WHITE PAPER

The Role of Space-based Communications in the 5G Era

INTELSAT

Published by
MOBILE WORLD LIVE

Introduction

The mobile industry is ushering in the 5G communications era. New standards are being finalised, testbeds are proving technology worldwide and the first commercial services have recently been launched. 5G will enhance consumer mobile services and enable a plethora of new use cases to serve a broad range of sectors from healthcare to education and from manufacturing to transportation.

The GSMA characterises the 5G era as an “age of boundless connectivity and intelligent automation.” Communication networks will have a more pervasive role in society, with the aim of connecting everyone and everything, anywhere in the world and whenever they need it. More than any previous mobile generation, 5G technology will expand connectivity to more people and devices than ever before, with the potential to generate economic and social benefits for consumers, entire industries and society in general.

Realising the vision for 5G and meeting the requirements for a diverse set of use cases will require new ways of designing and delivering mobile network connectivity and coverage. In this respect, the evolution to 5G will be far more transformative than past mobile generational shifts. More so than previous generations, 5G will rely on many technologies to create a network of networks, including 4G LTE, Wi-Fi and satellites, which are more aptly described as space-based platforms. Furthermore, the networks will be designed for flexibility and programmability by incorporating Software-Defined Networking (SDN), network virtualization, automation, network slicing and architectures such as edge computing.

The evolution to 5G is potentially momentous for the mobile industry. But typical of major technological change, the hype surrounding 5G risks promising too much, too soon and inflating expectations. This whitepaper presents a clear-eyed view of the 5G market, explains why 5G will be a network of networks, and examines how spaced-based communications systems will be critical components of mobile network operators’ 5G strategies.

The Evolution to 5G

5G is the fifth generation of mobile networks. Each generation since the early 1990's has delivered new capabilities and services: 2G introduced digital voice communications, expanded coverage and text messaging; 3G brought the mobile Internet and multimedia content; and 4G delivered mobile broadband, high-speed data and smartphones (Figure 1).

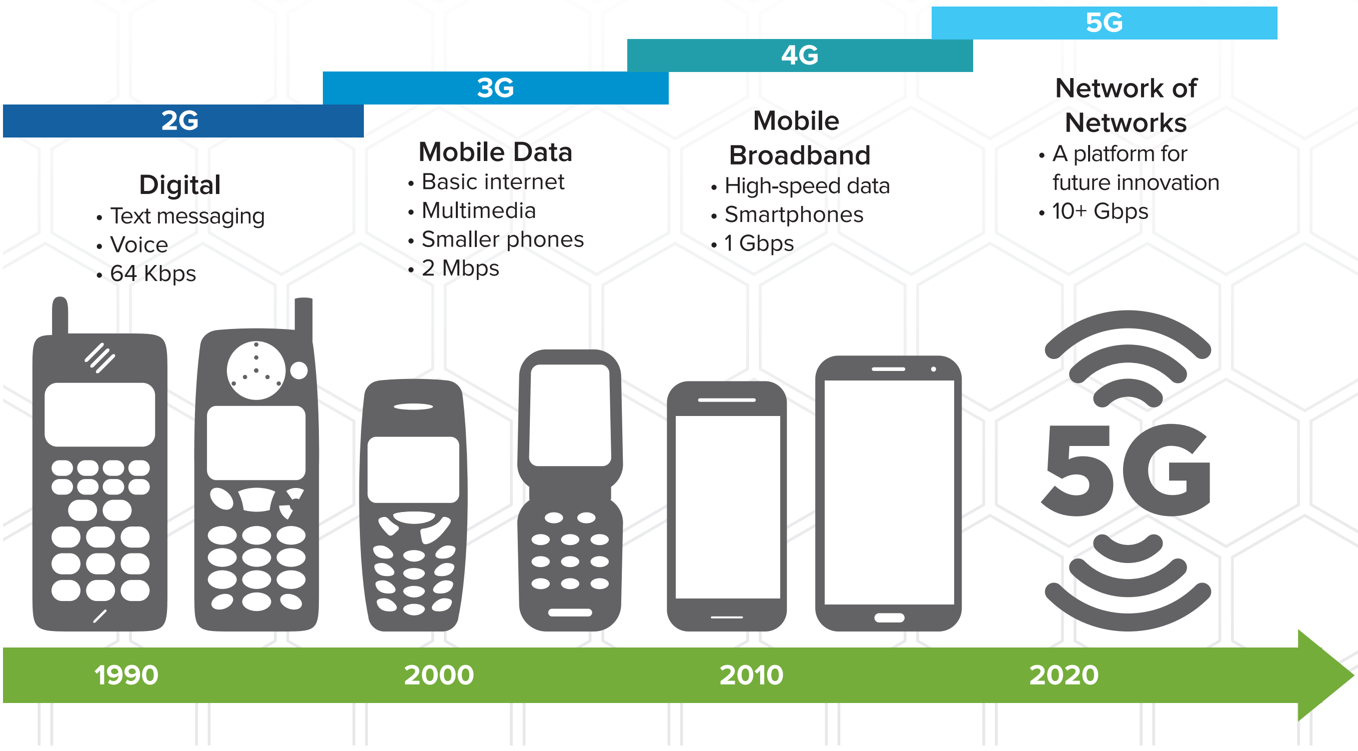
5G targets higher network performance, reliability, energy savings and cost efficiency as well as greater device connectivity. The advanced capabilities are needed not only to meet surging mobile data traffic levels, but also to support new revenue-generating services by expanding into vertical sectors, such as healthcare, manufacturing, transportation, public services and the automotive industry.

Mobile data traffic is expected to grow annually at a rate of 31 percent over the next five years to reach 136 exabytes per month by end 2024, at which time 5G networks will carry 25 percent of mobile data traffic globally, according to the latest Ericsson Mobility Report. By 2024, smartphones will consume four times more data on average than they do today, reaching an average 21 GB of data per month, driven primarily by video apps.

In addition to higher capacity for supporting mobile data growth, 5G will also enable mobile networks to connect a wider variety of devices and support a broader range of use cases. From massive amounts of Internet of Things (IoT) connectivity to mission critical communications, mobile operators will be able to deliver reliable, cost-effective communications services to enterprise sectors that have previously been difficult, or cost-prohibitive, to serve.

Unlike previous generations, the 5G network will be not just another "G" but more like a "platform for innovations," as envisioned by Qualcomm. The new network capabilities will put mobile operators at the heart of digital transformation initiatives in many industries.

Figure 1



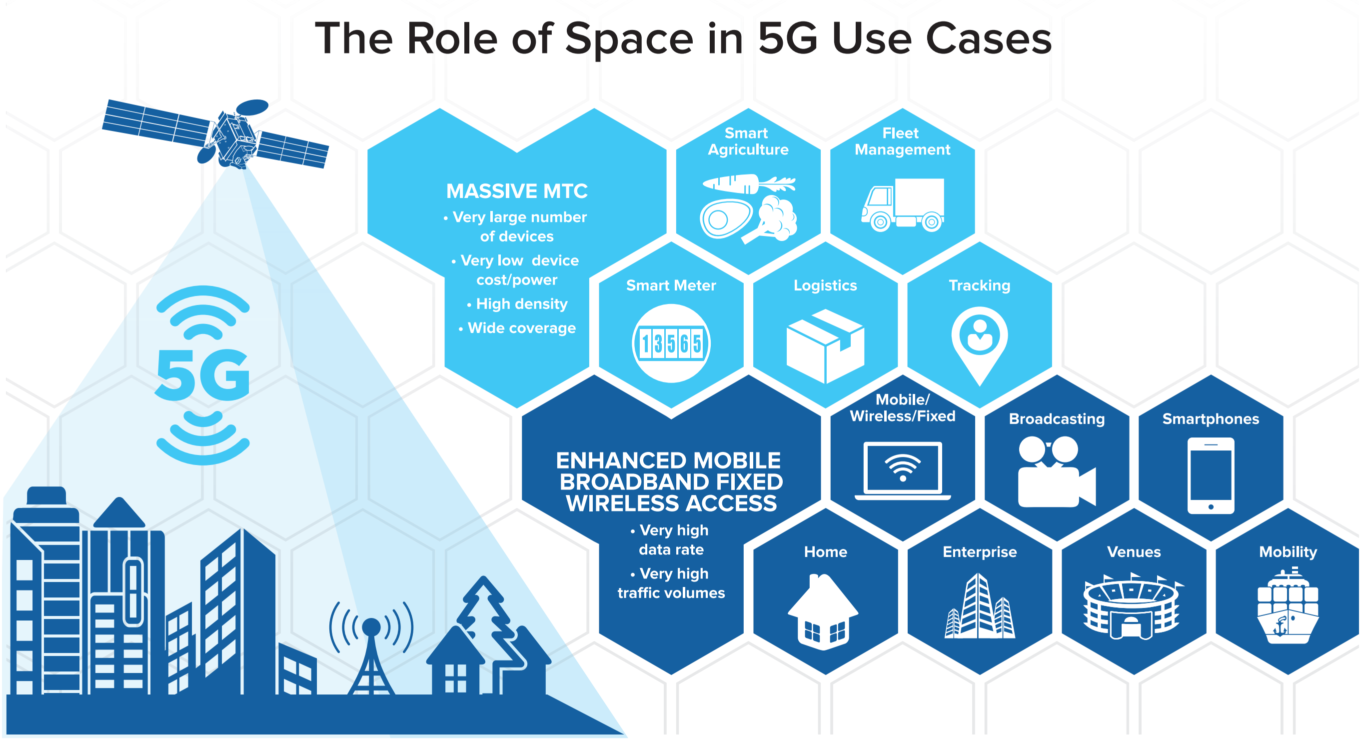
5G Evolution Leverages Existing Network Assets. The full capabilities of 5G are expected to be rolled out gradually, making the next mobile generation a network of networks and enabling operators to leverage existing infrastructure more so than in the past. With on-going improvements to 4G LTE networks -- whereby upgrades can achieve gigabit speeds – 5G will complement 4G networks as technology generations are expected to co-exist for longer.

Broadly, there are two deployment scenarios for 5G, as follows:

- Non-standalone (NSA), in which 4G and 5G New Radio (NR) resources are combined and the core network is either the existing 4G Evolved Packet Core (EPC) or new 5G Core (5GC). The earliest deployments will adopt NSA options.
- Standalone (SA), whereby only one radio access technology is used (5G NR or LTE) and operated alone with the core. SA will deliver the full capabilities of 5G. Later deployments, after 2020, are more likely to adopt SA.

The first commercial 5G deployments were launched in South Korea and the U.S. at the end of 2018, primarily for fixed wireless access (FWA). Most 5G deployments are expected after 2020, however, once standards are finalised, more spectrum is issued and there are more devices available. China, Japan, North America and South Korea are expected to lead the rollout of 5G. By 2025, the GSMA forecasts 1.1 billion 5G connections, which would be 12 percent of total mobile connections.

Figure 2



5G Use Cases

There are three main use cases for 5G: Enhanced Mobile Broadband (eMBB), Massive Machine Type Communications (mMTC) and Mission Critical Machine Type Communications (MC-MTC) (Figure 2).

Enhanced Mobile Broadband (eMBB). Most like today's mobile broadband services, this use case will also be the first deployed. Performance targets will dramatically improve mobile data rates, latency, mobility, user density, indoor and outdoor coverage, compared to today's networks, to support high-bandwidth applications such as broadcasting and augmented and virtual reality streaming, even in crowded environments where current networks are easily overloaded. FWA is another example for this use case, in which 5G network speeds match fixed-line capabilities. The goal is to support seamless mobile broadband connectivity everywhere in any network condition and at any time.

Higher data rates will accommodate usage scenarios such as real-time video conferences in offices or bandwidth-hungry multimedia apps consumed at various times of day and locations. Greater user mobility will support services consumed on fast-moving vehicles, such as trains or cars. Whether indoors, outdoors, in congested hotspots with many users, such as stadiums or shopping malls, and at any time of the day, 5G will deliver mobile broadband applications, multimedia traffic and linear video broadcasts.

Coverage requirements for eMBB span a wide range of scenarios from very small indoor locations to extremely remote environments. For example, eMBB will enable better small area coverage to serve indoor locations, such as classrooms where teachers can offer remote learning via real-time video conferencing, while it will also extend coverage in rural areas with low numbers of users to connect consumers and IoT machines.

Massive Machine Type Communication (mMTC). The use case envisions significant numbers of sensors or other devices connected via 5G and transmitting low volume of traffic that is not sensitive to latency delays. It requires coverage in urban as well as very remote areas to connect devices that are typically low-powered with long battery life. At the same time, the network must also have flexible capacity to support variable amounts of data traffic as some devices may need to intermittently send larger amounts of data (for example, a traffic monitoring camera in a smart city scenario).

The mMTC use case expands mobile network services into areas, such as smart cities, smart metering, remote monitoring, fleet management, logistics, tracking and smart agriculture. Sensors embedded in roads and railways can improve the efficiency, safety, security and energy consumption of transportation systems and vehicles. In agriculture, 5G-enabled sensor networks will help farmers monitor crop conditions and livestock, making their operations more efficient.

The key to enabling massive scale device connectivity is broad network coverage from deep into urban canyons to the most remote areas.

Mission Critical Machine Type Communications (MC-MTC). Also known as ultra-reliable low-latency communications (URLLC), this use case is characterised by strict requirements for very high reliability and availability as well as very low latency for critical communications. Applications include industrial automation, remote surgery, traffic safety, smart grid, emergency services and remote manufacturing.

> "5G will be a network of networks that embraces multiple technologies, including 4G LTE, 5G NR, Wi-Fi and space-based systems."

In the utility sector, for example, energy and water companies need accurate, real-time data about their critical infrastructure to keep supplies flowing as well as support more efficient smart metering applications. From remote windfarms to municipal water supplies in large cities, 5G-connected sensors can secure and modernise utility grids.

In manufacturing and mining sectors, the ability to have reliable, remote connectivity and processing can enable factory automation and remote control of critical infrastructure and heavy machinery, which will reduce their cost of operations and increase productivity.

The Role of Satellites in the 5G Network of Networks

To make 5G use cases a reality, mobile operators will need to rely on a variety of wireless infrastructure in radio access and transport networks. Since 5G embraces multiple 3GPP and non-3GPP technologies, including 4G LTE, 5G NR, Wi-Fi and space-based systems, the next mobile generation will be a network of networks.

Space-based platforms were recently added to the mix of 5G access technologies by the 3GPP, and the standards body is working on specifying requirements for satellite access that will be included with the full 5G specs in Release 16. The 3GPP recognises that satellite networks can deliver ubiquitous coverage and availability for 5G industrial and mission critical applications.

Space-based networks are vital to today's global communications infrastructure, providing services including mobile backhaul, broadband, linear and non-linear TV and IoT. In the 5G era, the advantages of satellites are even more profound – namely, ubiquity, resiliency and mobility as well as broadcasting.

Ubiquitous coverage. A small group or constellation of satellites can cover virtually all the inhabited Earth's surface. Even one satellite can cover a much vaster number of potential subscribers than any terrestrial network. Space-based platforms deliver continuous coverage worldwide and consistent coverage to targeted regions. Whether it's eMBB, mMTC or MC-MTC, 5G use cases require the ubiquitous coverage of space-based platforms.

Mobility and redundancy. When it comes to mobility, space-based platforms are ideal for providing connectivity to users aboard moving vehicles, such as planes, trains and ships. Higher mobility is one of the targets for the eMBB services. In addition, mMTC and MC-MTC use cases require guaranteed uptime and network reliability. For planned or unplanned network outages, space-based systems provide backup to restore services over terrestrial networks wherever a fault occurs.

Broadcast and multicast. Space-based networks transmit multimedia content via broadcast and multicast streams, which are important capabilities for enabling the 5G use cases – not only for consumer multimedia services, but also a variety of applications that require edge caching and local distribution. By broadcasting data or media to the network edge, whether it is for local content caching or software updates for edge servers, network operators can more efficiently scale services and network capacity.

These capabilities augment terrestrial networks and enable mobile operators to accelerate the development of 5G services and applications. Mapped onto the 5G use cases, space-based platforms can deliver multi-gigabit speeds anywhere in the world for eMBB; they can backhaul large-scale, remote IoT deployments for mMTC; and they can provide network uptime and reliable communications for MC-MTC, particularly via low-earth orbit networks.

Advanced Space-based Platforms for the 5G Era

Today's satellite networks are comprised of a variety of space-based platforms, including Geostationary Earth Orbit (GEO), Medium Earth Orbit (MEO), Low Earth Orbit (LEO) systems as well as High Altitude Platforms (HAPs).

- GEO space-based platforms cover large geographic areas from a fixed point approximately 36,000 km above the earth's equator and are synchronised with the earth's orbit. GEO platforms provide coverage to a specific area or region in a predictable and efficient manner. Because they are parked in space above the area being covered, GEO platforms only require small stationary directional antennas, which are lower in price compared to tracking antennas.

- MEO space-based platforms are non-stationary and orbit around the Earth anywhere from 5 to 10 hours at an altitude between 8,000 km and 18,000 km. Because these platforms are closer to the earth with a faster orbit than GEO platforms, they are deployed in larger constellations to provide continuous coverage. MEO platforms are commonly used for positioning information like GPS.

- LEO space-based platforms, as the name implies, orbit closer to Earth than MEO or GEO platforms at altitudes between 400 km and 1,500 km. To provide continuous coverage, LEO platforms must be deployed in even larger constellations than MEO. Because LEO platforms orbit the Earth every 1.5 to 2 hours, each space-born vehicle must follow behind the one before it in order to take over the communication. And because LEO platforms orbit closer to the Earth, they also provide faster connections than MEO and GEO platforms.

- HAPs comprise manned or unmanned planes, balloons or airships that operate at a fixed point relative to Earth at low altitudes between 20 km and 50 km. They cover smaller areas and can be quickly deployed to provide flexible broadband connectivity to specific locations. They can also provide remote monitoring for a variety of use cases such as detecting adverse weather conditions and earthquake activity or aiding in disaster recovery efforts.

High-throughput Satellites (HTS). Next-generation satellite technology, like HTS systems, deliver up to 10 times more throughput using the same amount of frequency on orbit compared to traditional fixed-satellite service (FSS). Throughput can exceed 100 Mbps. HTS systems feature high power density, which allows mobile operators to leverage smaller VSAT antennas, which are easier to deploy and install.

For 5G use cases, HTS systems for GEO, MEO or LEO installations can support mobile operators in delivering high-capacity broadband and broadcast services anywhere in the world. HTS systems also dramatically lower the cost-per-bit for delivering services.

Advanced Antenna Technology. Innovations in antenna technology and design, such as phased-array antennas, have made it easier to access high-throughput satellite capacity on the move. New satellite antennas are smaller, easier to install and more powerful than previous generations. These antennas are ideal for supporting 5G broadband on the move to planes, ships and trains, for example.

Space-based 5G Use Cases

The earliest 5G deployments are likely to centre around the eMBB use case in dense urban areas. But with the inclusion of space-based networks, operators can expand 5G services beyond city centres and support a wider variety of use cases. The following highlights some of the key space-based 5G use cases.

Edge Server Connectivity. Edge computing such as Multi-access Edge Computing (MEC) is a key feature of 5G networks, as performance and low latency targets require processing to be distributed from centralized data centres to edge servers closer to users. Space-based platforms can provide high-capacity backhaul connectivity and multicasting to large numbers of edge servers over wide areas, thereby complementing the terrestrial network with cost-effective scalability. Satellite-based backhaul can deliver content such as live broadcasts, multicast streams or group communications to the network edge as well as distribute software updates for MEC implementations.

Fixed Backhaul to Remote Locations. Just as in today's networks, space-based systems will facilitate 5G broadband connectivity to underserved areas where it is not feasible to deploy terrestrial infrastructure, such as remote villages, islands or mountainous regions. This also includes broadband services on board aircraft or ships, as well as in suburban and rural areas. Satellites will also support community 5G Wi-Fi services, where there is limited or non-existent broadband. Space-based backhaul will also provide disaster relief services, support emergency response teams as well as deliver broadband connectivity for one-off entertainment or sports events anywhere in the world.

Hybrid Networks. Space-based platforms can provide high-speed connectivity directly to homes and offices for streaming multicast content across large geographic areas, or unicasting content to devices or users. Hybrid networks also support the aggregation of IoT data in massive machine-type communications. High-capacity satellite links provide direct connectivity to users as well as complement terrestrial networks.

5G on Moving Platforms. Satellite-based networks are the only means for delivering 5G broadband to users on board moving vessels, including cars, ships, airplanes and high-speed trains. The capability not only applies to the eMBB use case but also mMTC, as satellites can aggregate traffic from IoT sensors installed in moving vehicles. This supports applications for fleet management, navigation and connected cars. In addition, space-based broadcast capabilities support over-the-air software updates for connected cars anywhere in the world.

IoT Service Continuity. In critical communications, space-based systems provide a resilient backup to terrestrial networks anywhere in the world. As IoT scales to massive connectivity in the 5G era, satellites will deliver the service continuity needed for critical communications as well as future industrial control applications.

It is important to note that since 5G is an evolution and will be combined with existing 4G infrastructure in the short- to medium-term, network operators don't have to wait for 5G to start supporting many of the above use cases. Space-based solutions can be deployed as part of 4G network strategies and will then be ready to support future 5G services.

Conclusion

Space-based communication platforms are set to play a larger role in mobile network strategies in the 5G era. The variety of use cases with diverse requirements as well as the ambition to connect everyone and everything make space-based solution providers ideal partners to deliver 5G network strategies. As a member of the GSMA and ATIS, Intelsat is leading the discussion about the important role of space-based communications in 5G networks. The seamless connectivity across technologies in the 5G era, enabled by the network of networks that includes space-based communications, opens new verticals for mobile operators to expand their markets and explore new revenue streams.

As the foundational architects of satellite technology, Intelsat operates the largest, most advanced satellite fleet and connectivity infrastructure in the world. We apply our unparalleled expertise and global scale to reliably and seamlessly connect people, devices and networks in even the most challenging and remote locations. Transformation happens when businesses, governments and communities build a ubiquitous connected future through Intelsat's next-generation global network and simplified managed services.

At Intelsat, we turn possibilities into reality. Imagine Here, with us, at Intelsat.com.

To learn more, visit www.intelsat.com

Produced by the mobile industry for the mobile industry, Mobile World Live is the leading multimedia resource that keeps mobile professionals on top of the news and issues shaping the market. It offers daily breaking news from around the globe. Exclusive video interviews with business leaders and event reports provide comprehensive insight into the latest developments and key issues. All enhanced by incisive analysis from our team of expert commentators. Our responsive website design ensures the best reading experience on any device so readers can keep up-to-date wherever they are.

We also publish five regular eNewsletters to keep the mobile industry up-to-speed: The Mobile World Live Daily, plus weekly newsletters on Mobile Apps, Asia, Mobile Devices and Mobile Money.

What's more, Mobile World Live produces webinars, the Show Daily publications for all GSMA events and Mobile World Live TV – the award-winning broadcast service of Mobile World Congress and exclusive home to all GSMA event keynote presentations.

Find out more www.mobileworldlive.com

19/02/8196-5G