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Virtualization of Ground System Technologies

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by Elisabeth Tweedie

It's no secret that the satellite ecosystem is undergoing enormous change. According to the latest "Satellites to be built and launched" report from Euroconsult, an average of 2,500 satellites will be launched each year until 2031, largely driven by the commercial market. To put this into perspective, before the advent of LEO constellations, launching 20 commercial satellites a year was regarded as a good year. This increase in volume is accompanied by commensurate increases in both complexity and sophistication. Naturally, low earth orbiting (LEO) satellites require constant tracking and handovers, in addition, the satellites themselves are becoming more advanced. The processing power per satellite has experienced exponential growth over the last few years, and software-defined satellites for example, can change their footprint and amount of processing power allocated to any one beam on-the-fly.

In order to unleash the full value offered by this new generation of satellites, the ground systems have needed to undergo their own revolution. New Ground promotes the empowerment and development of ground technology and services that will enable the satellite industry to harness the power of New Space and the move towards a 5G future in a multi-orbit, multi-access environment. New Ground has to be able to seamlessly transition between different orbits, constellations and frequencies in order to deliver best-in-class service to users. Given the complexity, and vast and ever-increasing numbers of satellites, virtualization and cloud are fundamental to this revolution.

Virtualization is one of the key concepts that will enable the ground system to move towards a fully integrated end-to-end, cloud-based service delivery. Unlike traditional ground systems, it is based on standards and open source resulting in improved scale, performance and security. In this piece we will dive into the benefits of each and the impact on New Ground.

The Move to the Cloud

This move to the cloud is also very much in-line with changes taking place elsewhere. More and more devices are being attached to networks, data processing is becoming increasingly complex and users need access from multiple locations. Couple this with the faster speeds and lower latencies offered by 5G networks, and it becomes obvious why companies everywhere are moving their computing needs to the cloud.

According to Gartner by 2025 over half (51%) of IT spending in four major categories: application software, infrastructure software, business process services, and system infrastructure markets, will have shifted from traditional solutions to the public cloud. This year 41% of spending in those four categories was allocated to the cloud. Covid was one of the key drivers to accelerate this transition. People working from home required access to company's databases, and moving these to the cloud made that access a lot simpler.

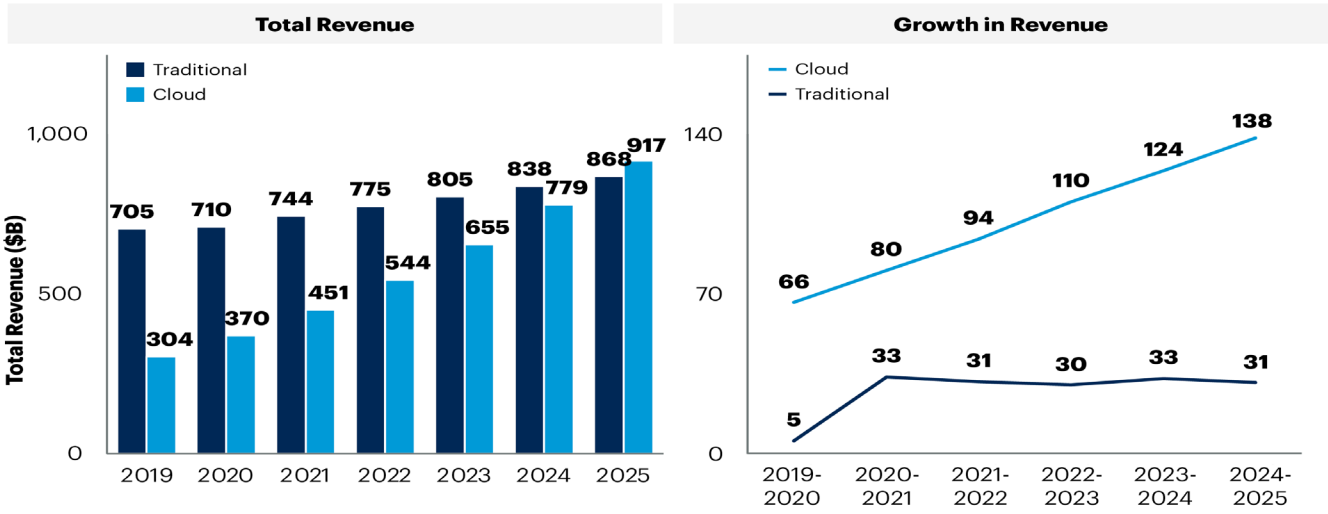
Regardless of what it is that prompts a company to move data and processes to the cloud, the move comes with many benefits, some of which themselves may facilitate growth and expansion. These benefits include:

- Cost savings – Buying new hardware when greater processing power is needed or storage requirements expand, is a major capital expenditure that not only may take many years to recoup, it has to occur in advance of the need. Moving all processes to the cloud immediately changes this capex into opex since the cost structure of the cloud model is usage-based.

- Security – Naturally, in a pre-cloud environment companies have their own security systems in place. However, it is generally recognized that the security offered by public cloud is vastly superior to anything that even the most sophisticated data centers can provide.

- Data - The sheer volume of data generated by thousands of devices is an order of magnitude higher than that generated by standard data processing and grows as more devices are added to the network. Handling the increased volume in the cloud, simply means that usage fees grow in line with the increase in volume.

Sizing Cloud Shift Worldwide 2019-2025



Source: Gartner
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Gartner

- Flexibility and Scalability –When all the processing is in the cloud, the only impact is an increase in monthly usage fees for the duration of the project resulting in significant savings for the organization. Similarly, as a company grows it can increase the number of users, by simply paying additional license fees. This scalability is particularly relevant as enterprises embrace IoT which requires the ability to deploy terminals rapidly and often on a massive scale.

- Disaster Recovery – A physical disaster on a company's premises, fire or flood for example, would damage hardware, and recovery and restoration could be a slow and laborious process. If the company's data is in the cloud, recovery is a much simpler and faster process. All that is needed are devices to log in with.

With all these advantages for a company, it's hardly surprising that the "2022 State of the Cloud" report from Flexera, showed that 100% of companies around the world were using either public or private clouds and 80% were using both.

New Ground

Let's apply this to Satcom's evolution – enter New Ground.

As already mentioned, the space segment is becoming increasingly complex, necessitating significant changes on the ground in order to deliver full value from the new systems. At the same time, terrestrial communications are also undergoing their own evolution in technology and business processes with the advent of 5G, so adding to the complexity and increasing the necessity to move to a virtualized, cloud-based system.

The advantages for satellite operators and service providers of having access to a virtualized ground segment are similar to those accrued by enterprises when they move their systems to the cloud. The two most important are cost savings and simplicity (of managing their networks and delivering services).

Significant cost savings will accumulate for the operator. In a hardware-based system, the teleport will contain racks of baseband processing equipment, some of which may be idle at times, but still take up real estate and need power and cooling. Move everything to the cloud and none of this is needed. Equally important is the fact that it means transitioning from an upfront capex-intensive model to a flexible opex model, essentially permitting operators to "pay as they grow."

In a hardware-based system, adding a carrier to a transponder, meant an additional modem and a technician to manually set the link's frequency, coding and modulation and network interfaces. A laborious, time-consuming job, with the potential for errors every time any of these parameters change. With the increased complexity from VHTS, UHTS and NGSOs, coping with everything in a hardware-based system is almost an impossibility. Add in software-defined satellites, which have the capability to put capacity where it is needed, when it is needed at a moment's notice and the traditional ground systems are simply inadequate.

Satellite has been used for years

Frederik Simoens
Chief Technology Officer-ST Engineering iDirect

Can you explain why we find ourselves working towards the virtualization of the ground segment?

The virtualization of the ground segment is happening for three main reasons:

1. A response to the evolutions that are happening in the space segment. As we all know, we're moving into a multi-orbit world and satellites are becoming much more flexible and dynamic. However, you can only realize the full potential of that New Space capability if you have the right ground capabilities that are in lock step. For that reason, we really need to evolve into a fully flexible and dynamic ground segment and that leads us into the second point,

2. The ability of the ground segment to digitize (that is all parts of ground infrastructure from the modems to the ODUs and the antennas) so that it can leverage the full capabilities of the cloud. Virtualization will enable the satellite ground segment to be completely flexible enabling that the ability to scale up and down, just like the satellites, with the capability to move bandwidth around as and when required.

3. The last element is related to telco and IT Convergence. We come from a long history of proprietary technologies, network stacks and NMS that made up our satellite communication systems. Today, we're moving to a much more standardized way of operating, leveraging proven Telco standards for true interoperability. Standalone systems will no longer make sense. Instead, a satcoms system needs to be managed along with other types if networks, such as terrestrial and cellular, and they will combine to create one seamless ecosystem so that operators can develop hybrid service offerings to deliver user access to the connectivity medium that makes most sense for them.

How will this be achieved?

This is a complex question and it's a process that won't happen overnight.

Standardization will be a pivotal part of the process. The DIFI (Digital Intermediate Frequency Interoperability) consortium made good progress in 2022 and released an updated version of its interoperability standard in August, labeled IEEE-ISTO Std 4900-2021: Digital IF Interoperability 1.1 Standard. This improved the maturity of the specification and was part of the group's goals for 2022 after it released version 1.0 last year.

Organizations such as DIFI are crucial in terms of coordinating different industry segments that must work together to implement the standard. These include cloud providers, satellite ground platform manufacturers, teleport operators, antenna manufacturers, ground segment ODU manufacturers (antenna, BUC/ amplifiers and frequency converter manufacturers). By working with standards bodies, satellite ensures that it will no longer be a niche connectivity technology.

If we only virtualize the modem side, then the antennas or amplifiers won't be able to speak the digital language, and this will mean that we cannot create a fully digital teleport. The satcoms industry must continue to work to standardize interfaces and increase their adoption.

In addition, the integration of satellite networks with terrestrial networks, for instance, requires interoperability at the management and orchestration layer. Here, the standardization work being done within 3GPP-NTN looks very promising. Another area is space/ground convergence, which requires tighter interaction between the satellite and ground assets. Again, standardization on how these different components should interface is currently being examined.

What is ST Engineering iDirect specifically doing to virtualize its technology?

in September, together with Microsoft Azure, we successfully demonstrated an important milestone: the ability of a virtual modem to extract information from a high-speed satellite connectivity link. Our demonstration showcased a virtualized SCPC modem receiving satellite signals digitally via an ethernet cable. Signals from satellites today are traditionally connected to physical modems via analog cables that are not directly compatible with cloud-based networks. This demonstration showed that, in the future, it's possible for virtual modems to run on third-party cloud infrastructure replacing the need for a physical on-premise satellite modem. It's proof that future satellite connectivity can be established from a cloud environment through the digital interface directly to the antennas.

What benefits will virtualization bring to ST Engineering iDirect's customers?

Virtualization has the potential to transform our customers' and their customers' businesses. The virtualization of our modems will not only enable our customers to deploy it faster as well as offering more flexibility and increased services over time – this extends the life of the modem letting our customer realize a faster ROI. It's a win-win for our customers.

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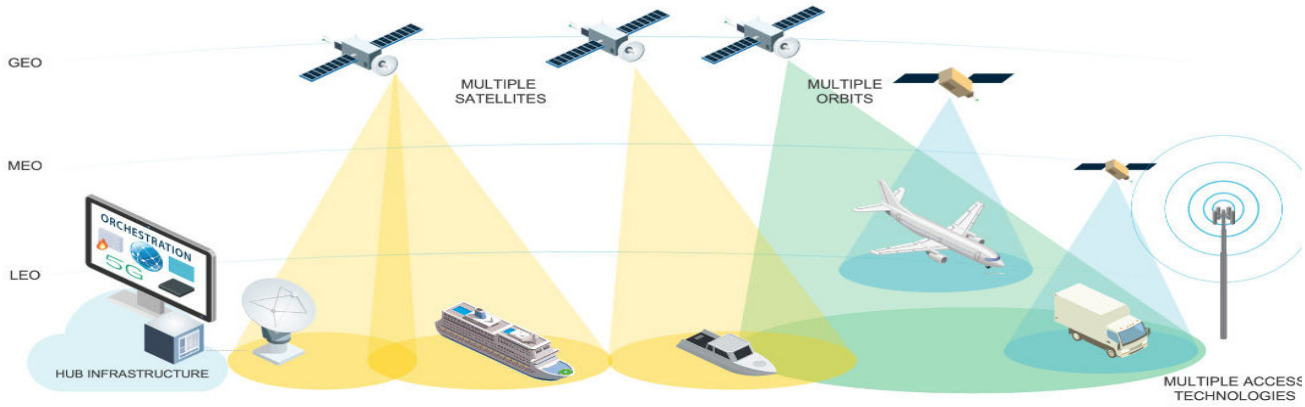
Virtualization is the first step for us, and our customer base is very familiar with the concept. It lowers costs and brings predictability, reliability and resilience. It allows you to put your digital processing and other elements in the cloud. The first two steps for us are to focus on proving that we can run our network management system (NMS) in the cloud and to virtualize our modem. The hub-side technology will come next.

This will allow our customers to design their networks in the most cost-effective way possible, building what this need today but knowing they can quickly adapt and expand as demand increases or requirements change.

This is a complex process. How long will this take?

Yes, this will not happen overnight. There are many things that need to happen in the meantime. We will move the racks of servers running already virtualized processes within a smaller private cloud network to the public cloud – this will include network management systems. Then, we will migrate modulators and demodulators that run on dedicated hardware, which is quite challenging. Simultaneously, we will also need to work on how they interface with other ground segment components such as antennas, amplifiers and frequency converters and this is where standardization comes in. While there is still some time to go, we are looking forward to making this a reality so that our customers can ultimately benefit from the huge flexibility, security, reliability and cost-effectiveness of the cloud.



The newer generation of multi-orbit satellites will require a more scalable, flexible, and secure infrastructure solution, and cloud infrastructure meets those needs.

in conjunction with traditional, centralized data centers, which are often owned or run by the customer. With the move to the cloud it is important for the VSAT service provider to follow suit and become more active in managing the end-to-end network, as opposed to stopping their involvement at the teleport data port, as has been done in the past. To optimize the network, the VSAT service provider needs to either co-locate part of its infrastructure with a cloud provider or implement dedicated access to multiple public cloud providers via direct connect, express route, or a similar offering.

Cloud-based solutions bring the added advantage of being able to accommodate current and future innovation trends in the satellite space segment through their inherent cost-effective scale and cost models.

This degree of virtualization and automation will provide satellite operators and service providers alike with a degree of scalability and efficiency far above anything that is possible with today's proprietary hardware-based systems.

Fortunately, led by forward-thinking companies such as ST Engineering iDirect, a New Ground is emerging. The company's goal is to move everything into the cloud: Network management, hubs and modems; resulting in lower cost and increased effectiveness of service delivery. Such a momentous move won't happen overnight. True to its heritage in ground-breaking research and development, ST Engineering iDirect is taking a rigorous, step-by-step approach to this transition and is making significant progress.

The route to New Ground for ST Engineering iDirect is based on three core principles: standardization, virtualization and automation of service provisioning (Orchestration).

Standardization

Standardization is the first step in this transition: Moving away from proprietary standards to adopt the same standards as the telco industry. This alone is a major change, and whilst it may lead to customers no longer being locked into a particular ground equipment manufacturer, it will also lead to customers starting to regard satellite as just another technology. Open and standardized architectures will allow seamless integration into terrestrial and hybrid networks. Satellite will become just another pathway to be used whenever it makes best commercial sense. One of the key drivers behind this is the fact that, for the first time ever, the satellite industry became part of the 3GPP, the standards-setting body for 5G. As a result of this, Release 17 defined the standards for non-terrestrial networks (NTN), i.e. satellite and high-altitude platforms.

Virtualization

Last year, ST Engineering iDirect formed a strategic partnership with Microsoft Azure to drive the adoption of virtualization and cloud, in order to facilitate the digital transformation of the ground infrastructure. Virtualization is the first step in the cloudification of the system. Once something has been virtualized, it can be run from anywhere.

In September 2022, the first milestone from this partnership was reached: the successful proof-of-concept demonstration of the demodulation capabilities of a virtual high-speed SCPC modem. The modem runs on containerized software on a commercial off-the-shelf (COTS) server in the Azure cloud. The same software can also be deployed at the edge, so this system is known as a hybrid cloud. At the ground station, the virtualized modem could be co-locat-

ed with the antenna, or alternatively, the baseband signals can be digitized and moved to the cloud. In March 2023, ST Engineering iDirect will do a second Proof of Concept (PoC) demonstration of the modulator capabilities of the virtual high speed SCPC modem.

The next step is to begin the process of virtualizing the baseband equipment, by migrating the waveform functionality in a modulator/demodulator to generic compute instead of custom hardware. This will allow a dramatic increase in how carriers and channels are defined and allocated for a given modulator and demodulator.

The final step is to fully virtualize the baseband functionality. To complete this step, the traditional analog L-band interface, has to be replaced by a digital interface. This was developed as a result of the company's leadership position in the Digital IF Interface (DIFI) Consortium. DIFI was formed in 2021, by satellite and related technology companies to enable the digital transformation of space and satellite by providing a simple, open interoperable Digital IF/RF standard to replace analog IF signals and help prevent vendor lock-in.

DIFI standards are based on VITA 49 (VITA Radio Transport (VRT) standard, an information-exchange standard defining a signal/spectrum protocol that expresses spectrum observation, spectrum operations, and capabilities of RF devices to promote interoperability between radio frequency (RF) systems and related equipment).

The standard allows end-to-end digital interoperability and, ultimately, interoperability between vendors, enabling all ground ecosystem technology to be compatible with each other, whether that is antennas, BUCs, modems or amplifiers.

"...New Ground promotes the empowerment and development of ground technology and services that will enable the satellite industry to harness the power of New Space and the move towards a 5G future in a multi-orbit, multi-access environment..."

When all the processes in the ground segment have been virtualized, they can be run from anywhere: public cloud, private cloud, edge servers or even in the teleport itself dependent on the functions.

Orchestration

Ultimately, when the ground system has been fully virtualized, operational complexities will be reduced, and there will be improvements in scale, performance and security. At this point, end-to-end service orchestration across multiple networks will be possible. A user will be switched from a GEO satellite to a LEO to cellular as the user's needs change, and the different communication channels become available. The system will automatically optimize traffic across the most efficient pathway. In the future, service orchestration may become even more streamlined with the addition of artificial intelligence (AI) and machine learning.

Networking and orchestration technologies need to work in unison across multi-orbit satellite, terrestrial and mobile networks to enable a truly seamless service offering. Orchestration matches software-defined satellite constellations with software-defined networks. Thanks to more seamless integration alongside terrestrial networks, satellite can play a more prominent role in hybrid networks and address more use cases which translates to new revenue streams and business growth.

Virtualization along with Standardisation and Orchestration is necessary to enable networking infrastructure to move to the cloud. By embracing this shift, the satellite industry can create enormous opportunity by improving its technology through scalability and delivering its services in a space where it is increasingly needed. For ST Engineering iDirect, it also involves an evolution of business models. Historically, the company has been both a hardware and software company; designing the physical equipment as well as the software that powers it. With virtualization and cloudification, ST Engineering iDirect will introduce new business models allowing for more flexible solutions, enabling its SP customers to scale on dynamic, cloud-based options, potentially even providing ground station as-a-service options which would result in the lowest total cost of ownership.

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