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From the Ground Up: The Role of Satellite in a New Communications Landscape

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The communications sector is undergoing an era of fundamental change, a change that is happening both way above our heads as well as down here on the ground.

On one hand, the telco industry is moving at full tilt towards 5G. This network of networks will see the interweaving of different access technologies that leverage automation, virtualization, and orchestration to meet the huge demand for connectivity with the right technology in the most cost- effective manner possible. Facilitated by cloud-based services, it will connect everyone and everything. Our homes will feature networked appliances. Our businesses and cities and transport networks will all be interconnected.

Simultaneously, there is a disruptive revolution going on within the satellite industry. Satellite capabilities have transformed. This began with the introduction of high throughput satellites that offer much higher throughput at lower cost. Satellites are powerful, software-defined, highly flexible, re-configurable, and able to switch seamlessly from one beam to another. Additionally, and most significantly, we are moving into the multi-orbit age, where many thousands of satellites are in the process of being launched into both low and medium Earth orbits, reducing latency and broadening out appeal to multiple applications both established and emerging.

So how are these two transformations related? Satellites have a critical role to play in the network of networks. Satellites are unique in their ability to bridge existing connectivity gaps and reach remote locations. They know no geographical boundaries and therefore can enable ubiquitous connectivity where terrestrial technologies fall short. Satellites will therefore be essential in the new world of 5G, and will need to be seamlessly integrated into this new connectivity fabric so that the right technology medium is always available for the right application at the right time.

Sounds ideal, doesn't it? But getting there is an extremely complex process, and there are some key foundation stones that must be laid to ensure that satellites can take their place in the network of the future.

Preparing the ground

Ground infrastructure is integral to the transformation of the space segment. Without it, there is no transformation. So, it's absolutely critical that it is right, and this takes industry collaboration involving the entire ecosystem.

The biggest challenge is how ground infrastructure providers can make such a complex task simple using smart resource management.

An LEO constellation requires numerous ground terminals at many locations around the world to manage a global satellite system. Each specific location needs a minimum of two terminals, but some major sites will require a minimum of three and as many as twenty. This presents the first great challenge: How does one go about managing such a high number of terminals?

The answer is by keeping things as simple as possible, using common 'smart' terminal packages with a configurable 'black box' interface. Each antenna system is then regarded as a fully independent and managed node and completely identical. This will mean that each site will be reliable and easy to set up, manage, test, and reconfigure.

The management, or "orchestration," of the system is sometimes referred to as a System Resource Manager and it is at the heart of the management of a LEO constellation. The System Resource Manager coordinates orbit, satellite availability and capacity – a complex role.

The approach taken to infrastructure design and management is key, and its development will allow hidden issues that surround the operation of any LEO constellation to be raised. However, more needs to be done within the industry to help manage key challenges such as spectrum efficiency and inter-satellite and inter-constellation RF interference. These are all critical areas of the multi-orbit puzzle that need to be solved in order to move forward.

Standards are vital in the move to the cloud

The satellite industry must embrace standards and cloud technology to ensure it can fully integrate into the 5G ecosystem. The telco sector is already accustomed to the development and adoption of standards. However, until recently, satellite systems have been standalone and proprietary. To integrate into the existing telco environment this has to change, and the industry will need to adopt standards already embraced by the telco sector such as 3GPP and MEF, and to also create new ones to enable interoperability of its own networks.

The establishment of groups such as DIFI (Digital Intermediate Frequency Interoperability), which is already testing its standard with ground equipment vendors and working with cloud service providers, is enabling the satellite industry to gradually move towards virtualization. This is a technology enabler that will allow cloud-based services to be deployed over satellite.

Signals from satellites today are traditionally connected to physical modems via analog cables that are not directly compatible with cloud-based networks. The analog signals currently used to connect modems, data centers, teleports, and terminals are complex and prone to error when it comes to digital signal processing. Migration to the cloud means that future satellite connectivity must be established from a cloud environment through the digital interface directly to antenna terminals.

The ability to convert hardware into software that is installed and managed remotely via third-party data centers will give satellite operators more flexibility over their networks and speed up how quickly they can respond to customer demands. Modems are a critical part of the ground segment. They are used in teleports and at customer sites to translate the satellite signals an antenna receives and convert them for transmission through other networks. By virtualizing the gateway, baseband, and modems that are usually located in the teleport, their functionality can be run on private or public cloud platforms. " style="font-family:'Arial',sans-serif">A virtualized ground infrastructure will be agnostic from the application and will be modified depending on the use case of the user.

Flat Panel Antennas

Flat panel antennas have been hailed as the holy grail of multi-orbit constellations and the key to unlocking their potential. The development of flat panel antennas that can seamlessly switch between orbits and frequencies and beams is a highly complex challenge, and although antenna development is progressing, there’s still a long way to go, with issues of cost and performance causing the most headaches. In addition, customer expectations are high and can be unrealistic which naturally leads to disappointment with levels of service.

One of the main challenges for the antenna manufacturing community is obtaining clarification on the performance data that satellite operators require. Each operator is unique and has varying requirements. Therefore, if operators can agree on a minimum set of requirements and the data they need, as well as ideal testing methods, this will help to reduce complexity for manufacturers. SOMAP (Satellite Operators Minimum Antenna Performance Group) seeks to achieve a set of standards that manufacturers can operate by. However, without a dialogue with the satellite operators, this can’t happen. It’s critical that this sharing of information is facilitated so that standards can be developed.

Will a flat panel antenna eventually be a combination of a smart antenna with a degree of physical course elevation control? It remains to be seen.

Being prepared for interference

It is a fact that as more constellations are launched the risk of interference will increase by a yet unknown quantity. Spaceflight is undergoing revolutionary changes, and the net effect is that the sustainability of orbit, including spectrum and the radio frequencies (RF) used as a resource, is at risk. Spacecraft operation depends on the reliability of RF transmissions. An increased number of operational objects orbiting the Earth results in increased RF traffic and noise levels due to the sheer amount of transmissions and the probability of a continuing rise in RF Interference (RFI).

Traditional day-to-day carrier monitoring operation is focused on monitoring the operators’ own respective links from ground-based locations in a round-robin process. Satellite Carrier Spectrum Monitoring (CSM) systems go through all carriers checking the RF quality of those links. This approach is efficient, well-established in payload operation, and fully sufficient for more or less static objects like GEO satellites.

However, non-GEO satellites are using the antennas, following the satellite, checking the RF quality, and switching from one to the next. An object flying through another satellite’s beam could create interference, disturbing the RF link quality, yet the interruption might be so short as to go unnoticed and unrecorded. Even if it is recorded, it is often impossible to identify the cause.

The growing number of commercial satellites both in development as well as operation, especially non-GEO satellites, will raise the likelihood of RFI and more cyclic disruptions in RF links.

To ensure the quality of these links, it is crucial to adopt a systematic approach to monitor such issues and identify correlations between any potential interference and other emitters in a monitored antenna beam. The changing conditions in near-Earth orbit should be reflected in the measurement and monitoring of RF links, maximizing the use of infrastructure resources and allowing for repeatable scenarios.

With the rise of phased array antennas in satellite constellations like Starlink and OneWeb, and the effective management of beam directions, interference problems at GEO satellite links are not necessarily a concern but should be monitored. However, the impact of non-GEO satellites with each other and their respective ground station RF links is not yet understood as there is a lack of integrated software systems to assess this conjunction of RF links. The greatest concern is interference at uplink ground locations, where an object using the same frequency could cross the uplink beam, affecting both user traffic and tracking telemetry and control RF links.

Are we ready?

The move to multi-orbit is a many-layered and complex endeavor, and though it is now in full flow there is still a long way to go in terms of readiness. Some individual constellations, such as Starlink, are already operational, but if we are asking whether the industry as a whole is prepared, the answer has to be “not yet.” The overall success of these constellations hinges upon the ground infrastructure and its management, landing rights, and regulation.

Arguments over spectrum remain critical to the way we build out both terrestrial and satellite infrastructure. Each region of the world has different priorities, and so spectrum decisions must be made by balancing practical use against services needed. Sharing needs to be avoided until smarter technology is truly available. Local regulations further complicate the issue, creating yet another hurdle to negotiate. There is plenty of spectrum to go around, but the current manual, four-year allocation of spectrum cannot continue. We must be more dynamic. Technology and users need us to do better.

By adding more usable layers to the communications structure we can make this a success. The cloud will be critical moving forward as it is a vital ingredient to solving the connectivity hurdles and can be implemented quickly to meet the demands of both use cases and user growth.

Finally, every part of this transformation must be properly managed, and it is important that every part of the ecosystem is engaged and sharing information. This is especially important between different constellation players. Space sustainability must be the priority, with every layer of connectivity managed as one.