Digitizing gateways for NewSpace: The ticket to play in the virtual satellite world

When Gottfried Wilhelm Leibniz developed the modern binary system 350 years ago, the digitization of the modern world was set into motion. Most enterprises on Earth have long embraced "digital transformation" to advance their business operations and benefit from the replacement or augmentation of physical devices with virtual functions. However, due to the nature of working in space, the satellite industry has been one of the last to fully adopt today's most widely spoken language: zeros and ones.

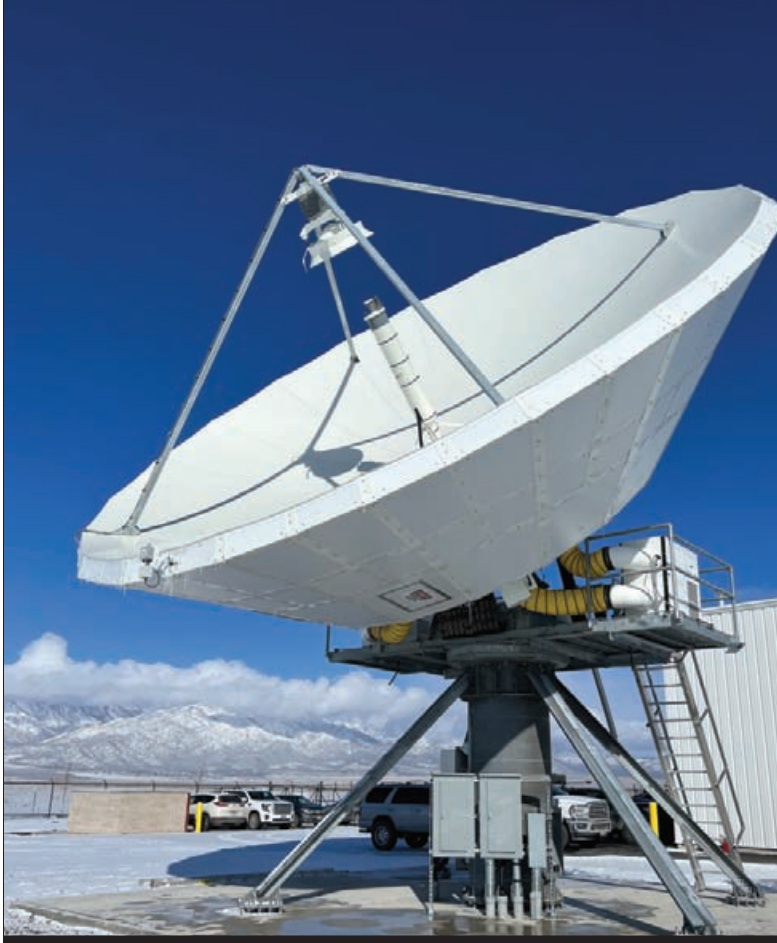
Jonathan Baker, Chief Technology Officer, Kratos Antenna Solutions

Market demand for more bandwidth and faster services has driven a space revolution of high-speed LEO constellations as well as increases in operating frequencies like Q/V-band, W-band, and laser—all of which must be addressed on the ground. The continued growth of terrestrial services has also pressured the satellite industry to keep pace with technology to stay relevant. Now, with new virtual ground systems, satellite operators can realize numerous advantages, from better performance, signal quality, and signal management flexibility to lower costs and increased revenue opportunities. However, transitioning to these new digital architectures and orchestrated ground operations requires a 'digital on-ramp' and this digital transformation begins at the antenna.

THE ADVANTAGES OF DIGITIZING

A digitized antenna gateway system improves quality and provides operators with the tools and flexibility they need to meet today's challenges and ultimately keep satellite at the forefront of continuing communications advances.

The first, and most basic advantage of digitization, is eliminating the range limitations between baseband and earth station locations inherent with traditional RF over fiber. In contrast, digitized RF, running over IP networks, overcomes these boundary constraints to gives operators greater reach and flexibility, providing new options for signal routing and site diversity. Digital frequency tuning allows for dynamic alignment with new flexible payloads and transponder frequency plans. Also, when traditional L-band and IF signals are digitized, signal processing will facilitate group delay, slope, level, pre-equalization, and other common signal distribution issues to be managed in new ways that improve overall link performance. Another significant benefit is that a standardized digital interface and gateway design can be used, thus minimizing system roll out and site integration time by simplifying the earth station architecture.

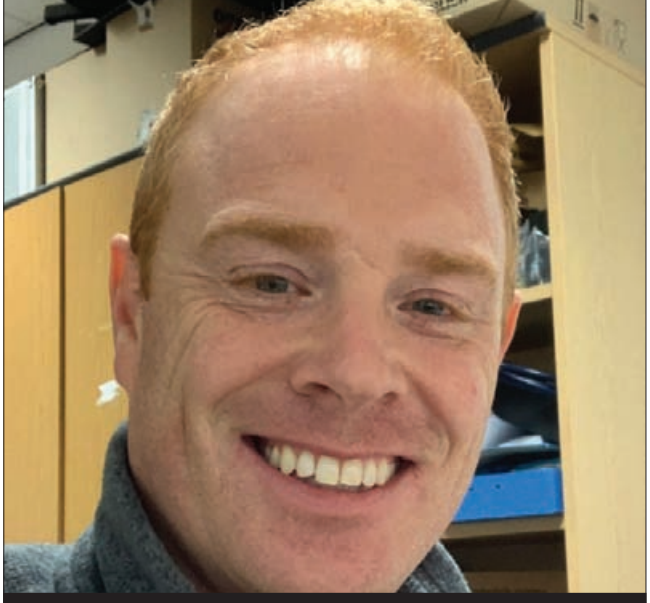


Digitizing parabolic antenna systems is the first step towards successfully leveraging IP networking and cloud adoption for digital architectures. Photo courtesy Kratos

Coupling these advances in signal processing with cloud technologies, and baseband signals can be kept in the Cloud and then converted to analog RF in the antenna hub. Just a few clicks on a cloud-based application and an antenna and RF system can be re-configured for a different carrier type or even a different use case. This enables the operator to maximize the capabilities of their asset and investment.

The advent of Q/V-band satellites is pushing the need for smart gateway diversity with M:N (a many-to-many relationship in the database) gateways being used dynamically. Combining the power of the cloud and digitized RF over IP means that M:N site diversity and redundancy can be realized in ways that were not previously possible. Moreover, the use of the cloud and digitized RF allows the antenna and RF gateways to be more closely aligned with operator OSS/BSS systems, providing more end-to-end signal and service management.

A digitized gateway system opens the door not only to a better understanding of data traffic flow but also to the



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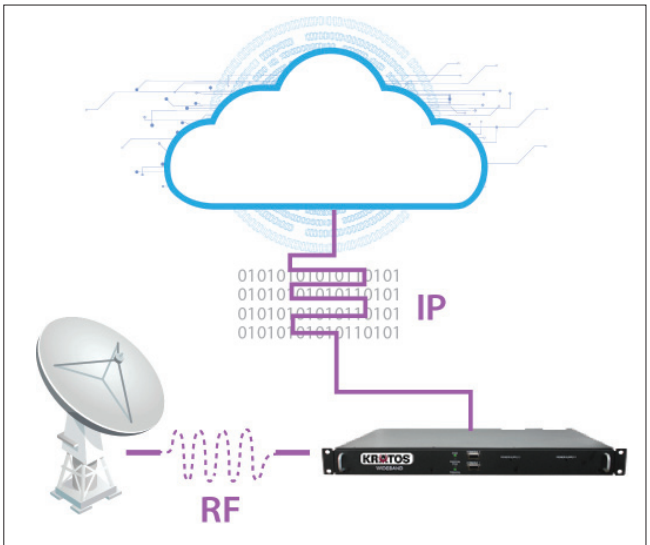
capability of machine learning for higher degrees of automation. Big data analytics deliver the possibility of greater digital signal storage and analysis, which benefits both operators and regulators while improving service quality.

THE CHALLENGES OF DIGITIZING

There is a constant tension between digital and analog signals and their relative trade-offs. On the one hand, digitization can provide much desired flexibility and control for signal processing, on the other, signal fidelity is most ideal when produced in the analog realm (albeit being susceptible to noise). Therefore, processing power and the sample bit depth will always be factors against digitization. Despite this, processing power will always improve, and bit sampling depths will also continue to improve thereby minimizing the effects of rounding and truncation.

In addition to signal fidelity, digitized RF also produces far larger amounts of equivalent data, requiring more bandwidth for it to be moved around the network, contributing to the argument against digitization. While compression techniques for this type of data have marginal benefit, cloud networks and high-speed data connections continually advance, and digitized data can take advantage of these standard high-speed data connections, rather than simply relying on dark fiber connections as is the case for RF-over-fiber solutions.

Despite these challenges, the pathway for the satellite industry's future growth and evolution depends on digitization. It is not a matter of 'if' but rather 'when' this changeover will happen.



Digitizers: OpenSpace SpectraNet digitized analog RF into IP packets for transport and signal processing in public cloud, private data center, or hybrid cloud environments. ●●●

WHAT ARE TODAY'S OPTIONS?

There are, of course, inherently digital antennas such as the FPA (Flat Panel Antenna) and ESA (Electronically Steerable Antenna) currently being manufactured. One example is the impressive user terminal that SpaceX has achieved at Ku-band. But these are small terminals, not gateways. While these solutions are ideal for LEO satellites and user terminals there will continue to be a need for fixed gateway antennas for GSO (geosynchronous orbit satellites).

FPAs are a long way from being able to offer the power, RF performance, instantaneous bandwidth, and competitive pricing for GSO satellite gateway high throughput satellite (HTS) applications. So, traditional large aperture parabolic dishes will likely be around for some time to come. But how can we modernize them and keep them at the forefront of technology? How can we use the power of the cloud, digitization, and wide acceptance of IP traffic to keep parabolic antennas and associated RF equipment up to date and at the cutting edge?

Digitization will not remove the need for high power amplifiers and LNAs (Low Noise Amplifiers) or LNBs (Low Noise Block Downconverters) in such gateway systems. We can consider how far up the RF chain it is possible to digitize in order to provide signal management flexibility and signal quality control, as well as to give operators the tools and capabilities necessary to maximize revenue from their assets.

The time has come to digitize the traditional gateway antenna by creating an antenna solution where the interfaces between the antenna and indoor equipment are carrying digitized, IP traffic-based signals. This can be achieved by integrating a digitizer, such as SpectralNet (an OpenSpace family product), at the antenna and other locations throughout the ground system.

STANDARDS FACILITATE DIGITAL TRANSFORMATION

Standards, whether it comes to data, computers, phones and nearly any other current technology, are a key facilitator to growth and advancement as well as global digital transformation. Operational and developmental standards at the appropriate interface points allow for interoperability that is beneficial to the industry and yet doesn't hinder innovation and competition. The market drives the will, the industry derives the way.

A recently formed group called the Digital Intermediate Frequency Interoperability Consortium (DIFI) has created a standard for building interfaces so that digital satellite data can be sent and received interoperably based on VITA 49. VITA 49 on its own is not an interoperable interface, it is a framework, and so it can be implemented in many ways.

DIFI has published a specific schema for VITA 49 to unite the industry on its specific implementation for interoperability. This implementation is designed to enable interoperability at the IF level to prevent vendor lock-in and ensure a robust, innovative, and competitive supply chain that will support the ground segment and help usher the industry forward to reap the value of digital transformation.

THE ROAD TO DIGITAL TRANSFORMATION BEGINS WITH DIGITIZING THE ANTENNA

According to Melvin Vopson, Senior Lecturer of Physics at the University of Portsmouth, "In 2018, the total amount of data created, captured, copied, and consumed in the world was 33 zettabytes (ZB) – the equivalent of 33 trillion gigabytes. This grew to 59ZBs in 2020 and is predicted to reach a mind-boggling 175ZBs by 2025."[1] The satellite industry is set to be a massive contributor as one of the last remaining tech industries that is not completely digitized.

Digital transformation, backed by standards, is expected to have impacts across the entire spectrum of the industry, from space to the ground. From digitizing antennas to virtual signal processing, to fully orchestrated ground systems, it will truly transform the industry and deliver new applications and opportunities that we've not even begun to consider.

The path to a flexible, efficient, and cost-effective software-defined ground system begins with digitization. Digitization provides fast, assured data transport without distance limitations. Once antennas are equipped with digitizers, IP networking can be leveraged. From there, depending on an organization's business model and goals, hardware modems, FEPs (Front End Processors), and more can be migrated into software with virtual products like OpenSpace quantum. Lastly, digitization opens the door to the adoption of fully orchestrated ground system operations with fully virtualized and software-defined ground systems like the OpenSpace Platform, by Kratos. Business activity and projected growth will determine what's next beyond digitization. Are you ready? ●

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