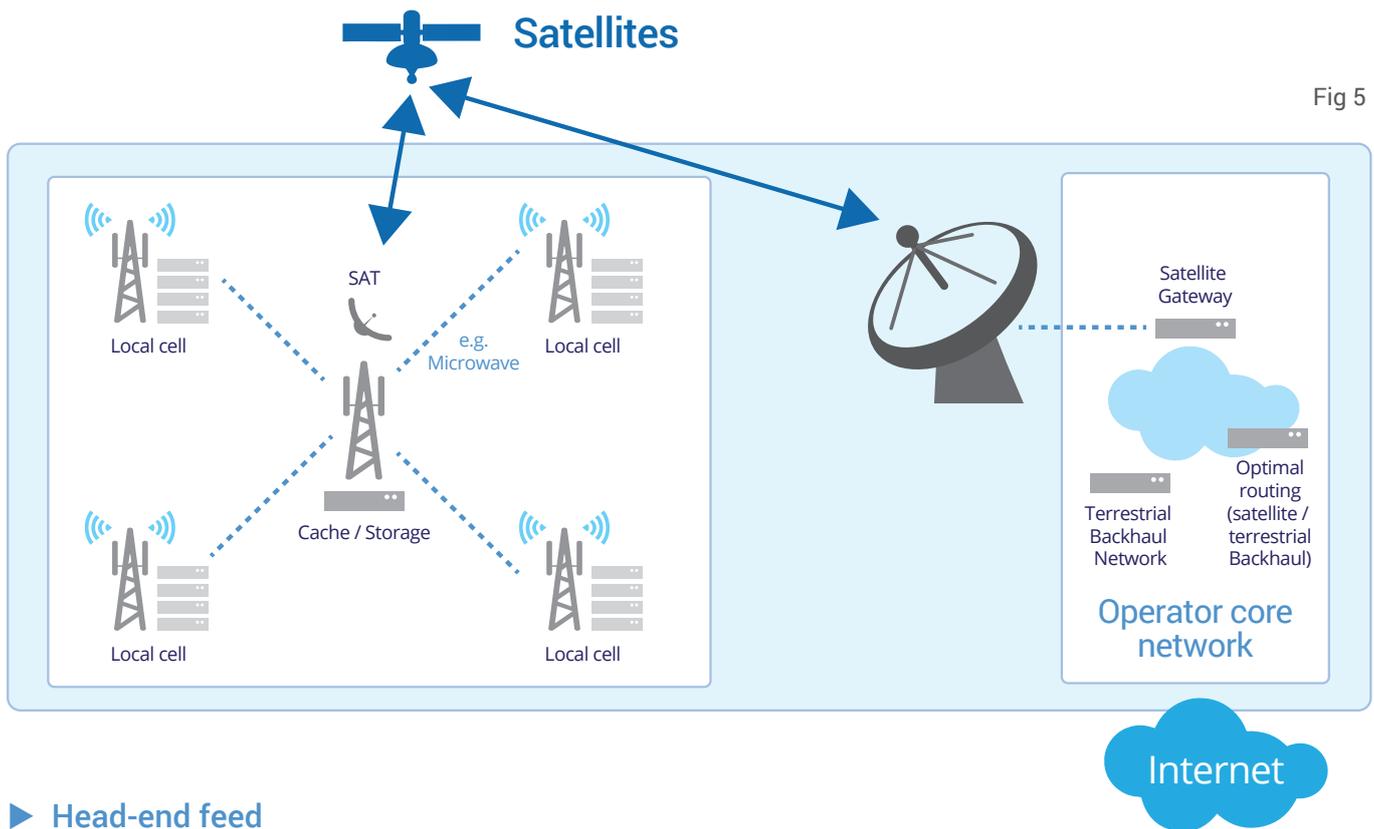


Fig 5

► Head-end feed

Head-end feed builds on satellite's inherent ability to efficiently transmit the same content to multiple locations simultaneously to enable the high-speed distribution of eMBB content such as videos or other common data closer to the network edge. This can take the form of both pre-positioning content in caches, and the multicast streaming of live video close to the network edge. This use of satellite is a natural extension of its existing role in efficiently distributing thousands of HD and UHD channels to broadcast and cable head-ends globally. It is not difficult to extrapolate this into a more data-centric world, where it is anticipated that a significant portion of the traffic will remain video.

Using satellites in this way deliver content with greater efficiency and immediacy, whilst reducing the demands on the large data warehouses and content distribution networks (CDN) nodes. Indeed, several ISPs are already making use of satellites in this manner to bypass network bottlenecks to efficiently deliver live TV feeds to their users. ¹⁵

Examples of this Use Case include:

- Expanding 5G coverage by carrying 5G traffic between the network core and “aggregation points” near the edge to which multiple 5G base are connected;
- Extending content delivery networks closer to the edge for network efficiency and content immediacy whilst reducing the demands of the large data warehouses and major CDN nodes;
- Providing efficient multicast/broadcast delivery closer to network edges for content such as live broadcasts (e.g. of news and major sporting events) and other ad-hoc broadcast/multicast streams, and group communications;
- Efficient MEC VNF (a virtual network function running on multi-access edge compute resources) update distribution to ensure software release update compliance.

5G as a Network of Networks

In today's digital world, the end user is typically agnostic to the technology being used to provide their service. Technology has evolved past the point where a user considers what technology option is best to meet their demands; they depend on the MNO or service provider to do that for them as part of their purchase of services. The delivery of services and content over network requires network operators, whatever the technology, to work together to deliver a seamless product to the user. The transition to network function virtualization (NFV) and software defined networks (SDN) along with end-to-end service management & orchestration (MANO) not only facilitates the integration of network functions of different technologies and vendors, it also potentially facilitates the integration of different technologies onto the same platform to enable the delivery of high-quality end to end performance to the final users.

Satellite technology will "blend in" to the overall 5G network architecture, by providing/deploying the suitable interfaces (APIs) for the terrestrial MANO systems, enabling the efficient management of satellite resources and fully supporting end-to-end 5G slicing connectivity requirements. The network management system will manage the traffic directed to the satellite according to bandwidth, Service Level Agreement (SLA), latency and other application requirements. It will allow (near) zero touch automation to services carried over the satellite links.

Not only are satellites capable of supporting all key 5G usage scenarios, they are vital for ensuring that the benefits of 5G are accessible to all. As already noted, the satellite industry has been working diligently with mobile and other industry stakeholders to ensure that the foundations are in place to ensure seamless integration of satellite technology into emerging 5G networks and to bring 5G communications to everyone, everywhere.¹⁶

Ensuring Satellites are an Integral and Effective Part of 5G

To ensure satellite's ability to meet users' growing 5G expectations, there are several key principles that regulators and policy makers globally must adhere to in adopting their policies and regulatory regimes. These include:

Technology Neutrality

A stable, resilient, inclusive 5G ecosystem requires policies that encourage competition rather than focussing solely on fibre or equating 5G solely with terrestrial wireless. Integrating satellite as an add-on, at a later date, will be inefficient and costly.

Policy-makers should avoid prescribing **artificial speed and latency requirements** that will result in underperforming or over-engineered 5G networks that serve very few use cases and meet the needs of fewer people.

Fostering and incentivising the emergence of common standards to enable the seamless integration and interworking of different technology solutions will further promote the 5G vision. For many 5G use cases, satellite technology is ready and policy-makers must focus on moving from demonstrations and trials to pilots where MNOs incorporate satellites into their systems in a controlled environment with real end-users.

Cost-Efficiency

Users across the world are disappointed that they do not have the broadband coverage they require in places where they live and work. In many cases, this lack of access is due to cost. In a 5G world, this lack of access, as demonstrated during the recent pandemic, can have severe consequences to economies, health and education. Accordingly, policymakers should ensure cost-effective platforms are available to meet user expectations. Satellite, because of its anywhere, anytime availability will often be the most cost-effective technology, especially in rural and remote regions. Huge investments into new technologies cannot be justified unless the benefits are realised for all citizens, not just a privileged few.

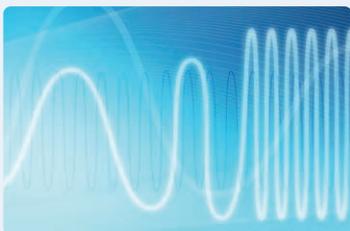


Regulatory Considerations

Emerging economies must ensure that regulation and licensing conditions promote the use of all 5G technologies, including satellite and hybrid solutions. Some countries take a General Authorisation approach to licensing which allows for unlimited satellite installations on their territory. Others charge fees per individual installation. This latter approach and other fees and duties applied excessively can prevent satellite from being adopted as one of the connectivity solutions, despite its vital role.

Only countries that promote a robust network-of-networks approach to 5G will fully reap the benefits of the new technologies and solutions of the 5G era.

Access to Spectrum Resources



Access to sufficient spectrum to meet user needs is a requirement for all wireless systems, whether terrestrial or in space. This means that regulators must take a balanced approach to spectrum allocation and use for all bands.

As terrestrial mobile systems move into higher bands, where satellite systems have been operating for many years, consideration needs to be given to the spectrum requirements of both sectors. A rapid deployment of terrestrial 5G networks is best served by focusing on spectrum bands that are not in use or planned to be used by satellite today so that both satellite and mobile can play their role. This will ensure that both technologies will have the spectrum required to work together, each enabling part of the value chain to ensure reliability, reach and quality of service.

Satellites today make intensive use of several frequency bands for their services, in various combinations of L-, S-, C-, Ku- and Ka-band frequencies. In addition, next-generation of HTS and VHTS systems – both GEO and non-GEO – are under construction and require even more spectrum, including in the higher Q, V and E bands. MSS systems also require more spectrum and this will be considered at WRC23. Given the long-term nature of these investments, it will be critical to maintain viable and sustainable access to both existing satellite bands, as well higher bands (such as the Q and V bands) to enable continued growth of capacity and to ensure that satellite systems can meet demands for 5G connectivity.

Conclusion

- ▶ By incorporating satellites into the 5G ecosystem the benefits of next-generation 5G connectivity can be made available to all users wherever they are.
- ▶ To successfully ensure that the 5G ecosystem includes all technologies, governments must embrace a standards-based, technology-neutral approach to regulation. This will enable the timely, widespread deployment of 5G.
- ▶ By working together, policy-makers and industry can improve the lives of all citizens by bringing them the full benefits of next-generation 5G communications.

Glossary of terms

Term	Description	Term	Description
3G	Third Generation of mobile networks	HTS	High Throughput Satellite
3GPP	Third Generation Partnership Project	IoT	Internet of Things
4G	Fourth Generation of mobile networks	LTE	Long Term Evolution
5G	Fifth Generation of mobile networks	LTE-M	LTE Cat-M1, supports IoT devices connected over 4G
ACM	Adaptive Coding and Modulation	M2M	Machine-to-machine
eMBB	Enhanced Mobile Broadband	MEC	Multi-Access Edge Computing
EMEA	Europe Middle-East	MMTC	Massive Machine Type Communications
ESOA	EMEA Satellite Operator Association	MNO	Mobile Network Operator
ETSI	European Technical Standards Institute	NB-IOT	Narrow band IoT
Frequency bands	The following satellite frequency bands terminology is frequently used (nominal transmit/receive in GHz)	NFV	Network Function Virtualisation
L- band	Between 1 and 2GHz	NR	New radio as in 5G new radio
C- band	6/4	NTN	Non-Terrestrial-Networks
Ku- band	14/11	RAN	Radio Access Network
Ka-band	30/20	SCADA	
Gbps	Giga bits per second	SLA	Service Level Agreement
GSMA	GSM Association	UE	User Equipment
HD	High definition (TV)	UHD	Ultra-High Definition
		URLLC	Ultra-Reliable Low Latency Communication
		VHTS	Very-High Throughput Satellite
		VNF	Virtual Network Function



Footnotes & References

- 1 C See ITU-R, "Key elements for integration of satellite systems into Next Generation Access Technologies" (rel. Jul 2019); see also ECC Report 280, Satellite Solutions for 5G (2018), ("ECC Report 280") (available at <https://www.ecodocdb.dk/download/e1f5f839-ba17/ECCRep280.pdf>).
- 2 See Press Release, "Inmarsat and Microsoft Azure IoT join forces to deliver cloud services via satellite" (February 25, 2019) available at <https://www.inmarsat.com/press-release/inmarsat-and-microsoft-azure-iot-join-forces-to-deliver-cloud-services-via-satellite>; see also Blog "Satellite connectivity expands reach of Azure ExpressRoute across the globe" (September 9, 2019) (available at <https://azure.microsoft.com/en-us/blog/satellite-connectivity-expands-reach-of-azure-expressroute-across-the-globe/>); Adrienne Harebottle, "IBM Cloud Solves Last Mile Challenges with Satellite", Via Satellite (October 25, 2018).
- 3 Compare GSMA Intelligence, Understanding 5G, at 6 (Dec. 2014) ("1 millisecond end-to-end roundtrip delay") and GSMA, The 5G Era, at 10 (2017) ("latencies of <10 ms for 5G networks").
- 4 This includes media content (video streaming, CDN content, popular content on YouTube, ...) but also support the deployment of augmented/virtual reality applications
- 5 GSMA Intelligence, Understanding 5G, at 12 (2014).
- 6 See, e.g., ECC Report 280, at 22 ("The new edge-focused network infrastructure that IMT 2020 will demand means that satellites can play a role in connecting and updating the large number of edge servers"); NSR, Wireless Backhaul via Satellite, at 128 (11th ed., 2017) ("Paradoxically, the low latency requirement for 5G networks is a big ally in this vertical for satcom as many new locations for content servers will be required. In the transition to 5G, content needs to be moved to the edge and many new locations will be required, densifying CDN networks and making satellite multicast a viable option.")
- 7 See SES Press Release "SES's and Gilat Telecom's Resilient Network Restores Connectivity in Africa" (February 10, 2020) (Restoring high-speed connectivity in the DRC within 4 days of major West African submarine cable cut) (available at <https://www.ses.com/press-release/ses-and-gilat-telecoms-resilient-network-restores-connectivity-africa>).
- 8 See FCC 2016 Broadband Progress Report, Report, FCC 16-6, GN Docket No. 15-191, rel. Jan. 29, 2016.
- 9 See ESOA, "ESOA Satellite Action Plan for 5G Standards", available at <https://www.esoa.net/cms-data/positions/1771%20ESOA%205G%20standards.pdf> (last accessed May 13, 2020).
- 10 See, e.g., K. Liolis, J. Cahill, E. Higgins, M. Corici, E. Troudt and P. Sutton, "Over-the-Air Demonstration of Satellite Integration with 5G Core Network and Multi-Access Edge Computing Use Case," 2019 IEEE 2nd 5G World Forum (5GWF), Dresden, Germany, 2019, pp. 1-5. See also, Blog, "Satellites bring multi-faceted 5G to Barcelona" (available at https://www.esa.int/Our_Activities/Telecommunications/Integrated_Applications/Satellites_bring_multi-faceted_5G_to_Barcelona); SATis5, Press Release, "Space-Enabled Internet of Things at Berlin 5G week", Nov. 19, 2018 (available at <https://satis5.eurescom.eu/2018/11/21/space-enabled-internet-of-things-at-berlin-5g-week/>); SAT5G Project, Press Release "EUCNC 2018 in Ljubljana, 18th to 21st June", (available at <https://www.sat5g-project.eu/eucnc-2018-in-ljubljana-18th-to-21st-june/>) (Last visited May 14, 2020); Press Release

"SaT5G project announces successful demonstrations of 5G over satellite use cases at EuCNC 2019 event in Valencia" (2019) (available at <https://www.idirect.net/2019/06/19/sat5g-project-announces-successful-demonstrations-of-5g-over-satellite-use-cases-at-eucnc-2019-event-in-valencia/>); Newtec, Press Release

"Newtec Enables World's First 5g Over Leo Satellite Demo" (2019) (available at <https://www.newtec.eu/article/release/newtec-enables-worlds-first-5g-over-leo-satellite-demo>); SaT5G, Press Release

"SaT5G project demonstrates 5G over satellite and holds industry briefing at University of Surrey" (2019) (available at <https://www.sat5g-project.eu/sat5g-industry-day-27-november/>); Press Release

"SaTis5 Demonstrates At The 10th Anniversary Fuseco Forum Of Fraunhofer Fokus In Berlin" (2019) (available at <https://satis5.eurescom.eu/2019/11/13/satis5-demonstrates-at-the-10th-anniversary-fuseco-forum-of-fraunhofer-fokus-in-berlin/>); SES, Press Release "Accelerating 5G roll out via satellite" (2019) (available at <https://www.ses.com/newsroom/accelerating-5g-roll-out-satellite>);

Press Release "Gilat Achieves Fastest Ever Modem Speeds of 1.2 Gbps Total Throughput over Telesat's Phase 1 LEO Satellite" (2019) (available at <https://www.gilat.com/pressreleases/gilat-achieves-fastest-ever-modem-speeds-of-1-2-gbps-total-throughput-over-telesats-phase-1-leo-satellite/>).
- 11 See Mike Robuck, "ONAP reaches to the sky with satellite deployment by SES Networks", FireceTelecom (2019).
- 12 See MEF Forum, "SD-WAN over Satellite Access" available at <https://www.mef.net/sd-wan-over-satellite-access>; see Press Release "Intelsat Recognized with SD-WAN over-Satellite "Service Implementation of the Year" Award" (November 26, 2019) (available at <https://www.intelsat.com/news/press-release/sd-wan-over-satellite-service-implementation-of-the-year-award/>); see also SES Insight paper, "Multi-Access SD-WAN Anywhere", available at https://www.ses.com/sites/default/files/2020-02/SD-WAN_Insight-Paper_Fixed-data.pdf.
- 13 This is in line with the requirements that "the 5G system shall be able to provide services using satellite access." 3rd Generation Partnership Project, "Service Requirements for the 5G System," TS 22.261 V17.2.0 at Section 6.3.2.3 (released March 2020).
- 14 See e.g. ECC Report 280; see also 3rd Generation Partnership Project, "Study on using Satellite Access in 5G," TR22.822 V16.0.0 Stage 1 (Release 16) (released June, 2018) (outlining numerous use cases for satellite in the 5G ecosystem); White House Office of Science and Technology Policy, "Ensuring America Reaches Its 5G Potential", rel. May 30, 2019 (available at <https://www.whitehouse.gov/articles/ensuring-america-reaches-its-5g-potential/>) (discussing satellite as a component of delivering 5G); Michael Kratsios, "Emerging Technologies and Their Expected Impact on Non-Federal Spectrum Demand", White House Office of Science and Technology Policy, rel. May 2019 (available at <https://www.whitehouse.gov/wp-content/uploads/2019/05/Emerging-Technologies-and-Impact-on-Non-Federal-Spectrum-Demand-Report-May-2019.pdf>); ITU-R "Key elements for integration of satellite systems into Next Generation Access Technologies" (Jul 2019).
- 15 See Press Release "SES Video Enables MultTV's ISP Customers to Deliver Pay-TV Content to IP Subscriber Homes" (June 6, 2017) (available at <https://www.ses.com/press-release/ses-video-enables-multv-isps-customers-deliver-pay-tv-content-ip-subscriber-homes>).
- 16 See 3rd Generation Partnership Project, "Study on using Satellite Access in 5G," TR22.822 V16.0.0 Stage 1 (Release 16) (released June 2018); see also 3rd Generation Partnership Project, "Service Requirements for the 5G System," TS 22.261 V17.2.0 (released March 2020).



EMEA Satellite Operators Association (ESOA)
Avenue Marnix 17 | 1000 Brussels, Belgium
+32 2 669 4274 | info@esoa.net | www.esoa.net | Twitter @ESOA_SAT

www.esoa.net

