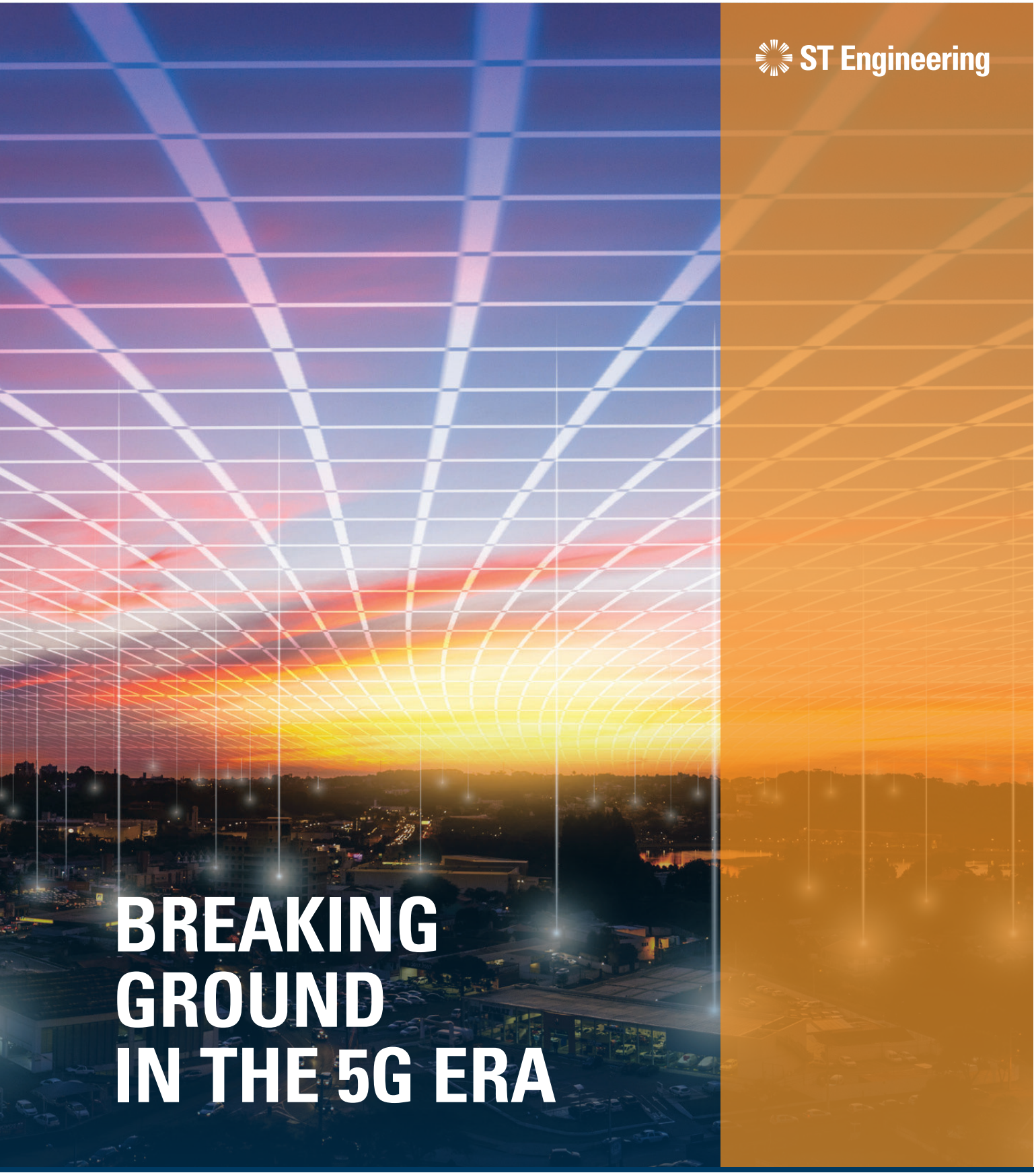


ST Engineering

BREAKING GROUND IN THE 5G ERA

iDIRECT

Innovation, standardization, virtualization and know-how are essential to realizing the opportunities that 5G presents to satcoms.

The 5G architecture standard has changed the communications landscape, and it is now punctuated by real opportunities for satellite to play an integral role. Acting as a banner for all standardization technologies, including Network Function Virtualization (NFV), Software-Defined Networking (SDN) and Metro Ethernet Forum (MEF), the 5G architecture standard potentiates both satellite's place in mainstream connectivity, and full interoperability within the end-to-end 5G network.

While the satellite industry is focusing on aligning with these open standards, satellite's capabilities are also increasingly better known. With satellite, people's lives are being significantly improved as they're brought online from within coverage gaps. MNOs will be able to complement their 5G services by adding satellite connectivity to their terrestrial networks in large scale. They will be able to take advantage of satellite's inherent multicasting functionality for new use cases, while preserving high-value wireless spectrum for latency-sensitive services.

Additionally, they can use satellite's longer range to complement the buildout of 5G in remote areas, where deploying terrestrial networks for enhanced broadband services is simply cost prohibitive. When it comes to delivery of 5G to premises, satellite will play a complementary role with terrestrial networks, delivering broadband connectivity across underserved or unserved areas, in addition to providing back up connectivity to enterprise sites. We also see maritime and enterprise providers among the early adopters of 5G standards within their networks. The relevance and need for satellite within the connectivity mix has never been more apparent. Especially now, with the proliferation of LEO and MEO offerings, it's clear that satellite will play a key role.

At ST Engineering iDirect, it is 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 importance of the 5G standard for satellite, key 5G technology innovations, the new applications and opportunities that 5G will address, and the advances we have made in satellite over 5G.

Satellite as an Integral Part of the Hybrid Network

The 5G standard has been designed by the wireless industry to leverage virtualization and automation and to streamline service delivery. It will ultimately form the fabric of an entirely new networking architecture — a network of networks — with multiple access technologies such as Wi-Fi, 4G, 5G and IoT.

The 5G standard brings technology together from three main areas: Evolved Packet Core (EPC/5G Core) from 3GPP and the cellular industry; NFV and SDN from the networking industry; and Cloud Computing technologies. In addition, the adoption of Open RAN, where the functionality is disaggregated and the Radio Access Network (RAN) is built using open interface specifications between the different elements, will help to further scale the cost- efficiency of networks.

What is crystal clear is that 5G standardization is key to realizing this bigger, faster, better 5G future. Satellite capacity must work seamlessly with terrestrial networks in order to enable interoperability and unlock new use cases. It is with that in mind, that current 3GPP research activities also highlight the importance of standardization around NTN (Non-terrestrial-networks), a proxy for standardization of satellite communication within 3GPP.

The end-goal is well understood. Satellite Service providers need to be able to steer communication traffic easily and effectively to the best options available in terrestrial and non-terrestrial networks, while deftly navigating bandwidth, latency and network conditions, all the while delivering QoS and meeting top user experiences.

5G: More than the Evolution of Wireless Standards

To better understand the magnitude of 5G transformation, it's helpful to take a quick look back at how each standard evolved. Initially, the early 2G voice networks consisted of a switch with centralized functions and a hierarchical RAN. In 3G, these became less hierarchical to handle basic packet data. 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/3 GPP network components with a flat IP RAN architecture.

The new 5G standard is further evolving this by virtualizing individual EPC functions, and then dynamically distributing them across the core and to the edge of the network, as facilitated by concepts such as network slicing and Multi-access Edge Computing (MEC). Additionally, 5G is a service-based architecture designed around services that will invoke inter-operability with standard APIs.

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're seeing adoption at various speeds, depending on the use case and region. However, it will be sometime until significant 5G cover age is truly available globally.

With major architectural changes in these areas, satellite must be ready for the shift that is redefining the new connectivity landscape.

5G as a Key Technology Enabler

In order for global satcom 5G deployments to become reality satellite must adhere to the standards used in the converged end-to-end network. Within such a hybrid network satellite plays a part in access networks that provide broadband connectivity to the consumer and in aggregation networks that connect network nodes to the core network. Each of these areas requires its own standards but there is also a clear convergence happening towards 3GPP/5G on the access and MEF on the aggregation side. Satellite needs to adhere to these standards in order to fully integrate into this fully converged network.

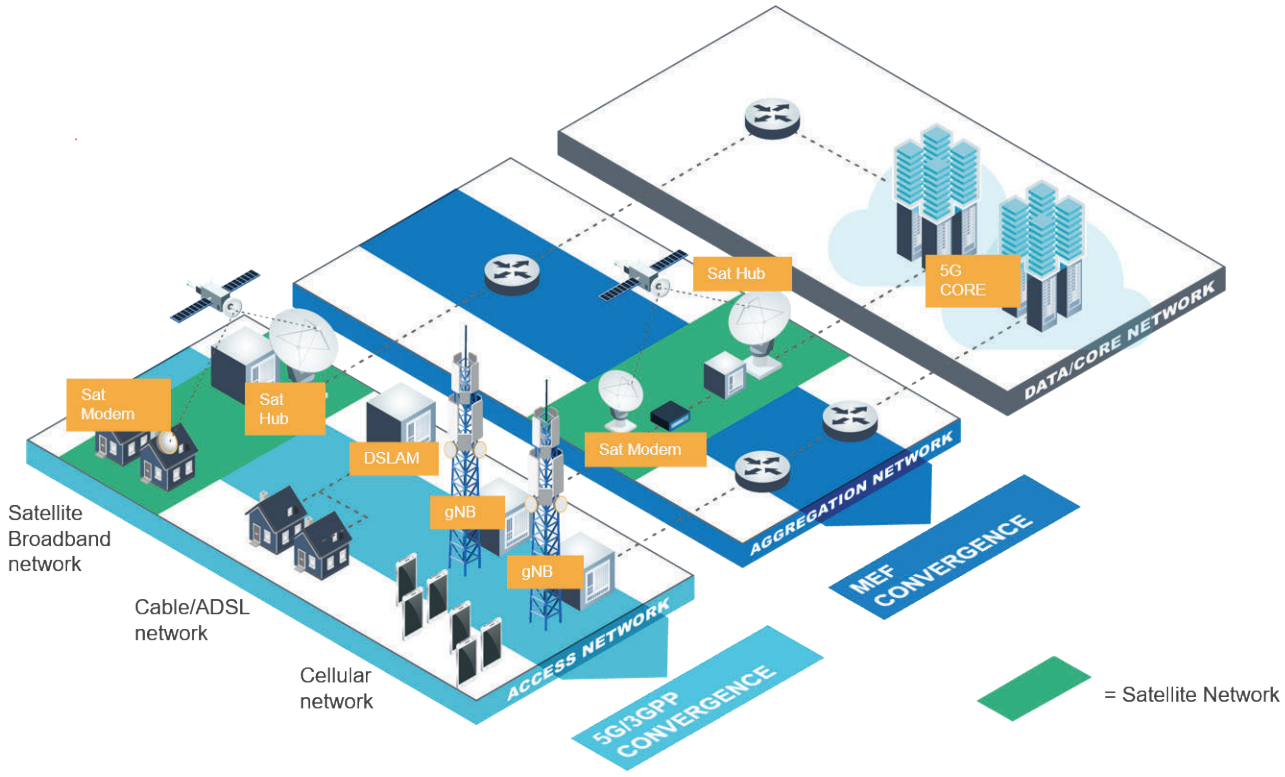
There are also other advances happening, revolving around using EPC, orchestration and the 5G New Radio (5G NR) waveform dramatically increasing speeds, decreasing latency, and allowing for complete network orchestration.

Digital transformation of the ground is also necessary to better integrate with telecommunications to enable 5G. Simply embracing proven principles and best practices from the larger scale telco and IT worlds, and adapting those to specific needs, can help accelerate availability and adoption. These key enablers are virtualization, cloudification and orchestration.

With virtualization and cloudification, ground networks can establish private cloud environments to extend capabilities and connect with functions and services available in major public cloud environments. Moving virtualized functions into the cloud has quickly become a key driving force for businesses today, as applications are moved out of on-premises data centers in a bid to innovate, cut costs and increase agility. The leading cloud players, namely Amazon (AWS), Microsoft (Azure) and Google (Cloud) have been seeking more in routes into the satellite industry, and have started to embrace the satellite ground segment.

With service orchestration, satellite and terrestrial hybrid networks based on open architectures and standardized platform APIs can be easily integrated, resulting in seamless service delivery while reducing operational complexities and ensuring that services are implemented in an automated, expedient and frictionless manner, as needed.

SATELLITE AS AN INTEGRAL PART OF THE HYBRID NETWORK



5G Applications & Satellite's Important Role

As 5G's common network architecture is satellite's ticket into the world of mainstream connectivity, so is satellite the way that 5G applications can change the world. With 5G's ability to connect virtually everyone and everything, including machines, objects and devices, an explosion of new applications and user experiences is happening. Some of these new user experiences will require ultra-high speeds and enhanced broadband, notably for gaming and broadband internet. Some will require quasi-real-time connections for ultra- low latency applications, such as for the autonomous car. Others will require massive scale for big data connecting millions of endpoints, such as with applications in M2M or IoT.

According to NSR, the opportunities for satellite are significant. NSR is predicting that 5G-differentiated applications such as 5G backhaul and hybrid networks will generate close to one-third of net satellite capacity revenue growth in backhaul within the next decade. The current use cases are extensive and include IoT, backhaul, maritime, aviation, land mobility, enterprise and broadcast. When looking at mission critical control, where lives could be lost or where downtime could result in a catastrophic end physically or financially, satellite is tantamount to a must-have lifeline. Such time sensitive information can often be addressed with data processing at the edge, referred to as edge computing, circumventing latency aspects often associated with satellite networks.

The need for satellite backhaul is very clear when considering the massive increase for bandwidth. MNOs must face a new rush of data and video demands from even more connected devices, along with the costs to deploy new base stations, lower ARPU in many unconnected areas, usage gap anomalies, challenging topographies and limited skill sets required to set-up network coverage. Here, satellite will play a key role in backhauling these massive amounts of bandwidth from remote areas driven by enhanced mobile broadband applications. When it comes to delivery of 5G to premises, satellite will play a complementary role with terrestrial networks, delivering broadband connectivity across underserved or unserved areas, in addition to providing back up to enterprise sites.

With satellite, MNOs can connect remote or rural areas cost-effectively. They can also complement their 5G services with content distribution over satellite, an effective way for large scale networks to utilize satellite's inherent multicasting functionality. In this way, MNOs preserve high-value wireless spectrum for more latency-sensitive services. Ultimately, MNOs and service providers can better adopt satellite services, leading to more use cases and new applications in turn.

This is satellite's prime time, after all, it has been proven with 3G and 4G that satellite can cost- effectively backhaul massive amounts of cellular data over long distances. We expect 5G backhauling to be no different.

IoT networks mark another massive opportunity in emerging 5G applications. From sensors to surveillance and even ATMs, M2M communications will accelerate greatly with 5G, helping to push IoT further along. The burgeoning M2M and IoT markets are churning out massive applications that equal a massive amount of sites, number of connections and bandwidth. Not only is satellite needed for backhauling from aggregation points, but remote connectivity is needed to enable IoT in far out places.

When considering the advances in the satellite industry with the emergence of new powerful satellite constellations dedicated to IoT, the advances in antenna terminal sizes with new phased-array technologies and powerful new modems coupled with scalable waveform technologies, satellite's case becomes even more compelling. There is no doubt satellite is the enabling access technology to meet the three connectivity expectations of customers: Everything, everywhere, always.

Our Key Advances in 5G

From standardization, new network architectures and virtualization, to the fresh innovation needed to unlock the 5G market and a solid number of 5G applications, satellite has a glorious mainstream entry point. At ST Engineering iDirect, we understand that a bigger, better, faster 5G future isn't possible without innovation and collaboration of ground technology partners. We understand this is key in order to harness the promise of new software-defined satellite constellations and of New Space. ST Engineering iDirect is leading this industry movement – we call it New Ground.

On the standardization front, we've worked relentlessly with many partners on initiatives and testbeds to transform the fabric of the satellite network to better integrate with 5G. We've been working diligently to develop the 5G architecture standard along with other innovation required to align satellite, so that it takes its place as an integral part of the new connectivity landscape.

For us, collaboration with technology partners is key in order to push forward these concepts. Over the years, we have been participating directly into the 3GPP standards initiatives around 5G, as well as other organizations such as 5GPPP and ETSI driving a number of frameworks supporting 5G deployments. As we adopt new 3GPP standards and releases defining 5G, we see a substantial rise of satellite network deployments. They will become both easier and more cost effective.

Most recently, ST Engineering iDirect showcased the full integration of satellite into the 5G network together with Hellas Sat. We've also been participating in a number of industry initiatives around orchestration through the MEF, standardizations of IETF, and other industry initiatives in Linux foundation and ONAP. In addition to these industry standards and industry initiatives work, we've also been participating in a number of 5G consortiums and other grant-based projects of the European Space Agency (ESA) and European Commission (EC), namely SaT5G, Satis5, Edgesat and OSMOSIS.

With our partners in 2018, we were the first to successfully demonstrate live satellite integration into 3GPP network architectures, demonstrating the key benefits of network slicing and SDN/NFV/MEC-enabled 5G construction testbeds.

For SaT5G, we worked with partners to integrate satellite ground infrastructure with a commercially available 5G core Non-Terrestrial-Network (NTN) into a live satellite network. The integrated 5G NTN consisted of a remote terminal connected over satellite to the 5G-enabled ST Engineering iDirect hub, with the connection using the native satellite radio at the physical layer. Our 5G-enabled gateway included physical network functions for terminating the native satellite connection, along with a satellite RAN, and a standard and unmodified commercially available 5G core network, both of which were virtualized.

In the ESA-sponsored working group, Satis5, ST Engineering iDirect took part in the research and development of an end-to-end system able to support multi-orbit operation with 5G.

We have also been involved with proof-of-concept testing for 5G content distribution leveraging edge computing, where video content distribution technology is designed to operate over a satellite network with 4G/5G and MEC integration – the ESA project OSMOSIS. By leveraging efficiencies of a tightly integrated cellular-satellite hybrid network, an enhance-duser experience is achievable for multimedia streaming on mobile devices while reducing network operation costs.

Over the years, we have also been an active member of the Global Satellite Operators Association (GSOA), which is focused on driving a number of the satellite-based interests in 5G into the larger standards bodies as well.

Developing Satellite 5G Architecture

We are committed to driving the new 5G standards for satellite networks. We're building the principles of EPC, multi-waveforms, edge computing and cloud-based architectures into our platform so it is no longer a separate, standalone network. Rather, it must become part of the multi-radio network architecture of 5G.

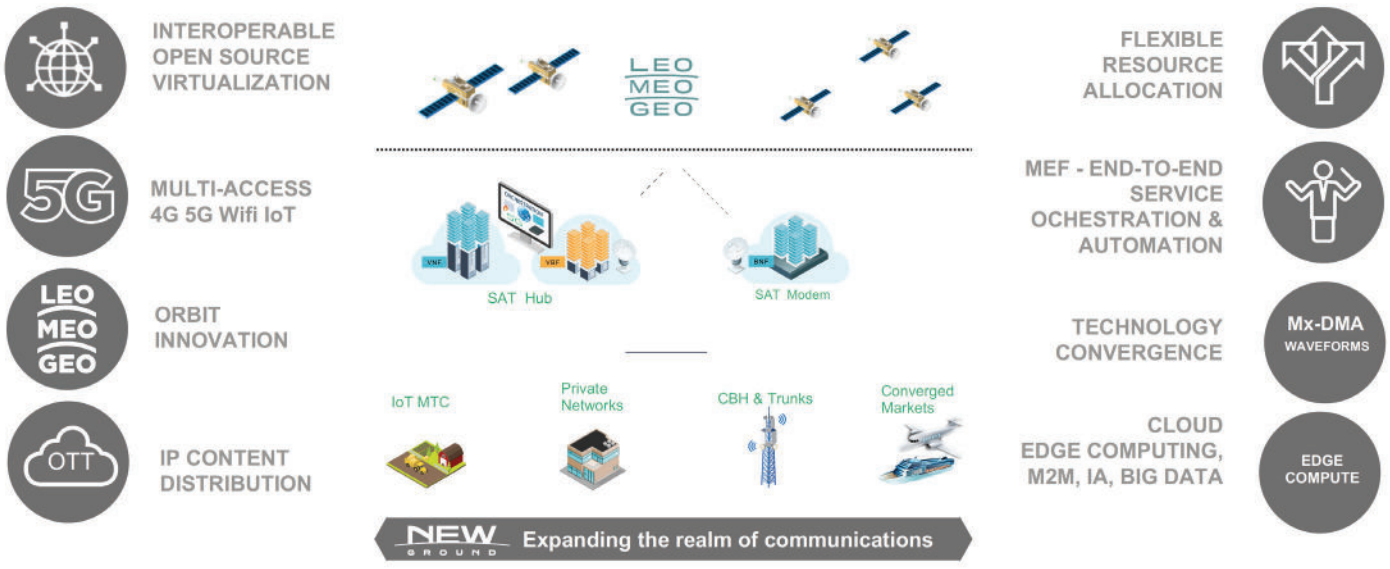
To align with these standards-based technologies, we're adopting architecture models based on 5G core NFV and SDN principles, and are extending our system to support more deeply integrated systems through common APIs to link OSS/BSS platforms with the platforms of our customers. To that end, we're developing proven network architectures that provide open APIs for end-to- end network orchestration and business system integration across multi-orbital satellite, terrestrial and mobile networks. Working with multi-service constellations such as SES mPOWER allows us to build our vision of a GSO and NGSO, multi-orbit, multi-access platform to deliver next-generation services and applications enabled by emerging 5G standards.

Additionally, we are aligning our interfaces on these MEF carrier Ethernet protocols as common terrestrial standards to ensure seamless integration with terrestrial networks. We produced our 5G-enabled Intelligent Gateway (iGW) as part of our ground infrastructure, introduced a high density hub solution with the Intelligent hub (iHub) and deployed native cloud-based solutions for our XIF Dialog Hub.

Our Mx-DMA return technology also fully addresses 5G use cases, not only for very high throughput, but also IoT or M2M. The technology abides to Self-Organizing Networks (SON) rules with automatic configuration, optimization, and diagnostic functionality.

On the remote side, we ensure that our solutions are 5G enabled and that we are continuously adding new capabilities in order to optimize 5G processing, building and expanding on our already developed solutions for multiple market verticals such as maritime, aero, private networks, emergency services, land mobility and IoT.

CONSIDERATIONS FOR GROUND SEGMENT ARCHITECTURES



The Satellite 5G Opportunity

Armed with these innovations, our first- hand 5G know-how and the momentum we have gained on our 5G journey thus far, the satellite industry is able to realize countless opportunities presented by this 5G era. Over the last several years, we have been at the forefront of 5G exploration and development. We are not only a strong 5G pioneer today; we are one armed with proven 5G-enabled innovation and implementation successes. We will be using these together with our strong momentum to continue breaking new ground today, and in the future.

Join us and learn more at idirect.net/story/new-ground/

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