THE 5G FUTURE AND THE ROLE OF SATELLITE

ST Engineering

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Today, we are on the verge of seeing what a truly "connected world" looks like. It's projected that soon there will be 6 billion people, 30 billion devices and 50 billion machines online. That's essentially everyone and everything connected, across every geography, supporting every application from consumer broadband, mobile gaming and connected cars to global business networks, ships, planes, soldiers, first responders and connected farms.

Supporting a connected world is a daunting challenge that today's telecom infrastructure is simply not equipped to handle. This fact is driving the development of the new 5G networking architecture. The 5G standard promises blazingly fast broadband speeds, exponentially higher efficiencies, massive scalability, significantly lower costs for mobile and fixed networks, and ultra-low latency applications such as connected car and massive M2M and IoT applications.

5G also defines a common network architecture to which all access technologies can adhere. As such, 5G will dramatically change how satellite is integrated into mainstream, achieving full interoperability within the end-to-end 5G network. In the past, the satellite industry has played catch-up, spending extra time on the backend to find ways to integrate satellite technology into the prevalent standards and technologies. With 5G, the satellite network will be developed from the get-go to interoperate within a 5G architecture.

5G provides the ultimate opportunity for the satellite industry to break out of its niche and for satellite service providers to offer a much wider range of services, while enabling mobile and fiber operators to leverage satellite connectivity to expand their coverage areas and offload their networks through critical functionalities like multicasting, backhauling, and mobility access where satellite is a better access technology.

We believe the opportunities for satellite are enormous. Mobile network operators will be able to complement their 5G services with satellite connectivity to offload their terrestrial networks in a large scale. They will be able to take advantage of satellite's inherent multicasting/broadcast functionality for new use cases, such as the connected car, while preserving high-value wireless spectrum for latency-sensitive services. Or, they can use satellite's longer range to complement the buildout of 5G in remote areas where building terrestrial networks for enhanced broadband services is simply too cost prohibitive.

At ST Engineering iDirect we make it our mandate to foster industry collaboration that ensures satellite's place in the future 5G connected world. We see the movement toward 5G as a path to standards-based access for a fully converged, end-to-end network.

This paper will provide you with an overview of the key 5G technology innovations, the new application and use cases 5G will address, and our view of the 5G opportunity for satellite.

More Than Just Another Standard

For mobile operators, 5G is far more than a faster version of the 4G/LTE standard. 5G will be an entirely new networking architecture — "a network of networks" — with multiple access technologies such as Wi-Fi, small cells, and traditional mobile wireless networks as well as terrestrial and satellite. It is being designed by the wireless industry to virtualize, automate and streamline service delivery. It brings technology together from three main areas: Evolved Packet Core (EPC/5G Core) from 3GPP and the cellular industry; Network Function Virtualization (NFV) and Software Defined Network (SDN) from the networking industry; and Virtualization and Cloud Computing technologies.

These technologies, defined by the new 5G standard, will prompt network-wide innovations across telco, mobile and satellite networks. It is expected to transform how the communications industry at large operates, and how users experience new connectivity services. Some of these new user experiences will require ultra-high speeds (e.g., broadband, gaming), some will require quasi-real-time connections (e.g., autonomous car), and some will require massive scale for big data connecting millions of endpoints (e.g., M2M/IoT applications).

To better understand the magnitude of this transformation, it's helpful to take a quick look back at each standard and how its architecture evolved. Initially, the early 2G voice networks consisted of a switch with centralized functions and a hierarchical Radio Access Network (RAN). In 3G, these became less hierarchical to handle basic packet data (e.g., text messages). As the network evolved to better handle data services through packet data, more distributed RAN elements became prevalent. 4G/LTE networks today are centralized around EPC/3GPP network components with a flat RAN architecture.

The new 5G standard is evolving this structure even further by virtualizing individual EPC functions and then dynamically distributing them across the core and to the edge of the network, as governed by concepts such as Network Slicing and Multi-access Edge Computing (MEC).

The rollout of a new standard — whether from 2G to 3G or 3G to 4G/LTE — has taken anywhere from three to eight years. In fact, 4G adoption is still ongoing. With 5G, we will begin to see gradual adoption at various speeds depending on the use case starting as early as 2019. However, it will be years until significant 5G coverage is available globally.

When 5G begins to roll out, it will start in high-tech countries such as the United States, parts of Europe, South Korea, China, Japan and India. 4G will not disappear anytime soon, either. In fact, the 5G standard has been written to be backwards compatible, so any 5G modem could work on the 4G standard as well. The 4G standard and its multiple variants will continue to play a key role in the network, particularly for less bandwidth-heavy and more latency-tolerant use cases.

This means that a mobile network operator may choose to use 5G for some applications that depend on 5G characteristics, such as communications between self-driving cars, while continuing to use 4G for other services. As a result, operators need to plan for both 4G today and 5G tomorrow, as they will coexist and share the same network resources for the foreseeable future.

Key 5G Innovations

To successfully build the all-connected 5G future, the communications industry must achieve a few key technological innovations. These innovations revolve around using EPC, orchestration and a new waveform called 5G New Radio (5GNR) to dramatically increase speeds, decrease latency and allow for complete network orchestration.

A key promise of 5G is to provide faster speeds. This will be achieved primarily by two innovations: the use of SDN functionality and the RAN's operation using the waveform NR in higher frequency bands.

SDN functionality and NFV work in unison to split up EPC functions within a cellular network. They will split traffic into the data plane and the control plane, thus separating decision-making from traffic handling. Virtualizing and slicing the functions within the network will allow dynamic orchestration of network resources. Thus SDN functionality enables more efficient use of network resources to achieve higher speed connections.

Greater speed will also come from the use of higher frequency bands. Unlike 3G and 4G networks, 5G networks will run over higher frequencies, such as 3–6GHz, which overlaps with C-band satellite and 26–30GHz, which overlaps with Ka-band, often referred to as "millimeter wave" within the wireless industry.

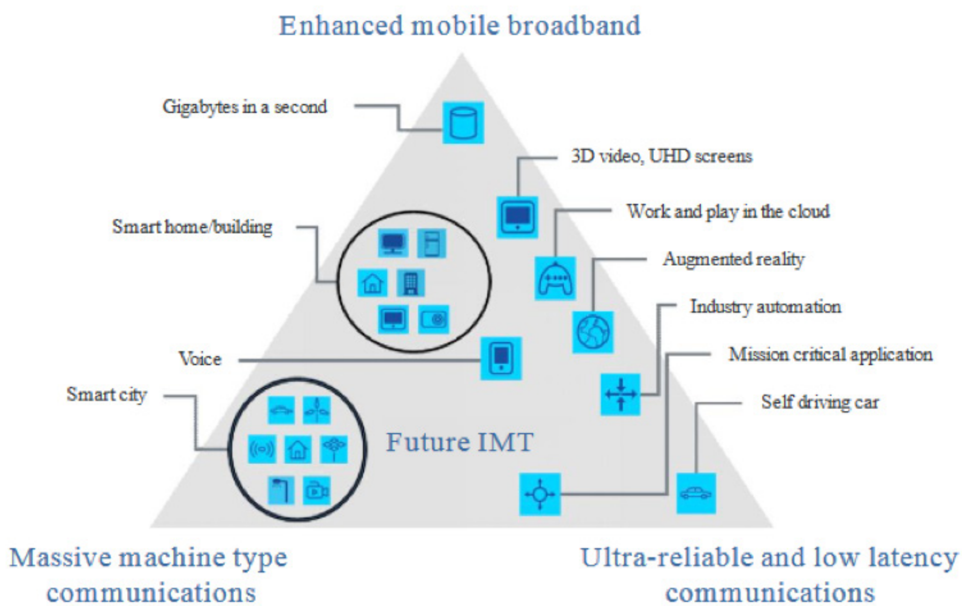
The use and the rights to these bands are being negotiated right now and will vary by country and region. However, commonly considered bands, in particular at these higher frequencies, are capable of carrying extreme bandwidth yet only over very short ranges. As a result, a substantially higher number of mini-base stations will be needed to cover the same area than conventional base stations would today.

While the ultra-high frequency transmission across short distances will reduce latencies somewhat, the more important reduction in latency will come from the efficiencies that result from core 3GPP data and control plane functions being pushed to the edge of the network.

Another innovation in developing the 5G standard stems from allowing multi-radio waveforms under one standard. The goal is for 5G architectures to provide integrated services across many access networks, such as Wi-Fi, small cells and satellite. One of the most important part of this is the development of the 5GNR waveform. 5GNR was ratified by the 3GPP working group as outlined by IMT-2020. It will act as the waveform standard for connectivity that the 5G base station will use to communicate with User Endpoints (UE), promising fiber-like performance at a significantly lower cost-per-bit.

5G Applications and Satellite's Crucial Role

The advanced communications of 5G are expected to transform three major use cases: Enhanced Mobile Broadband (eMBB), Ultra-Reliable and Low-Latency Communications (URLLC), and Massive Machine-Type Communications (mMTC). Satellite has a critical role to play in each of these categories.



Source: ITU

Enhanced Mobile Broadband (eMBB)

With 5G comes the opportunity to offer vastly enhanced and faster broadband connectivity (e.g., voice, video, data) to wide area networks, hotspots for mobile or fixed networks.

- **5G to Premises:** Satellite will complement terrestrial networks, such as broadband connectivity to a home or office, in an underserved area, or to enterprise sites as a backup.
- **5G Fixed Backhaul:** Satellite will bring broadband connectivity where it is difficult to deploy terrestrial connections in rural and remote areas across a wide geographic region only or best covered by satellite.
- **5G Mobility Backhaul:** Satellite will bring broadband connectivity to remotes or UEs on the move, such as airplanes, trains, vehicles or maritime vessels.

Ultra-Reliable and Low-Latency Communications (URLLC)

The second set of 5G use cases are URLLC applications that are particularly important for mission-critical and pseudo-real-time applications. Let's consider the case of autonomous cars, where latency is absolutely critical. To operate successfully, autonomous cars need to be able to talk to each other and their surroundings (also referred to as 'vehicle-to-everything' or 'V2X') within milliseconds. Until the introduction of 5G, there has been no network capable of handling the sheer scale and low latency required to make autonomous driving a reality. The 5G standard is about to change that with lightning speed connections and smart routing. For example, in this use case V2X data is distributed the fastest if it doesn't have to be routed to the core network and then back out to the base station. Rather, connectivity is established at the edge, such that the same base station is used to connect the vehicle and the local sensors.

It is clear that satellite connectivity, regardless of its orbit (GEO, MEO, LEO), will not support certain latency sensitive applications and services, and therefore is not an optimal access technology option in V2X or autonomous driving per se; however, it will have a role in the connected car application at large, such as in passenger infotainment and car software updates. In the case of the connected car, multicasting will allow media streaming, such as OTT and software updates, to be broadcasted to millions of cars simultaneously, vastly reducing the congestion that would otherwise be put on the base station. Satellite will complement the terrestrial buildout through traffic offloading. This would also require the endpoints (base stations or cars) to be hybrid in nature, with satellite and cellular connectivity modem technology incorporated.

Massive Machine-Type Communications (mMTC)

The third set of use cases are mMTC for M2M or IoT devices and sensors. SDN functionality will play a critical role here as it allows for a given UE to be serviced with far fewer resources, in return enabling several UEs to be serviced with the equivalent resource of a single 4G UE. This already showcases the promised scale that comes with 5G.

The 5G architecture needs to dramatically scale as it will be connecting and backhauling data from millions of smart devices and sensors inside homes and urban infrastructure, as they will become prevalent in smart cities of the future. While small in nature, the sheer aggregated volume of this M2M and IoT connectivity will have a major impact on the network load. In order to offload 5G networks, one opportunity for satellite can be backhauling non-latency sensitive data from these devices, or more precisely, from the aggregation points back to the core network.

Where ST Engineering iDirect Sees the Satellite Opportunity

Satellite can no longer be a separate, standalone network. Rather, it must become a standard radio interface within the multi-radio network architecture of 5G. In the future, an intelligent 5G network will need to automatically engage satellite — seamlessly, quickly and easily. And our industry will shift from a peripheral position in the global communications infrastructure to a central player in achieving a truly connected world.

Adapting satellite to work seamlessly with 5G cellular and terrestrial networks will empower end users anywhere in the world with consistent, reliable, high-performance experiences. Service providers will be able to decide how they can best serve customers — whether it's through satellite, terrestrial or mobile networks, or all of them combined.

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Our 5G Strategy

Fostering Collaboration and Standards

We see the movement toward 5G as a path to standards-based access for a fully converged, end-to-end network. To help drive the 5G standard and the adoption of satellite forward, we are fostering collaboration among various ecosystem partners and participates in industry standard bodies to ensure that our future solutions are compatible with the evolving 5G standards, and in turn to make sure the 5G standards properly accommodate satellite.

Driving 5G Satellite Innovations in Trials

Along with a team of consortiums partners (SaT5G, SATis5 and OSMOSIS), we were the first in 2018 to successfully demonstrate live, first-of-its-kind satellite integration into 3GPP network architectures demonstrating the key benefits of network slicing and SDN/NFV/MEC-enabled 5G construction testbeds.

Developing a Satellite 5G Architecture

We believe in driving the new 5G standards for satellite networks. As a result we are leveraging principles of Evolved Packet Core (EPC), multi-waveforms, edge computing and cloud-based to build into our platform so that it no longer is a separate, standalone network. Rather, it must become a standard radio interface within the multi-radio network architecture of 5G.

Visit http://www.idirect.net/5g/ to find out more.

Glossary

Standard Bodies

3rd Generation Partnership Project (3GPP)

The 3rd Generation Partnership Project is a consortium of seven telecommunications standard development organizations called "organizational partners." ETSI in Europe is one of these partners, as is ATIS in the U.S. Other members include standards bodies and associations from Japan, China, India and South Korea. 3GPP is responsible for developing the technical specifications that will become the 5G standards. In June 2018, it approved Release 15, the Standalone (SA) 5G specification. The specifications for the Non-Standalone New Radio (NSA NR) air interface were approved in 2017. ST Engineering iDirect participates in the meetings to help influence the standardization for satellite integration.

http://www.3gpp.org/

European Telecommunications Standards Institute (ETSI)

The European Telecommunications Standards Institute is a not-for-profit organization with 800 member organizations in 66 countries. It provides members with an open environment to support the timely development, ratification and testing of globally applicable standards for ICT-enabled systems, applications and services. ST Engineering iDirect helps influence the members to standardize and document satellite integration

https://www.etsi.org/

Alliance for Telecommunications Industry Solutions (ATIS)

The Alliance for Telecommunications Industry Solutions is a forum for information and communications technology (ICT) companies. It is accredited by the American Standards Institute (ANSI) and aims to develop standards and solutions to shape the future of ICT. ATIS is the North American partner for the 3GPP and a member of the ITU.

http://www.atis.org/

Metro Ethernet Forum (MEF)

Metro Ethernet Forum is an industry consortium dedicated to adoption of Carrier Ethernet networks and services. Composed of service providers, incumbent local telcos, network equipment vendors, and other networking companies that share an interest in Metro Ethernet.
ST Engineering iDirect is a MEF member since 2018.

https://www.mef.net

5G Consortiums and Working Groups

Satellite and Terrestrial Network for 5G (SaT5G)

SaT5G is a consortium funded by the European Commission and part of the Commission's Horizon 2020 program. It is one of the initiatives included in Phase 2 of the work of the 5GPPP. It aims to integrate satellite into 5G by defining satellite-based backhaul and traffic offloading solutions. Read up on ST Engineering iDirect's milestones demos in our Press Release section.

http://sat5g-project.eu/

SATis5

SATis5 is another organization focused on integrating satellite into 5G. It is part of the Advanced Research in Telecommunications Systems (ARTES) program of the European Space Agency (ESA). One of the main objectives of the organization drive technology innovation aimed at opening 5G market opportunities. As part of this group iDirect is involved in the research and development of an end-to-end system to support multi-orbit operation with 5G. Read the Press Release News Room.

https://artes.esa.int/projects/satis5

OSMOSIS

Is another ARTES ESA funded program that ST Engineering iDirect participates in. The objective of this program is to enhance the end to end hybrid network to use broadcast techniques to populate network edge CDN appliances.

https://artes.esa.int/projects/osmosis