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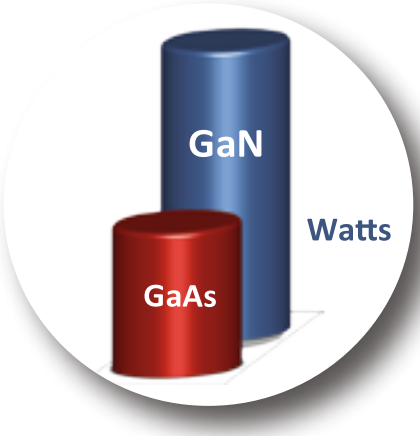

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Successful NASA ISS Resupply Mission by SpaceX

Those goodies that the astronauts are awaiting will arrive thanks to another successful SpaceX launch on Monday, August 14. Resupply missions to the International Space Station are celebrated as they make the bridge to the astronauts when a favorite snack is craved or they have the need of a basic necessity — they can't just hop into a car and head to the store — and that's when SpaceX delivers. That's a big thumbs-up for an astronaut's favorite snack!

On August 14, 2017, SpaceX successfully launched its twelfth Commercial Resupply Services mission (CRS-12) from Launch Complex 39A (LC-39A) at NASA's Kennedy Space Center, Florida. Liftoff occurred at 12:31 p.m. EDT, or 16:31 UTC, and was followed approximately two and a half minutes later by successful separation of the first and second stages. The first stage of Falcon 9 then successfully landed back at SpaceX's Landing Zone 1 (LZ-1) at Cape Canaveral Air Force Station, Florida.

SpaceX and NASA SpaceX CRS-12 makes it an even dozen as this was the twelfth of as many as 20 missions to the ISS that SpaceX will fly for NASA under the first CRS contract.

In January 2016, NASA announced that SpaceX's Falcon 9 launch vehicle and Dragon spacecraft had been selected to resupply the ISS through 2024 as part of a second Commercial Resupply Services contract award.

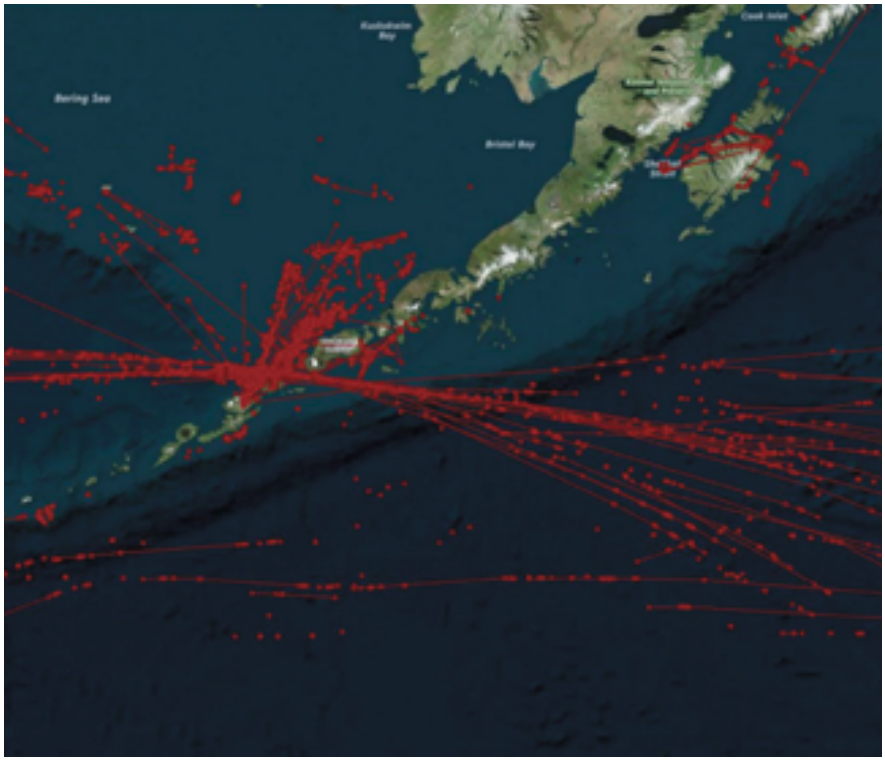
Then, on August 16, ISS astronauts Jack Fischer of NASA and Paolo Nespoli of ESA (European Space Agency) will use the station's 57.7-foot (17.6-meter) robotic arm to reach out and capture the Dragon spacecraft and attach it to the station.

The Dragon spacecraft is filled with more than 6,400 pounds of supplies and payloads, including critical materials to directly support dozens of the more than 250 science and research investigations that will occur during Expeditions 52 and 53.

The Dragon is scheduled to depart the space station in mid-September, returning with more than 3,300 pounds of science, hardware and crew supplies to Earth. About five hours after Dragon leaves the space station, it will conduct its deorbit burn, which lasts up to 10 minutes. About 30 minutes are required for Dragon to reenter the Earth's atmosphere and splash down in the Pacific Ocean off the coast of Baja California.

For more than 16 years, this global endeavor, has had more than 200 people from 18 countries visit the unique microgravity laboratory that has hosted more than 1,900 research investigations from researchers in more than 95 countries.

For more information about the mission and payloads, visit ***www.nasa.gov/spacex***



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Innovation: How Does Your Company Measure Up?

by Lisa Kuo, Head of Commercial Programs + Business Development, The Aerospace Corporation

The space industry is tough — the return on investment (ROI) timeframe is lengthy, the entry into this dynamic market is expensive and failures are oftentimes irrecoverable.

However, in recent years, Silicon Valley and other tech hubs around the world seem to have cracked the code with the rise of space tech startups. In an industry long dominated by giants such as Lockheed Martin and Boeing, the startups are finding ways to build satellites for less than millions and to then launch them even less expensively with the "build and they will come" mentality. More impressively than the technology, these companies are overhauling the business of space. Take SpaceX as a prime example. SpaceX is vertically integrated, the firm's employees are versatile and technology is used as a means to the ultimate end goal of colonizing Mars.

Every startup touts "innovation" à la Silicon Valley style. In the early days of the space industry, the phrase "innovation" was constantly frowned upon as that phrase inherently has come with high risk and was consistently avoided by large corporations. As the price of entry into space and the price of failure has significantly dropped, innovation is the new darling of venture capitalists. Is your company innovative? This is a highly subjective question, with eager investors outside of the space arena looking to find the next SpaceX.

The space industry is not the only one facing this challenge. Cornell University, INSEAD and the World Intellectual Property Organization have all been attempting to assess the innovation of countries using a framework called the "***Global Innovation Index***." A series of parameters that describe attributes of innovation is calculated and scored.

There are many similarities between a country and a space startup company: they both require long term vision and investment strategy.

Instead of looking solely at the newness of the technology offered, the framework's emphasis is on criteria such as: how conducive a company is for cultivating ideas, how robust are leadership directives and how accessible are knowledge resources.

A sample framework for assessing a company's innovation index, modeled from the "Global Innovation Index" is shown in ***Figure 1*** on the following page.

A more conventional method of evaluating innovation of a company emphasizes IP management.

However, as a space company will have a longer ROI timeframe, the ability to sustain that innovative spirit for the long run is crucial. Therefore, a better approach, such as this sample framework, should also concentrate on the environment to induce further innovation. How does your management team make a decision? How does your company embed collaboration in engineering practices? What is the talent acquisition strategy? Are you addressing the correct market for the offering? These are all considerations for sustainable innovation.

What can a startup, with limited resources, do to ensure checking as many boxes in this framework as possible? There are some simple solutions that startups adopt as noted by Aerospace Corporation. For instance, instead of hiring full-time talents, many startups connect with universities and national labs for occasional expertise consultation as well as for recruiting talent. Not all issues are as easy to address. Two industry experts were asked to share their observations regarding innovation and the lessons learned.

Need for Diversity in the Founders Circle

Jeanette Quinlan is the U.S. managing director for Startburst Accelerator who oversees many space startups and matches them with investors. As part of Startburst's growing ecosystems portfolio, she is always on the hunt for innovative startups.

"*Even the definition of 'innovative products' is very different from a few years back,*" she said. "*In the early days, startups just wanted to be acquired by large corporations. Startups would develop and patent a new technology, and then wait to be acquired. Nowadays, large corporations are not necessarily just looking for the technology, but also the team dynamics and operations to execute the business. As it turns out, the best way to acquire their innovation is to 'partner' and not necessarily 'acquire' anymore. This will ensure sufficient diversity within the lifecycle of product offerings and can better adapt to market shift. Large corporations can also leverage the startups to better direct their internal R&D funding.*"

The rise of competing mega-constellation systems are a prime example of how diversity promotes innovation.

"The mega-constellation companies are in essence, 'frenemies'. They need each other to sustain a vibrant market and stimulate the ecosystems. The same is true for the players in the value chain. Small satellite launchers, deployers, rideshare coordinators, and ground data companies, collaborate and compete simultaneously. This dynamic leads to even more innovations, since there are so many more opportunities."

How are startups gearing up to deal with this new dynamic?

"It becomes paramount that the founders have diverse perspectives, so they can be open-minded to new dimensions of their businesses. As space arena has been traditionally a homogenous market, we'd like to see our portfolio companies be as diverse and robust as possible. A phenomenon we're seeing is the lack of female founders in the space startups. Among the ~100 portfolio companies that we work with, I've only seen four or five female founders. There is no doubt that there is a high ratio of female team members in each of these companies, however women shy away from taking the driver's seat."

Any recommendations for all the founder-wannabe female space enthusiasts out there?

"We'll be coordinating a women's networking event at the upcoming Satellite Innovation Symposium in Silicon Valley, I hope all female space enthusiasts can come join us, network, share your experiences and be a role model. Help us build a support system for future female founders."

Connect Early, Connect Often

Christian Patouraux, the CEO of Kacific Broadband, saw the need to disrupt the communication market in the regional areas.

"Kacific is a byproduct of my personal experience living through the disaster recovery effort in the Pacific. When I witnessed first-hand the lack of resources in villages in the developing countries, and understood the cause of this, I realized the timing was ripe for a disruption."

Kacific is a next-generation wholesale broadband satellite operator, servicing public sectors, businesses and consumers in urban areas, rural villages and remote communities in territories with highly dispersed pockets of population.

"We are providing a regional innovation. The available solution in a very fragmented part of the world such as the Pacific and South East Asia are not suitable for the users, and no infrastructure is in place to support their needs. Innovating the business model by removing excessive infrastructure in a traditional satcom model, we are filling in a gap long neglected by traditional service providers."

When your targeted customers are dispersed, the very nature of the core team members will be diverse. How does a small company keep the core team focused on the mission of the company?

"The core team needs to be very aligned with the 'why' of the company's existence. Kacific is set out to provide the customers long neglected by the traditional telecom companies. It's very enticing to take advantage of such customer groups, therefore enforcing the 'why' of the company and making sure it's part of our guiding principles is very important. The very nature of our business creates a diverse team, both personality and location wise. We make sure that we are completely aligned, among ourselves and our customer's needs. When they are out there seeing the customer and their situation, the 'why' should ring true and will guide them on the 'how' and 'what' in execution. We were fortunate enough to have a small core team completely aligned about why we need to disrupt the current market. Will more markets adopt this business model? We certainly believe so. How big can we grow before we cannot efficiently keep alignment of our innovative spirit? As a company grows, it is hard for that message not to get diluted and eroded down the chain. But if you are a seasoned entrepreneur like Elon Musk with a strong core team, it is still doable."

The Difficult Part — Staying Innovative

This is an exciting time — leading edge companies are exploring dimensions beyond technology for industry disruption. However, innovation in the space industry needs sustaining power to achieve the highly desirous end result of revenue acquisition and profit.

How innovative is your company? The answer goes beyond the technology that's been developed in your own R&D department. Innovation requires your company to invest in an innovation inductive environment and that will ultimately be a key factor in your company's longevity.

Time to take that innovation index framework and have a hard look at how innovation applies to your success!

www.aerospace.org/

With more than 20 years' experience in business development/ marketing for both government and commercial space programs, Lisa has cultivated a keen sense of the bottlenecks of the satellite industry, as well as where the industry is going next. She has enabled countless space-based missions ranging from architecture mission designs, technology implementations for new applications, and innovative business arrangements.

She joined The Aerospace Corporation in 2016 with a mission to enable more space projects in the industry by leveraging the Aerospace Corporation's unique experience and expertise, and she is fluent in both Chinese and Japanese in language as well as business culture. Prior to joining Aerospace, Lisa leveraged her multi-lingual advantage as the Director of Commercial Satellite Systems Business Development for Asia Pacific region at Boeing Space and Network Systems, and also worked as a system engineer at Northrop Grumman Aerospace Systems.

Lisa has an M.S. in Electrical Engineering from the University of Southern California, an M.S. in Aerospace and Mechanical Engineering from the University of California at Irvine, and a B.S. in Atmospheric Sciences from National Taiwan University in Taipei, Taiwan.

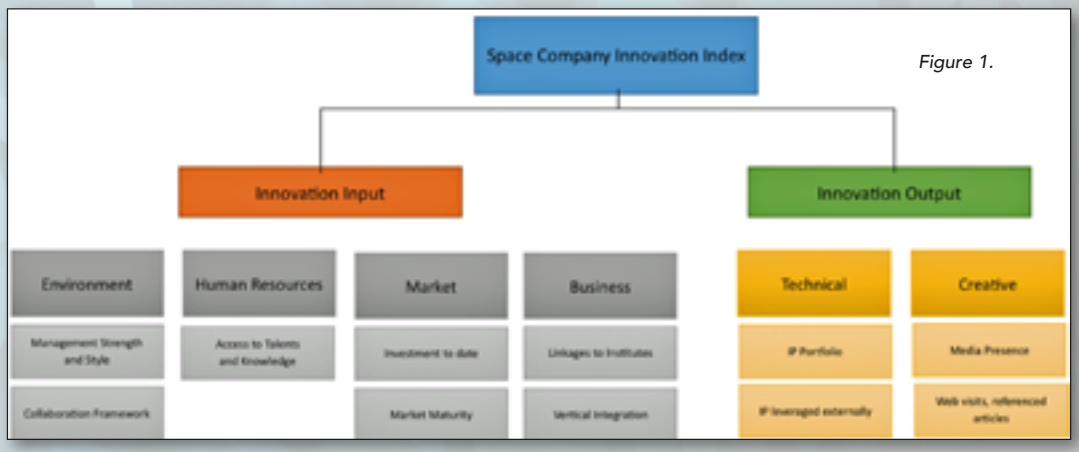

Figure 1.

SATELLITE INNOVATION SYMPOSIUM

THE SILICON VALLEY SATELLITE BUSINESS SHOW

The **2017 Satellite Innovation Symposium** aims to pinpoint key imminent market changes that will become obvious in years to come. While infrastructure and capital status have dominated for decades, key innovations will continue to cause major disruptions to the established marketplace. ***What innovations will define the satellite communications industry going forward?***

The full itinerary of sessions, breakfast, lunch, refreshments and a cocktail reception are included with admission to the event. An optional wine tasting tour with invited speakers and other satellite professionals is also available the day prior to the event.

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Two Satellites Punch Their Way to Orbit via Vega Exertion

For the second time this year — and the tenth overall since entering service in 2012 — Arianespace (*www.arianespace.com*) has successfully launched a payload via the Vega rocket from the Spaceport, with this lightweight vehicle's latest mission delivering the OPTSAT-3000 and VENμs Earth observation satellites to Sun-synchronous orbits.

Lifting off from the Spaceport's SLV launch complex at precisely 10:58:33 p.m. French Guiana time on August 1, Vega lofted its multi-passenger payload during a flight sequence lasting 1 hour, 37 minutes.

Speaking from the Spaceport's Jupiter control room, Arianespace Chief Executive Officer Stéphane Israël declared the launch a success and reflected on Vega's new "10-for-10" operational record, which includes four of these successes achieved during the past 11 months.

He noted that in five years of activity, Arianespace's lightweight vehicle already has orbited a total of 25 satellites for 19 customers worldwide, both institutional and commercial, serving a wide range of space applications, such as Earth observation, science, technology and education.

During the initial phase of the mission — designated Flight VV10 in Arianespace's launcher family numbering system — Vega was powered by three solid propellant stages, followed by multiple burns of the bi-propellant upper stage before separate deployments of the two spacecraft.

The payload fairing, which encapsulated Flight VV10's two satellite passengers during Vega's ascent through the denser layers of Earth's atmosphere, was manufactured using a new "out of autoclave" production process.

The first passenger released by Vega, OPTSAT-3000, is an Earth Observation (EO) satellite for the Italian Ministry of Defence. The satellite was built by Israel Aerospace Industries (IAI) based on inter-governmental, Italian-Israeli agreements. Once operational, OPTSAT-3000 will enable national defense entities to acquire and use high-resolution imagery from any part of the globe.

The OPTSAT-3000 system was supplied by Telespazio as prime contractor, which has responsibility for the entire system; while OHB Italia was responsible for the launch services and related engineering support.

General Enzo Vecciarelli, Chief of Staff of the Italian Air Force, acknowledged the superb capabilities of a great team that was responsible for OPTSAT-3000's development and launch. In comments at the Spaceport's control center, he noted this launch marks another step forward in European cooperation in space, "*which is something that we really need, because we live in a critical time for the security and stability environment — where there is a lack of situational awareness.*"

The second passenger orbited on Flight VV10 — VENµs, also produced by Israel Aerospace Industries — is an EO and exploratory mission for the Israel Space Agency (ISA) and France's CNES space agency at the benefit of Israel's Ministry of Science, Technology and Space.

VENµs (an acronym for ***"Vegetation and Environment monitoring on a New Micro Satellite"***) will study the evolution of Earth's vegetation during this scientific mission, while the satellite's technological mission will provide in-flight qualification of the Israeli electrical propulsion system, based on Hall-Effect thrusters.

CNES is in charge of the multi-spectral camera, its image programming and processing, as well as the distributing ground station; while the camera's development was performed for CNES by Elbit Electro-Optic Systems, Elop Ltd.

Peretz Vazan, Director General of Israel's Ministry of Science, Technology and Space, called the launch a "spectacular event," and provided his "mazel tov" (congratulations, in Hebrew) to all involved in the success.

An Eye on the Future

In addition to bringing Vega's tally of successes to double-digits, Flight VV10 also marked the rocket's first launch under a new operational organization between Arianespace and the vehicle's production prime contractor, Italy's Avio.

The payload fairing, which encapsulated Flight VV10's two satellite passengers during Vega's ascent through the denser layers of Earth's atmosphere, was manufactured using a new "out of autoclave" production process.

Under the new arrangement aimed at enhancing competitiveness, Avio now assumes responsibility for preparing the launcher until liftoff; while Arianespace maintains full responsibility for customer relations, as well as operations for the final countdown and launch decision.

Reinforcing Arianespace's continued focus on innovation, Flight VV10's Vega also used a new "out of autoclave" payload fairing that was developed by RUAG for the next-generation Vega C launcher, with the manufacturing process also to be applied to payload fairings for the follow-on Ariane 6 heavy-lift vehicle.

Flight VV10 continues Arianespace's busy schedule in 2017, wherein eight launches have been completed during the year's first seven months using the company's family of launchers (two with the lightweight Vega; two with the medium-lift Soyuz; and four using the heavy-lift Ariane 5). The company's next mission is scheduled for early September, when Ariane 5 will lift off from French Guiana on a flight to geostationary transfer orbit with a pair of relay satellites: Intelsat 37e and BSAT-4a.

OHB Italia
The OPTSAT-3000 Push From Kourou

Earth observation satellite OPTSAT-3000 was successfully launched on board the VEGA flight VV10 from European spaceport Kourou, French Guyana on August 2 at 01:58 GMT / 03:58 CEST.

Space technology group OHB SE's Italian subsidiary, OHB Italia (***www.ohb-italia.it/***), was responsible for the launch contract with VEGA and the associated engineering activities. OPTSAT-3000 is an Earth Observation (EO) program for the Italian Ministry of Defence and is comprised of a high-resolution optical satellite and a ground segment for on orbit control, mission planning and the acquisition and processing of images.

The photo in the next column reveals Vega's two satellite passengers, OPTSAT-3000 and Venμs, encapsulated within their protective payload fairing. The photo is courtesy, 2017, ESA-CNES-ARIANRSPACE / Optique video du CSG - S MARTIN.

OPTSAT-3000 will allow national defence entities to acquire and use high-resolution images from any part of the globe.

The OPTSAT-3000 system will be interoperable with Italy's second-generation COSMO-SkyMed radar satellites.

This will give the Italian Defence Ministry access to state-of-the-art technology, and ensure maximum operational capabilities because of the combined optical and radar data offered by the two systems.

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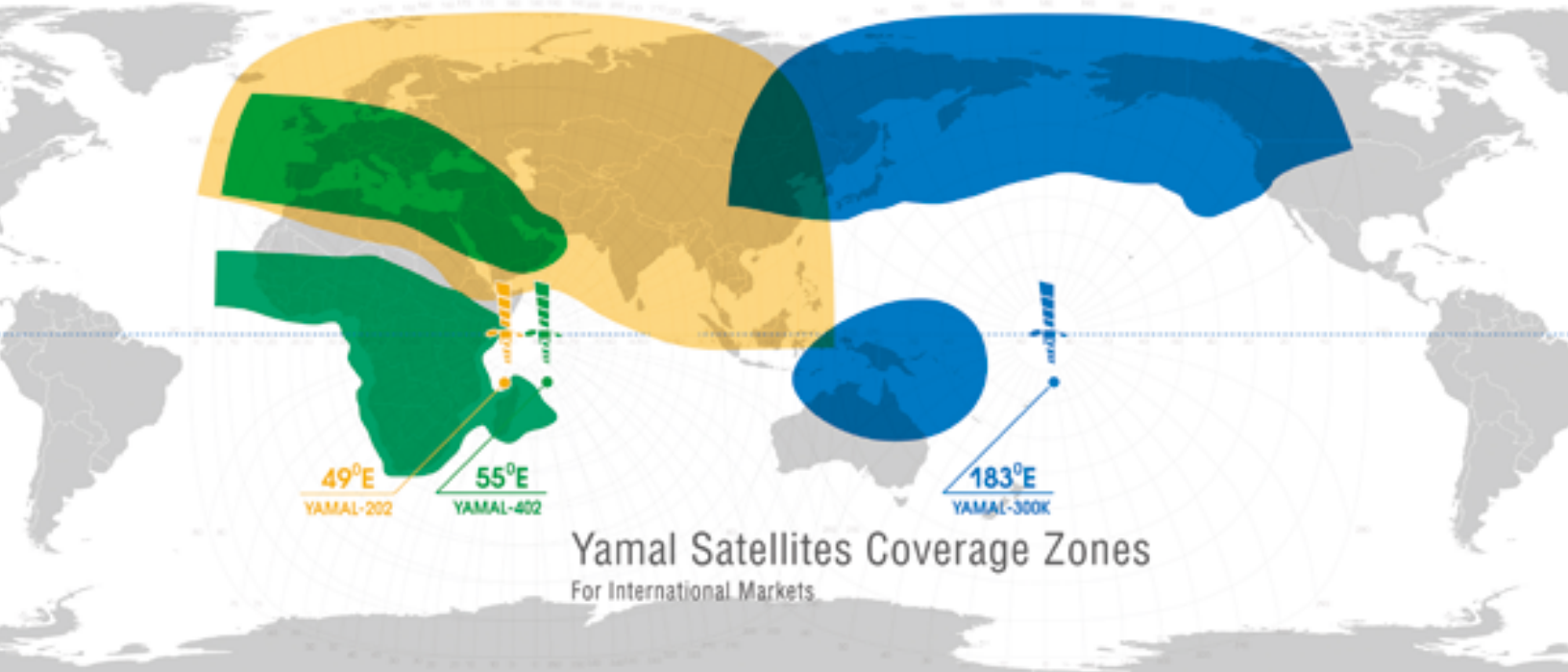


Yamal Satellites Coverage Zones

For International Markets

The teamwork involved with the launch preparations at space port Kourou. Photo is courtesy, 2017, ESA-CNES-ARIANRSPACE / Optique video du CSG - S MARTIN.

The OPTSAT-3000 system was provided by the prime contractor Telespazio, while the satellite and ground control systems were built by Israel Aerospace Industries (IAI), selected by the Italian Ministry of Defence. OHB Italia was directly contracted by Telespazio.

Roberto Aceti, the Managing Director of OHB Italia, stated that his company's responsibilities covered all of the launch services aspects and included engineering support directly at the space port.

Milan-based OHB Italia contributed substantially by providing a variety of services prior to the launch.

These included shipment of the spacecraft and the necessary ground support equipment to the space port, provision of interface rings for mounting the satellite to the launcher and for separating it in orbit, and satellite acceptance tests.

Regarding management of the technical interfaces, OHB Italia assured the connection and coherency between launcher and satellite with special focus on environmental loads compatibility and satellite separation.

OHB Italia also contributed to the separation system's design that enabled the safe release of the satellite.

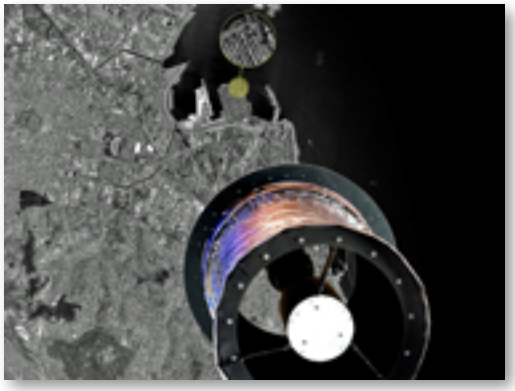
Being the formal interface to the customer Arianespace, OHB Italia's Program Manager acted as Director Mission Satellite during the final chronology of the launch.

Elbit Systems - OPTISAT 3000 and VENµS Head To Orbit With Highres Imaging Systems

Two of Elbit Systems (*www.elbitsystems.com/*) advanced space imaging systems, Jupiter and Venus, were launched to space on August 2.

The high resolution reconnaissance Jupiter imaging system (*artistic rendition at the top of the next column*), for the Italian Ministry of Defense, were launched onboard the IAI OPTSAT 3000 satellite.

The super spectral VENµS imaging system was launched onboard the French-Israeli VENµS environmental satellite. Both satellites were launched from French Guiana onboard an Arianespace Vega rocket.



The JUPITER space camera provides spatial resolutions of 0.5 meter resolution (PAN) from an altitude of 600 km and is Elbit Systems' most advanced light-weighted space imaging system developed for installation on smallsats.

The JUPITER imaging system contains very high resolution panchromatic imaging and has the capability of adding a multi-spectral (MS) channel.

JUPITER is designed for a range of military and civilian applications including advanced military surveillance and reconnaissance, detailed high value target investigation, definition of small and discrete objects and situational awareness.

The civilian applications include homeland security missions, emergency planning and operations, environmental monitoring, and infrastructure imaging.

The VENµS space camera features 12 narrow spectral bands with 5.3 meter spatial resolution from an altitude of 720 km. The VENµS satellite has been developed and manufactured as a joint effort between the French Centre National d' Etudes Spatiales (CNES), the Israeli Space Agency (ISA), Elbit Systems' Electro-optics (Elop) and Israel Aerospace Industries. The VENµS imaging system provides multi-spectral

high-resolution Earth imaging, previously unmet by legacy space imaging systems for a variety of applications, including a global scale monitoring of agriculture, receding of forests and vegetation, desertification, air pollution, the detection of volcanic ashes, dehydration of water reservoirs as well as oil spills and water contamination.

VENμS will play a vital role in creating guidelines for future scientific experiments and space imaging missions.

Elbit Systems' Electro-optics Elop has systems in use within a wide variety of major space programs for military, commercial and scientific applications, including Israel's Ofeq family of satellites, the EROS program of ImageSat International and a satellite of the Korean Aerospace Research Institute (KARI).

The two satellites on Vega flight VV10 were enveloped by a payload fairing that was manufactured by RUAG Space in a faster and more cost-efficient process in Emmen, Switzerland.

RUAG Space Fairing Well With Vega Flight VV10

Vega flight VV10 was initiated from the launch pad in Kourou. On the top of the rocket, protecting the two satellites, a new RUAG Space (*www.ruag.com/*) payload fairing debuted, one that was manufactured out of autoclave.

This advanced process was — for the first time— applied for the payload fairing of a Vega rocket, after having succeeded initially on an Ariane 5. The new procedure reduces both throughput time and cost, thereby allowing for a higher delivery volume and flexibility. According to the company, with this advanced process, RUAG consolidates the firm's position as the global leader in carbon structures for launch vehicles.

In order to run it, RUAG has invested in a state-of-the-art manufacturing hall in Emmen, Switzerland. Relying on tailor-made machinery and automated processes, the new composite centre was inaugurated in 2016.

The carbon-fiber based payload fairing consists of two half-shells, which separate in space. These shells

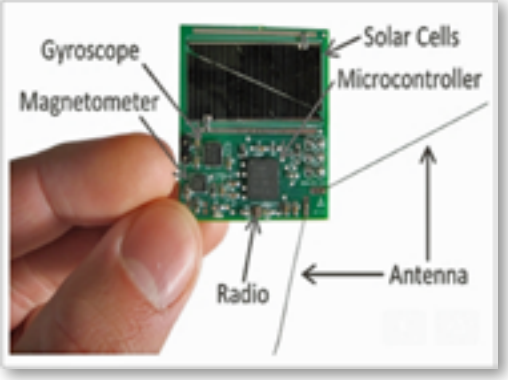
are newly cured in an industrial oven instead of an autoclave.

This requires less energy, and — thanks to its size — the industrial oven can cure an entire half-shell in one piece. The costly and time-consuming vertical integration of individual shell elements can be avoided. Overall, the Vega payload fairing is 7.8 meters high, and has a diameter of 2.6 meters at its largest point. Due to the out-of-autoclave manufacturing approach the fairing is around 70 kg lighter as the original fairing, cured in an autoclave.

Peter Guggenbach, CEO of RUAG Space, stated that the out-of-autoclave process is quite advanced and responds to the needs of today's space industry. Shorter lead times, less cost, flexible adjustments and higher delivery sequence — this is RUAG's contribution to make access to space more affordable.

InfoBeam

The World's Smallest Satellite is Launched



Breakthrough Starshot, a multi-faceted research and engineering program to develop and launch practical interstellar space missions by Breakthrough Initiatives, successfully flew their first spacecraft — the smallest ever launched.

On June 23, a number of prototype "Sprites" — the world's smallest fully functional space probes, built on a single circuit board — achieved LEO, piggybacking on OHB System AG's Max Valier and Venta satellites. The 3.5-by-3.5 centimeter chips weigh just four grams but contain solar panels, computers, sensors, and radios. These vehicles are the next step of a revolution in spacecraft miniaturization that can contribute to the development of centimeter- and gram-scale "StarChips" envisioned by the Breakthrough Starshot project.

The Sprite is the brainchild of Breakthrough Starshot's Zac Manchester, whose 2011 Kickstarter campaign, "KickSat," raised the first funds to develop the concept. The Sprites were constructed by researchers at Cornell University and transported into space as secondary payloads by the Max Valier and Venta satellites, the latter built by the Bremen-based OHB System AG, whose generous assistance made the mission possible.

The Sprites remain attached to the satellites. Communications received from the mission show the Sprite system performing as designed. The spacecraft are in radio communication with ground stations in California and New York, as well as with amateur radio enthusiasts around the world. This mission is designed to test how well the Sprites' electronics perform in orbit, and demonstrates their novel radio communication architecture.

Breakthrough Initiatives — including most notably, Breakthrough Starshot and Breakthrough Listen — are a set of long-term astronomical programs exploring the Universe, seeking scientific evidence of life beyond Earth, and encouraging public debate from a planetary perspective.

Breakthrough Starshot is a $100 million research and engineering program aiming to demonstrate proof of concept for light-propelled spacecraft that could fly at 20 percent of light speed and, in just over 20 years after their launch, capture images and other measurements of the exoplanet Proxima b and other planets in our nearest star system, Alpha Centauri.

breakthroughinitiatives.org/

An Achievement of Lofty Proportions

The Vector-R launch vehicle in flight. Photo is courtesy of Vector.

Talented folk from Boeing, SpaceX and Virgin Galactic merged their expertise and founded Arizona-based Vector, a satellite launch startup... and their work has now led to the company's Vector-R rocket making its first successful flight.

The launch is also a first from Georgia's Spaceport Camden. In the 1960's, this site was a NASA static test fire site for solid state rockets and was then repurposed by Vector for their launch purposes. The company's goal is to become a viable launch provider and this flight certainly illustrates success as the firm continues to progress toward their objectives, one being to become a platform for commercial payloads as well as to lower the cost of such efforts.

Aboard the Vector-R were also test packages from companies Astro Digital, the Center for Applied Space Technology and NASA's Ames Research Center. Also of interest is that this test flight included a demo of a 3D-manufactured injector for the rocket's engine, developed by the company in partnership with NASA's Marshall Space Flight Center.

Launch capabilities for smallsats that are reasonable as far as cost is concerned and enabling developers to build apps for space using an API through software-defined satellites are all part of Vector's mission.

Orbital launch capabilities are expected to become available next year for around $3 million. The firm recently managed to garner Series A financing to the tune of $21 million, which was led by Sequoia Capital.

As of now, Vector states the company is on track to achieve their target of achieving orbital launch capabilities by next year — this test flight is highly encouraging as also included in the mission was a demo of a 3D-manufactured engine injector, which was developed in partnership with NASA's Marshall Space Flight Center, and which will help it achieve its low cost launch goals.

vectorspacesystems.com/

The Internet of Things Is Out of this World

A Globecomm Perspective

A Q&A with Julie McGowan, Senior Director, IoT and Wireless Sales, Globecomm

Search on Google for "Internet of Things" (IOT) and you will get more than 200 million hits. That's no surprise. IoT is projected to grow from 15 billion connected devices in 2015 to 31 billion in 2020, according to HIS.

Most of those devices will connect over terrestrial networks — but the ability to connect anywhere, anytime already depends on one of the earliest high-tech inventions: satellite. In this issue, we focus on satellite technology that is building an Internet of Things truly circling the globe.

IoT offers industrial companies new and better options for protecting assets than in the past. Among the most powerful is geofencing: the ability to track the location of valuable assets and establish a virtual "fence" around where they are supposed to be. How does geofencing actually work? What can a company that provides satellite services do to enable it?

Julie McGowan

When an asset is outside an established Location Area (LA), Geofencing provides event triggered capability. For years, organizations have had no visibility of their assets when out of range. Misplaced and stolen inventory can potentially amount to millions of lost dollars per year for larger enterprise companies.

Event triggering, or "customized notification," whether an alarm, email, text, etc., provides an organization the ability to "act" on retrieving an asset. The goal and outcome is to retain inventory and protect the bottom line. Satellite access, because it is global, whether it is paired with cellular, Wi-Fi or by itself expands the overall reach inside and outside of the LA.

Managing massive data flows is the other topic that you will be talking about. It is big challenge, from taking in data from outside to managing its flow through the enterprise and often out again, at least in some form. How do IoT systems capture and aggregate this data efficiently? How can this increase business intelligence in the enterprise?

Julie McGowan

The ideal scenario for an enterprise that is managing massive data flows is one platform for everything, including: provisioning, billing, invoicing, and network management, with the outcome, again ideally, of having more streamlined operations.

That "ideal" is still largely a fantasy. However, more than ever they need to strive for this goal. It is vital that they do. While managing data across multiple facets of organizations is challenging, we have found that an enterprise can get very close to its goal by taking five initial actions. They are:

- *Establishing detailed criteria for the data flows across the entire company (not just IT)*
- *Identify ways to store information for retrieval and distribution on a just-in-time basis*
- *Discussions regarding how time-sensitive data is to be used for decision-making and for improving departmental and company-wide efficiencies in all areas of the business*
- *A schematic for filtering information based on organizational roles. These would naturally be prioritized by job title and function*
- *Access to data regardless of location or geography. This is a critical IT task and possibly the most complicated task because every technical standard, protocol and software code will be unique*

Taking these five actions creates a baseline and results in a smarter, more information-based decision-making process, which translates into the delivery of not only better customer service, but also allows the data to be used to innovate upon new products or services regularly.

If you were to look at the range of benefits that a company like Globecomm offers to a client as it relates to IoT, what would say are the major ones today?

Julie McGowan

I would say that our global reach across multiple verticals such as Wireless, Government, Enterprise, Media, and Maritime is significant, because the verticals overlap more and more.

Our experiential levels are higher because of this. I would also say we have the benefit of having global roaming agreements in place for both cellular and satellite coverage. Globecomm is a classic "one-stop-shop" for everything, ranging from application to connectivity to platforms. We design it, build it, manage it and find ways to add value to it for your business customers.

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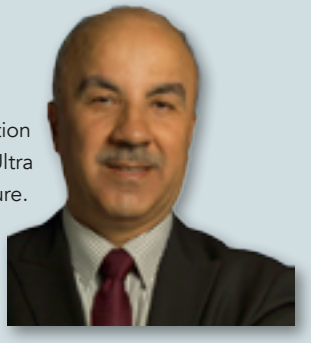
With an Eye to the Future

A NOORSAT Perspective

by Omar Shoter, Chief Executive Officer, NOORSAT



Since the firm's establishment in 2004 as the first privately owned satellite service provider in the Arab World, NOORSAT has constantly strived to ensure that the firm offers their customers cutting edge, cost-effective services.

NOORSAT's core business has always been broadcast; however, the company also offers a wide range of raw capacities for non-Direct-To-Home TV telecom and data services. Headquartered in Bahrain, with a regional office in Amman, Jordan, NOORSAT is focused on enabling their customers, whether they are broadcasters or businesses, to grow and to thrive.

To date, NOORSAT carries more than 350 TV and radio channels in both Standard Definition (SD) and High Definition (HD) quality to all viewers across the Arab World. NOORSAT is the only company that offers DTH TV services on both the 7/8 degrees West and 25.5 to 26.0 degrees East orbital positions. These are the only two hotspots that serve the Arab World, through Badr Al Nile® (NOORSAT 7 and NOORSAT 7B satellites) and Badr Al Arab® (NOORSAT 1 satellite).

There remains a solid demand for DTH TV services across this region of the world, with growth being driven heavily by a rise in demand for regional content across the Arab World.

A Focus on HD

NOORSAT delivered the first High Definition (HD) TV bouquet across the Arab World over the former NOORSAT 2 Satellite at 7 degrees West, which today is capable of delivering HDTV channels for customers across the Arab World. The company was well prepared for the emergence of HD and the firm's equipment was upgraded well in advance of this broadcast technology coming to the market.

Today, a major focus for the NOORSAT team is the continuation of the firm's aim to convert channels from SD to HD format. Though 80 percent of the viewers in the region are already equipped to receive HD, the area is lagging behind the rest of the world. Of the 1,500 channels broadcasting in the region, less than three percent are doing so in HD, with many broadcasters deterred by the cost of investing in more capacity.

For a broadcaster, the reality is often that HD requires them to purchase more capacity, due to the amount of bandwidth that HD consumes. NOORSAT, however, is able to offer customers a seamless and cost-effective means of transitioning to HD without the need to invest in large amounts of extra capacity.

To support HD growth in the region, NOORSAT has launched a DVB-S2 bouquet on the NOORSAT 7B (E8WB) satellite at the orbital location 7/8 degrees West to increase the number of HD channels on the most viewed hotspot in the Arab World.

NOORSAT's optimized solution and state-of-the-art equipment provides HD channels with high quality transmission from the firm's teleport at extremely competitive rates.

The Arab World is still engaged in the transition to HD, so the introduction of channels in Ultra HD is something to be tackled in the future. However, NOORSAT is watching UHD and 8k development and the technology's emergence in the region and will be ready to equip its teleport to offer such new services whenever that need arises.

Raw Capacities for Data and Telecom Services

Data-centric service demand is also an important part of NOORSAT's business, as the appetite for broadband continues to grow.

Businesses especially have great need for connectivity and the company works with them to ensure that their mission-critical needs are met. NOORSAT offers capacities that can serve broadband access, data applications, VoIP, GSM backhauling and raw capacities for VSAT services for private and governmental networks. In addition, NOORSAT's broadcasting center can easily access international fiber lines, simplifying the process of connecting different parts of the world to the firm's teleport.

Capacity on NOORSAT 3B (E3B) and NOORSAT 4B (E21B) can be used to establish secure and reliable communication networks and to overcome connectivity gaps in remote or rural areas. Many businesses today are geographically dispersed and connecting branch offices can be a challenge. However, services provided by NOORSAT can eliminate the problem that large distances pose.

Customers may establish VSAT networks to connect their various sites with no dependency on terrestrial networks, providing these locations with telecom and broadband connectivity and catering to their long distance communication needs.

This capacity can also be used for mobile backhauling and IP backbone networks, thereby complementing the terrestrial networks and providing connection of remote networks to the main infrastructure. Current market trends, such as the proliferation of the mobile phone and the requirement to provide increasing amounts of services to rural areas, mean that there is demand for services that can be deployed anywhere, without any requirement for terrestrial infrastructure. Rolling out terrestrial infrastructure or cell tower construction in more remote regions is often far too costly — satellite services can provide the go-to solution for users in remote areas.

The Future

NOORSAT is working to become the premier platform for DTHTV in the Arab World. In doing so, the company is consistently maintaining pace with industry developments and providing new, satellite-based associated services as well as a cost effective HD service, all as the market demands.

As a company, NOORSAT recognizes the need for business agility in order to meet customers' specific requirements. In every part of the business, care has been taken to ensure that the firm's space and ground infrastructure is future proofed and able to meet whatever service demands are made. This, coupled with a friendly and knowledgeable customer service team, means that NOORSAT will move into the future with the confidence that the company can serve customers to the highest standards.

noorsat.com/

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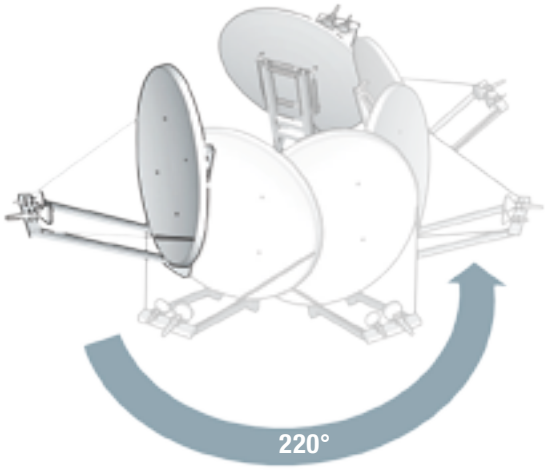

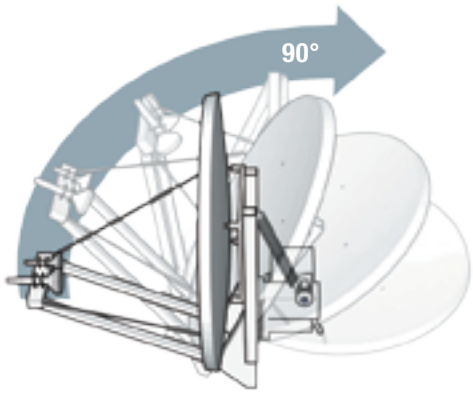

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The Forrester Report: The Big Four Results

... perhaps the hard times are over...

by Chris Forrester, Senior Contributor

The close of the month of July saw the satellite industry's 'Big Four' operators (Intelsat, SES, Eutelsat and Telesat) declare their latest financials.

By and large, these companies showed some improvement on their positions in 2016. However, much more importantly, there was a greater sense of optimism emanating from the four businesses.

Worth remembering is that at precisely this time last year that one of the quartet when reporting their results added to an already perfect storm created in May of 2016 that had sent satellite confidence into free fall that resulted in downgrades from market analysts and inflicted significant damage to share prices across the industry. Billions were eradicated from stock market valuations and extreme nervousness and market volatility was the result. One analyst at the time stated that since the release of the Eutelsat profit warning, rightly or wrongly, the market has had only fear and loathing for data business.

Giles Thorne, equity analyst at Jefferies, summed up the position neatly on July 28, saying, "*It's been a little over a year since Eutelsat blew itself and the sector up on a clumsy downgrade. It's re-rated significantly off its lows as it has shown that the issues in its business are a long way from what the market was implying.*"

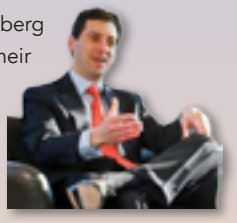
That nervousness still persists and operators are having to explain their plans and actions in extreme detail in an attempt to regain market confidence. There's a wonderful expression from a somewhat forgotten British prime minister, Harold Macmillan, when asked what was likely to blow a government's plans off course, replied, "***Events, dear boy, events***."

The same could be said of the satellite industry, especially for those players with a major stake in the DTH and video industry. Today's near-daily "events" are called Netflix, Amazon Video, Hulu and even Sling TV. These are the players which the consumers are embracing and there's no mystery that these entities represent threats with the hope they do not wholly manifest themselves and impact fully for generations to come.

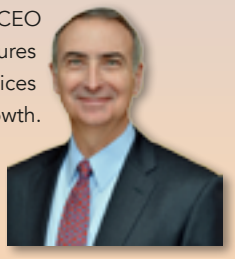
The past year's patience might be beginning to pay off, if the financial reports and associated commentary are any sort of guide.

As for July 2017's financials, Telesat kicked the week off with its three months statement ended June 30 and reported consolidated revenues of Can$226 million, or a decline of three percent (Can$6 million) from the same period in 2016. "*The decline in revenue was primarily due to short-term services provided to another satellite operator in the second quarter of 2016, partially offset by favorable foreign exchange rate changes on the conversion of U.S. dollar revenue, as the U.S. dollar was approximately five percent stronger on average against the Canadian dollar than it was during Q2/2016. Excluding the impact of foreign exchange rate changes, revenue decreased by 5 percent (Can$12 million) compared to the same period in 2016,*" said Telesat.

For the six months ended June 30, 2017, revenue was Can$461 million, a decrease of 1 percent (Can$6 million) compared to the same period in 2016. When adjusted for changes in foreign exchange rates, revenues declined two percent (Can$9 million) compared to the same period in 2016. Operating expenses were Can$99 million, an increase of 11 percent (Can$10 million) from the first half of 2016. Telesat's all-important backlog fell from Can$4.1 billion at the end of Q1/2017 to Can$3.9 billion at the end of Q2/2017. The firm's EBITDA margin is probably the best in the industry, at 81.3 percent (82.5 percent a year ago).



However, in an equally positive note, CEO Dan Goldberg told analysts that the company would continue with their plans for LEO satellites due to their low latency (high speed) connectivity. Telesat will launch two LEO satellites later this year. Telesat has plans for as many as 117 LEO satellites and Goldberg told analysts that it was hard cash that was driving the company. "*We're certainly not going to depart from that philosophy" for the low-orbiting constellation*," he said.

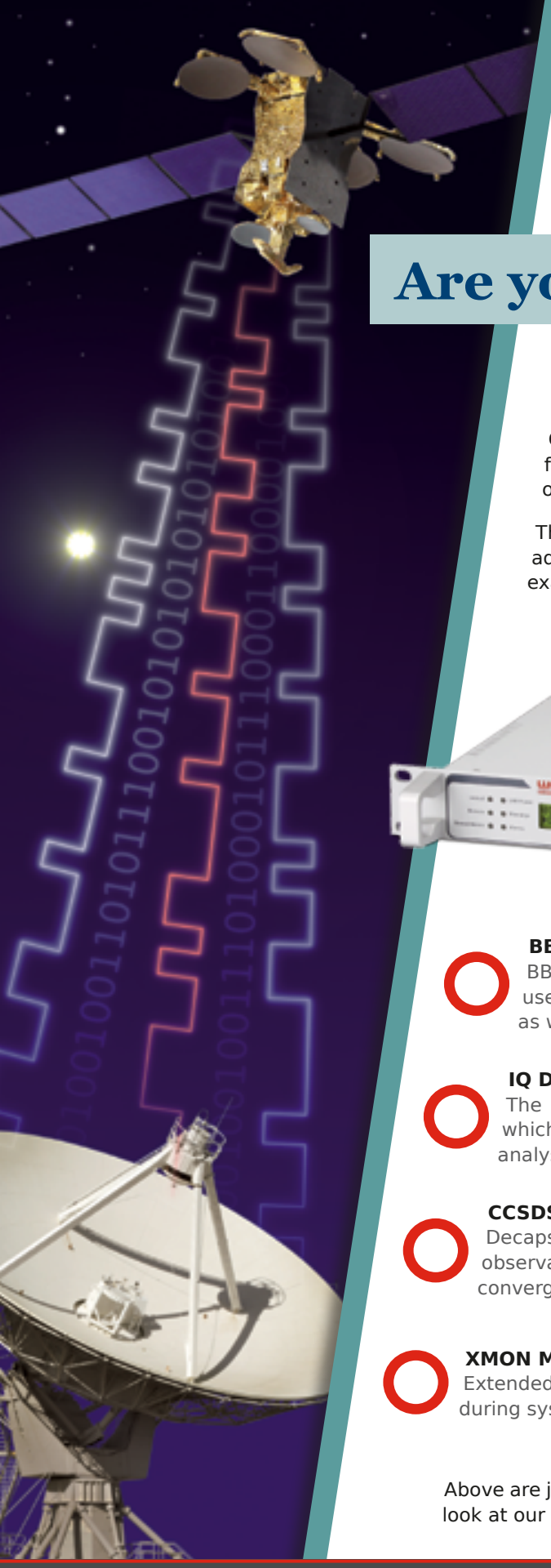


Intelsat unveiled their Q2 numbers on July 27 and CEO Steve Spengler said there were continued pricing pressures as services renew for certain wide-beam network services applications, creating a headwind to year-over-year growth. There had also been some non-renewals of capacity contracts. These pressures led to a fall in Intelsat's contracted backlog, from $8.5 billion in March 2017 to $8.2 billion as of June 31.There will be good news, helped by Intelsat 35e, which successfully launched on July 5, 2017 and began on orbit testing on July 24. The satellite is expected to enter into service in Q3/2017.

The planned Q3/2017 launch of Intelsat 37e on an Arianespace rocket will be the operator's final launch of 2017. The company said that while overall backlog was down, its new 'Epic' fleet grew their contracted backlog and is now comprised of more than 140 clients.

Intelsat reported total revenue of $533.2 million and a net loss of $23.8 million for the three months ended June 30, 2017. "We are making progress on sales of Intelsat Epic services with several new contracts on Intelsat 33e now completed, demonstrating that our new satellites are delivering superior performance for our service provider customers," said Spengler. "*The introduction of new Intelsat Epic enabled services, such as our operationally-efficient wireless solutions for 2G and 3G network extensions, expands our market opportunities as we continue to deploy the Intelsat Epic network. Progress on these optimized managed services, plus continued development of distributor relationships, support our return to growth as we complete our network deployment.*"

Intelsat reaffirmed their overall 2017 guidance — their Network Services division experienced a fall of six percent during the quarter-year, to $214.9 million. Intelsat's Media division saw revenues rise five percent, to $222.2 million. Government revenues fell eight percent to $86 million. CFO Jacques Kerrest stressed that Intelsat's finances — in spite of the failure of the OneWeb/SoftBank



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merger — were in good shape, and as for refinancing, "*we will do something when we think it's appropriate.*"

Spengler's comments to analysts explained that new contracts had been won with important distributors in the Middle East. This includes contractors with Etisalat in the UAE and Saudi Telecom, and stressed that Intelsat's "*robust program*" would help drive growth. "*We remain comfortable with the assessment we provided and as a result, today, we affirm our full year guidance for revenue and adjusted EBITDA.*"

Intelsat, along with the other 'Big Four' players, are winning valuable contracts in the aviation/mobility sectors from airliners and their own hopes and ambitions for In Flight Connectivity. Spengler noted that in the case of mobility, there is a very significant end-user demand from the airlines to provide connectivity for aircraft. And so, mobility service providers are out getting contracts with the airlines. They know what aircraft and what routes are required and then they go seek to put together the infrastructure for that. Their infrastructure decision is limited to satellite, that is what they are focused on. So that's how they evaluate the business case and they're making commitments quickly to meet that demand.

Spengler also spoke specifically about Intelsat's relationship with OneWeb. "*Our partnership with OneWeb is very much connected to having long term supply and capability across LEO as well as GEO for the mobility sector whether — again, whether it's mobility — Aero or mobility maritime or other new emerging mobility applications. We still feel that there is a robust Ku-band ecosystem of technology that's going to continue to develop on the ground with antennas that are going to support the sector. And the fact is, right now, there is not the ability to have global networks in Ka-band today. Global networks are only possible in Ku-band.*"

On the question of the threat from 'Events' such as OTT, Spengler was also confident of the role satellite had to play. "*OTT is a factor internationally, but when you look at developed markets, the terrestrial networks really aren't built at this point in time to have a material impact with OTT-type services. So, we expect that there is going to be a continuation of demand for television distribution across the developing world whether it's DTH or whether it's feeding cable head ends. And we're seeing that strength in our business and stability in that of our business as well.*"

Eutelsat's full year results were released on Friday, July 28. A 2.2 percent (like for like) fall in revenues for the year (from 1.529 billion euros last year to 1.477 billion euros) and a 2.7 percent fall in EBITDA profitability, the satellite operator turned in a significant 160.5 million euros improvement in free cashflow (from 247 million euros to 408 million euros) in the year to June 31.

Rodolphe Belmer, the company's CEO, said, "*During the past year, we have delivered or over-delivered on all our financial commitments. In particular, our strong performance on free cash flow generation has enabled us to reduce net debt to below 3.3x EBITDA, and to recommend a strong, 10 percent rise in dividend. Our performance was supported by solid commercial momentum in our core video business and in other verticals — particularly mobile connectivity, as well as the strengthening of our financial profile. In consequence, we are on track to achieve top-line stability in FY 2017-18, with a return to slight growth thereafter.*"

Eutelsat's all-important video segment saw accelerating take-up of H services on the firm's Hot Bird fleet, with "*Significant contract renewals in Europe and in MENA with Arqiva at 28 degrees East, and Digiturk at 7 degrees East.*" However, the Broadcast segment also saw revenues fall back 2.2 percent, largely down to the rationalization (in other words 'loss') of capacity and the ending of its contract with TV d'Orange.

Eutelsat's overall fill-rate for its fleet stood at 67.9 percent (down from 70.9 percent in the previous year). Eutelsat's transponder count is up, from 1,328 to 1,372. The operator's contract backlog is also down eight percent, at 5.2 billion euros (from 5.6 billion euros) and EBITDA margin of 76.7 percent. Belmer told analysts that the company's dividend to shareholders would rise usefully by 10 percent to 1.21 euros per share.

He updated analysts on the company's cost-saving plans and various asset disposals through the year, not least the sale of its holdings in Hispasat. Belmer stressed that the company's aim was to return to "*top-line growth*" and maximizing its existing assets to improve free cashflow and "*from 2019 onwards, reach onto growth in the medium term by building on our core video business and in the longer term, paving the way to capture the connectivity opportunity. UHD is coming at lower pace evidently because it's only the beginning of this technology, but still we have five UHD — commercial UHD channels on our fleet and well within our plan. As you know in the next three years we should reach 20.*"

Belmer, and deputy CEO Michel Azibert talked positively of improvements in transponder lease rentals at a "*slight price increase*," which has to be good news following on from regular reports of lease prices being squeezed. "*[They] are a sign that what we have consistently saying that our video business is resilient and has room for slight growth going forward. It's proven with what there are indications that it's true because of those two very important contracts [Arqiva and Digiturk renewals].*"

One element touched on by Belmer was Eutelsat's litigation — with ViaSat and Panasonic Aviation — against Inmarsat over that firm's S-band usage and plans for Europe. "*We believe that we have a very strong case that we have brought to the General Court Of Justice with our claim that the usage of the license (in the 2 gigahertz license issued by the European Union) was a distortion of usage. The license has been attributed back in 2008 with certain conditions, which are not respected at all and we think we have a very strong [case]. And that's why we joined the ViaSat litigation. And second, we most probably will engage in litigation at the local level, if needed.*"

Questioned on the call, Eutelsat's management were clear that the recent renewals (Arqiva and Digiturk) had seen flat volumes and price increases resulting in absolute revenue from Arqiva set to rise in FY18. Giles Thorne (Jefferies) commented, "*Along with the Digiturk renewal at 7 degrees East ("a good renewal in a difficult political context"), management feel they have validated what they've always said, that video revenue trends should be resilient. For video 'constructionists' like us, this is a critical data point — for the 'deconstructionists,' this will momentarily allay, although not expire, the view that satellite video is doomed to decline. Elsewhere, we note the message that the HD promotional strategy has proven very successful (30 percent y-o-y in HD channels).*"

SES completed the week with its half-yearly results, reporting a growing backlog and improving trends. SES said that revenues were up 9.6 percent to 1.049 billion euros and that the firm had achieved an EBITDA margin of 65.5 percent (66.4 percent last year) and an operating profit margin of 29.2 percent (31.3 percent last year). SES' all-important contracted backlog rose from 7.3 billion euros to 7.5 billion euros. Generally, however, the SES report was a 'steady as it goes,' given that SES says the firm is enjoying an improving trend in its video division; however, Q2 revenues are falling 1.9 percent (Q1/2017 fall was down 4.2 percent).

Karim Michel Sabbagh, President and CEO, said, "*SES continues to make a positive start to 2017 and is well positioned to generate sustained growth and improving returns. SES Video continues to deliver differentiated services and enhance the viewing experience, with the proportion*

of integrated solutions nearly doubling versus last year. The improving trend in Q2 2017 underpins our stable outlook for 2017 before the temporary impact of changes due to launch schedule and satellite health, which are expected to result in a slight decline. SES Networks' distributed network capabilities are driving strong growth across our data-centric verticals, expanding with global fixed data, aeronautical, maritime and government clients. The development agreement, with Boeing is the latest milestone in delivering next generation technology that will form the basis for SES's future network and will expand the future addressable market."

As of June 30, 2017, SES's global fleet carried a total of 7,741 TV channels, representing a y-o-y increase of four percent. SES's HDTV channel count grew by six percent, y-o-y, to 2,587 channels, while the SES satellite network now also carries 20 commercial UHD channels (as of June 30, 2016, that number was 16), including regional variations. Consequently, HD penetration increased from 32.7 percent to 33.4 percent over the last 12 months. Over that same period of time, the proportion of total channels broadcast in MPEG-4 increased from 58.9 percent to 63.5 percent of SES's total TV channels.

SES' Networks division saw revenues grow 24.9 percent to 343.4 million euros (up 7.5 percent like for like). SES' Mobility division also saw a strong half-year, with revenue growth up 88.1 percent to 83.8 million euros (up 37.1 percent like for like). Sabbagh reported that SES Video growth for FY 20171 is expected to be stable, in line with the previous outlook, before the combined impact of the later launches and changes in satellite health. Including the temporary impact of these changes, SES Video is expected to decline slightly in FY 2017, returning to growth thereafter. The previous targets for the three SES Networks verticals are all re-affirmed. For FY 2017, SES is targeting a return to growth in Fixed Data, strong growth in Mobility and stable-to-slight growth in Government.

SES's future revenue trajectory will benefit from the contribution of recently added and forthcoming GEO-MEO investments, which are planned to be launched by the end of 2019 and are expected to generate incremental annualized revenue of up to 750 million euros (equivalent to around 35 percent of 2016 group revenue) at 'steady-state.' More than 30 percent of this revenue is already contracted.

However, there are anxieties, not least of which is the health of SES fleet. The well-publicized failure of AMC-9 and the lost revenues of some 15 to 18 million euros, and the less publicized problems with NSS806 (representing a loss of 7 to 9 million euros) prompted Sami Kassab, analyst at Exane/BNP-Paribas, to suggest that "***30 percent of all satellites on the SES fleet have encountered technical anomalies, the highest rate in the industry.***" If correct, this is not the sort of performance reliability that would generate confidence in any business.

Kassab, in general, favors Eutelsat in his reports and has trimmed SES' EPS by 5 percent "*for 2017 and 2018, reflecting a combination of launch delays, technical anomalies and forex (c. 30 percent of the 2018 cut). We still consider the stock to be generously valued in the context of an ongoing, disappointing, top line performance,*" he stated in his summary note on July 28 and with a miserable 20 euros per share target price.

And this is certainly worth repeating... never forget, "***Events, dear boy, events!***"

Senior Contributor Chris Forrester is a well-known broadcast journalist and industry consultant. He reports on all aspects of broadcasting with special emphasis on content, the business of television and emerging applications. He founded Rapid TV News and has edited Interspace and its successor, Inside Satellite TV since 1996. He also files for Advanced-Television.com. In November of 1998, Chris was appointed an Associate (professor) of the prestigious Adham Center for Television Journalism, part of the American University in Cairo (AUC), in recognition of his extensive coverage of the Arab media market.

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Collision — The Real Risks

A Space Data Association Perspective

by Dr. Mark Dickinson, Chairman, The Space Data Association (SDA)

The risk of collision in the geostationary arc is very real. In fact, recent studies have shown that the risk in orders of magnitude is higher than had been previously thought.

Naturally, the consequences of any collision could be catastrophic, not just for the affected satellite, but for the entire space environment. However, the current mitigation measures, based on the available systems, services, and data, are simply not providing the degree of protection required.

In an earlier issue of *SatMagazine*, those risks were discussed as well as the need for a better system with enhanced capabilities to maintain the sustainability of the space environment by this author. As an association of the world's leading satellite operators, whose members account for more than 60 percent of the active geostationary satellite population, the Space Data Association (SDA), is uniquely positioned to leverage the technical experience and knowledge of its members to address this fundamental challenge.

This system is the Space Data Center (SDC) 2.0, which was announced by the SDA and Analytical Graphics Inc. (AGI) in March this year. Available in 2018 to SDA members, SDC 2.0 is based on AGI's ComSpOC product, which has been designed to provide enhanced space traffic management (STM) and Radio Frequency Interference (RFI) mitigation services.

ComSpOC itself was put to the test following the recent AMC-9 anomaly. Given SES' active participation in the SDA and its critical role in the specification of SDC 2.0, the satellite operator immediately reached out to AGI to obtain timely orbit information. This led to the operator very quickly gaining precise location information.

Safety of Flight

For SDA, ensuring safety of flight means protecting satellites while also safeguarding the viability of the space environment for the long term. A collision in the geostationary arc could destroy an active spacecraft and create a debris field that could permanently render a large part of that arc effectively unusable. In this scenario your neighbor's problem has the potential to become your own enduring operational problem.

For decades, many deemed the risk of a meaningful collision remote, even as new space actors entered the domain, launching more satellites. As the SDA studied the issues, understanding evolved. The SDA technical team quantified GEO collision risk using five diverse and independent techniques, each of which consistently produced GEO collision risk estimates that are orders of magnitude higher than previously published.

With the consequence of a collision being so profound, responsible operators must act to maintain the long-term sustainability and viability of all orbital regimes through sound operational planning, practices and the using the best possible systems.

Addressing the Challenges

As satellite operators, some major challenges must be faced when it comes to ensuring the safety of flight. For example, the nature of operator antenna networks makes the removal of absolute ranging biases very difficult, often resulting in kilometers of difference between the estimated and true satellite positions.

There are also limitations in the availability and accuracy of data related to non-member satellites and debris objects, particularly those with sizes in the 20 cm to 1 m range. Although the publicly available data is crucial for enabling space situational awareness, it does have its limitations including the lack of complete and consistently available data.

SDC 2.0

After extensive research, experts from among the SDA members organizations strongly believe that the functionality that SDC 2.0 provides will be absolutely critical for safeguarding and preserving the geostationary orbital resource for continued safe space operations.

Here are some of the features that will make that possible:

Catalogue of Objects

SDC 2.0 collision avoidance (CA) services will be based on a highly accurate and independently generated ComSpOC catalogue of objects in or traversing the GEO arc. This catalog will evolve to include all objects larger than 20 cm, which will be the most extensive catalogue available for flight safety services. SDC 2.0 uses advanced non-cooperative maneuver detection and characterization algorithms for all active catalogue objects ensure the rapid determination of orbits during and after maneuvers. The same maneuver detection capability will independently audit and verify operator-supplied maneuver plans to ensure the highest quality of future maneuver information and CA products.

Actionable Collision Warnings

Having an accurate catalogue will ultimately ensuring that operators only receive e actionable collision warnings. All satellite operators receive conjunction warnings, sometimes multiple per day, however they are often not actionable due to uncertainties in the accuracy of the data. Acting on these warnings may result in unnecessary avoidance maneuvers being performed, or even worse maneuvers that increase the likelihood of a conjunction occurring. With SDC 2.0, the number of warnings is greatly reduced, the accuracy of the data means that you only get a warning when you actually need to action it.

Calibrating Operator Information

SDC 2.0 will be able to validate and calibrate the operator-provided information. The output from this process can allow individual bias measurements to be removed by the operators, yielding much more accurate orbit knowledge. Achieving realistic collision probability estimates and actionable conjunction warnings demands that covariances for catalogue objects in turn be realistic. These covariances may also be instrumental in obtaining realistic geolocalization error ellipses. SDC 2.0 unified catalogue processing eliminates inter-system biases, which is of critical importance for flight safety warnings.

RFI Reduction

SDC 2.0 will also include a number of features to help reduce satellite interference, something that continues to be a problem for satellite operators.

Currently, if a geolocalization is needed to determine the source of RFI, the operator typically undertakes a lengthy evaluation to determine a suitable neighboring satellite that is compatible and available. Once that neighboring satellite is identified, ephemerides and RF parameters are often required, and the manual exchange and coordination of this data between operators can take several days.

This becomes further complicated and delayed by reference emitter availability, time dependence of geolocalization accuracy, and geolocalization equipment availability.

SDC 2.0 includes RFI functionality that will allow the construction of geolocalization scenarios, facilitating higher-accuracy solutions in substantially shorter time frames. This functionality enables machine-to-machine data exchange with SDA member geolocalization systems.

It will also include a Carrier ID database, which supports management and coordination of Carrier ID reference numbers, streamlining the process of identifying the interferer and resolving interference.

Coordination

Working with other satellite operators is absolutely crucial when it comes to ensuring flight safety. The framework and protections provided by the SDA allow fellow operators to work together in a highly collaborative and effective manner.

SDC 2.0 will give members the correct tools to ensure they are adhering to space safety themselves, as well as mitigating any risks of being affected by other operators or space debris.

With the risk of collision so high, it is more important than ever that operators work together and invest in tools and processes to reduce those risks and safeguard the space environment.

www.space-data.org/sda/

In April of this year, Mark Dickinson, the Vice President of Satellite Operations Inmarsat, was elected as the new Chairman of the Space Data Association (SDA). Dr. Dickinson succeeds the outgoing SDA Chairman, Mark Rawlins, Eutelsat, who will continue as a Director of the group.

In his role at Inmarsat, Mark Dickinson is responsible for the operation of Inmarsat's fleet of geostationary telecommunication satellites, as well part of the team defining the specifications and following the development of Inmarsat's future satellites.

Also joining the SDA was Jean-Luc Froeliger as a Director to represent Intelsat, replacing Mark Daniels.

The SDA was established in 2009 by the international commercial satellite operator community to coordinate activity and safeguard space-based infrastructure in the space environment in which satellites are operating.

"*The SDA has always taken steps to best ensure the future of the entire satellite industry*," Mark Dickinson stated. "*I am happy to play a leading role in that future, especially at such an exciting time for the SDA. The upcoming launch of SDC 2.0 is an important step for the industry, helping us to secure the future of space safety.*"

The Space Data Association Limited (SDA) is a non-profit international association of satellite operators that supports the controlled, reliable and efficient sharing of data critical to the safety and integrity of the space environment and the RF spectrum. It maintains the Space Data Center, a database of high-accuracy orbital information, which is operated by Analytical Graphics, Inc. (AGI) of Exton, Pennsylvania. Established in the Isle of Man the SDA is open to all satellite operators and other participants.

Rethinking Satellite Services: The Need For Simplicity

with Bill Marks, Kymeta Chief Commercial Officer, and,
Mark Rasmussen, Intelsat Vice President and General Manager, Mobility

Tackling the issue of simplification of the provisioning of satellite services brought these two subject-matter experts together to offer their thoughts to *SatMagazine* readers.

Why is buying satellite capacity today so difficult?

Bill Marks

Satellite solutions are largely inaccessible for industries that are unfamiliar with the technology. They don't know where to buy the necessary hardware, capacity, or services—or what technology is needed for each application. Not only would they need to figure out what equipment to buy, but they would also need to learn how to purchase spectrum from a satellite operator or service provider in either megahertz or megabits per second. We want to make satellites as easy and accessible as cellphones are today, especially for new markets that are being introduced to satellites for the first time.

Mark Rasmussen

I think the better question might be, "*Why hasn't the satellite sector advanced simple access to satellite-based solutions*?" The answer to this question lies in the transformative technologies that are just now coming into the mainstream: High Throughput Satellites (HTS), which in turn enable new technologies — such as electronically steerable antennas. Combined, these changes are supporting new business models that should streamline access to satellite-based broadband that is available, reliable, and cost effective.

How should services be simplified for markets that have not traditionally used satellite?

Bill Marks

Until this point, companies have only been solving for one piece of the puzzle. What's really needed is hardware that is affordable, versatile, and simple to install, coupled with services that are easy to understand and purchase. Today, satellite services are purchased in either a committed information rate (CIR) or maximum information rate (MIR), which is impossible to understand for the unsophisticated satellite buyer. Companies will often purchase beyond their estimated needs to ensure that access will be available, and are charged even if those services are not utilized. Kymeta's groundbreaking terminal technology, combined with KĀLO™ services with our partner Intelsat, aims to change this. The goal is to offer one cohesive hardware and service bundle that is easy to understand, easy to install, easy to use, and easy to afford.

Mark Rasmussen

Satellites are often the best way to deliver connectivity to unserved and remote areas, but the process of acquiring the services and integrating them into existing operations should be simpler for network operators. The satellite sector has taken two major technology steps: with the advent of high-throughput satellite (HTS) platforms such as Intelsat Epic^{NG} that can deliver the much larger volumes of data due to their multi-spot design, as well as higher power, and second, the development of next-generation antennas that make it easier to access this throughput. The intersection of innovation in space and smart antenna technology will lead to a lower cost-per-bit of throughput, lower installation costs, and reduced operational costs such as maintenance.

What do these markets need from a service solution? What common challenges do they face when it comes to connectivity?

Bill Marks

We view markets in two camps. The first are those Kymeta hopes to enhance, who currently use satellite solutions and services in their complicated form. The second are industries we plan to enable: future markets that have never used satellite that are experiencing an increasing need for better connectivity. For example, trains, regional coaches, and buses have struggled with limited or no connectivity outside of major metropolitan areas for years. Alternative energy facilities often operate off-the-grid, yet require high bandwidth communications that won't require a highly trained technician to install or maintain. In partnership with Intelsat, Kymeta is offering KĀLO, which provides a fully provisioned end-to-end connectivity solution and has introduced a simplified way for customers to buy and sell connectivity, especially in sectors that are currently unreached or underserved by terrestrial networks.

Mark Rasmussen

Historically, the satellite sector has been tasked with delivering carrier-grade or enterprise-grade services that support critical life-line services. However, Intelsat and Kymeta have introduced service options that will address these new requirements, unlocking new markets for satellite solutions. We believe KĀLO, which runs on our IntelsatOne Flex managed services infrastructure, will change the way satellite services are purchased by direct users, integrators, and service providers because it will be sold much like cellular services are sold. This can unlock fast-growing vertical sectors that have been historically difficult to support, including rail, energy, IoT, first responders, buses, connected cars, and more.

What changes or improvements must take place across the satellite industry to make satellite more accessible?

Bill Marks

This is what I like to call "the perfect storm"—changes in the last five years and the next five years that will enable satellite access to the masses. The advent of high-throughput satellites has lowered the overall cost of satellite capacity by increasing the amount of available capacity in space. Large investments are being made to distribute new Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations, which will further add to the capacity, while making coverage more ubiquitous by eliminating challenging look angles. Satellites themselves are becoming less expensive.

Ten years ago, a satellite would cost hundreds of millions of dollars to build, but new LEO satellites are expected to cost less than one million dollars to manufacture. In addition, the price to launch satellites is rapidly decreasing thanks to innovative companies like SpaceX and Blue Origin. Finally, companies like Kymeta pull it all together by addressing what has previously been the major choke point of mobile satellite networks and consumer accessible satellite solutions—a low profile antenna with no moving parts that is compatible with future satellite constellations, easy to install, and scalable. This environment will allow us to build solutions that are easy to understand and affordable to the public. Never has this level of innovation across the entire satellite ecosystem happened at the same time.

Mark Rasmussen

The experience of implementing Intelsat Epic^{NG} and bringing it to our customers has affirmed our beliefs about the potential of HTS. Intelsat Epic^{NG} delivers major performance breakthroughs in an open, scalable, all digital platform. However, no single technology or company can reach all possible geographies or meet the needs of this many vertical sectors. Satisfying this demand requires hybrid communications solutions combining wireline, wireless networks and satellite. This integration of satellite and terrestrial solutions is the only way to bring more value to customers who seek seamless solutions, new business models and increased technical support to serve traditional sectors as well as fast-growing new opportunities.

Kymeta's flat mTenna antenna.

How is Kymeta's partnership with Intelsat changing the paradigm for satellite services?

Bill Marks

For many, including myself, this is one of the most exciting times in satellite history. Yet others who refuse to innovate may be facing a massive decline in their business. The mobile phone industry is a perfect example: cellphones took off when the cellphone itself and cellular services became understandable and affordable for the average consumer. That's what Kymeta and Intelsat are proposing—easy to understand and acquire hardware and bandwidth packages.

Customers will be able to buy satellite connectivity in familiar, flexible, by-the-gigabyte packages combined with pay-for-what-you-use pricing. Kymeta has also eliminated the limitations of traditional ground systems—making satellite capacity accessible to anyone, anywhere, while on the move. The potential for satellite in these new markets is enormous, especially if the industry focuses on acquiring new customers. The companies that will survive are those that can embrace these innovations and adapt to a new way of thinking about how and what they sell.

Mark Rasmussen

Working with Kymeta is leading to the production of antennas and products that will fully optimize the performance of the Intelsat Epic^{NG} fleet and simplify access to the satellite technology. Kymeta's flat, thin, light and low-cost satellite tracking antennas will provide complete flexibility to establish connectivity via any device and enable multiple applications. Their 70 cm flat panel antenna will be critical for a variety of applications in the mobility sector. The smaller 20 cm antenna will be perfect for the connected car. A car has a hundred million lines of code, which means that a simple software upgrade could be approximately 500 megabytes—going to hundreds of millions of cars. For customer convenience and cost-efficiency purposes of downloading these large files, it makes more sense to opt for satellite and the power of multicast instead of a global mobile phone network. Kymeta's 20 cm antennas combined with the higher performance of Intelsat Epic^{NG} offers car manufacturers a secure, highly efficient, and more cost-effective solution for software upgrades.

www.kymeta.com
www.intelsat.com

Innovation: The Changing Picture of Broadcast

A Newtec SatBroadcasting™ Perspective

by Hans Massart, Broadcast Market Director, Newtec

The broadcast market is an ever-shifting landscape and the way in which people consume content is changing at a rapid rate.

More and more events and programming are being broadcast in Ultra-High Definition (UHD) and being made available to consumers via different distribution channels. Consumer expectations have increased as 4K-capable televisions become the norm.

To maintain pace with these changes, for any kind of resolution, broadcasters need to be able to ingest, produce and transmit high-quality content from an ever increasing number and variety of locations and sources.

In order to deliver this, broadcasters need to find new ways of making the most of their existing space segment by deploying more reliable and cost-effective ground infrastructure solutions, allowing them to keep pace as the industry adapts to changing methods of content contribution and distribution.

A Changing Picture

One area wherein these changes have been particularly significant is newsgathering. Traditionally, covering Outside Broadcast (OB) events live was expensive and logistically complex. Investing in dedicated satellite trucks or expensive satellite services, simply wasn't possible for many media companies — even a live presentation using a single camera typically required costly transponder space.

The high cost and complex challenges of deploying a traditional satellite truck on site, as well as the need to operate traditional cameras, also restricted editorial options and coverage of events.

While bonded cellular technology changed the game for newsgathering, it could not fully replace satellite links, especially in situations where cell coverage is poor and available bandwidth is limited. At the same time, satellite technology advanced and the on-site needs of newsgathering crews evolved with the changing requirements of broadcasters.

To cover live news events today, newsgathering crews need to deploy mobile solutions that can transmit more than just video. They require access to multiple applications, including Voice-over-IP (VoIP), video clip transfer, web and archive browsing, email and social media.

Access to newsroom and production applications, such as Avid iNews or Octopus Newsroom, also needs to be enabled. All these applications require a reliable, bi-directional, IP multi-service communication link of sizeable bandwidth to allow news crews to operate as if they are in the studio.

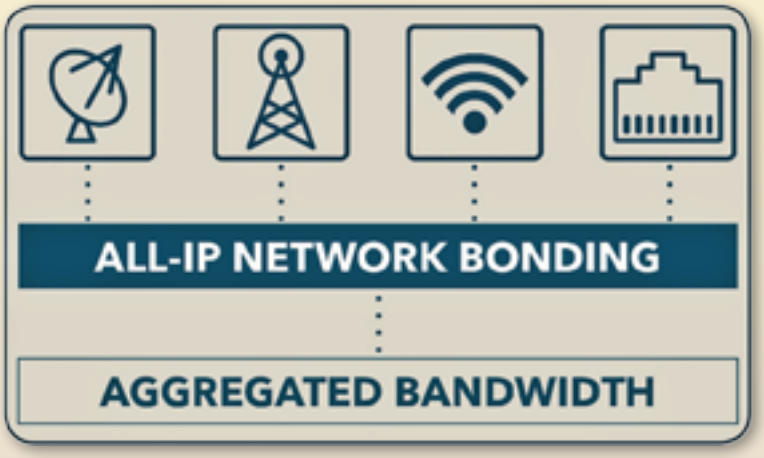

Figure 1. Aggregation of bandwidth through-all-IP bonding

Keeping Pace

Modern mobile newsgathering kits need to aggregate enough IP bandwidth to concurrently handle all applications a remote location requires. To do this, the crew needs to be able to bond all available IP networks at the required point in time — whether 3G/4G, microwave, Wi-Fi, fiber, Ka- or Ku-band satellite.

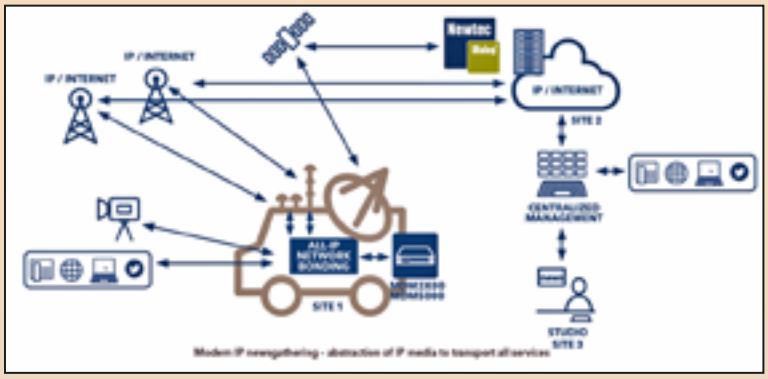

Figure 2. Modern IP newsgathering — abstraction of IP media to transport all services

Additionally, an intelligent connection management system is required, one that is able to flexibly re-distribute available satellite bandwidth over the concurrently communicating remote terminals, depending on available IP bandwidth aggregated over different media by each terminal and taking into account the different Quality of Service (QoS) the running applications require.

In the race to be first-to-air, flexibility, agility, efficiency, reliability, compactness or portability and ease of use are critical. (***Please see Figure 2 above.***)

When terrestrial links are unavailable or don't provide enough uncontended bandwidth, or when events take place outside of cost-effective coverage areas, the portable newsgathering kits need to be able to activate the IP satellite link.

However, providing this connectivity over satellite is not without challenges. One such issue relates to the fact that current satellite technologies, such as MF-TDMA and SCPC, do not adequately support either the on-demand bandwidth or high efficiency/high bit rate transmissions that are required.

Switching between the two is possible, but can cause considerable satellite link outage, packet loss and space segment fragmentation.

At Newtec, this difficult choice between the two has been remedied through the development of Mx-DMA®. This combines MF-TDMA flexibility at SCPC-like efficiencies by adjusting the frequency plan, symbol rate, modulation, coding and power for every terminal in the satellite network every second, based on the return traffic demand, QoS management and weather conditions for the terminal population in the network.

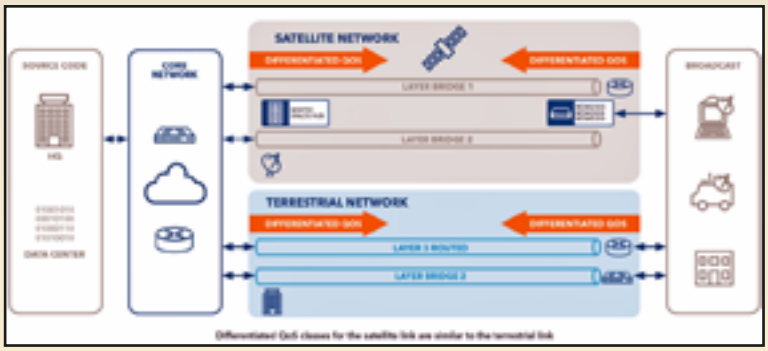

Figure 3. Differentiated QoS classes for the satellite link are similar to the terrestrial link.

A dedicated scheduling system is recommended when a satellite operation is required to work independently of other IP media. Whether this is an intelligent connection management system that works across different IP media, or whether it is a dedicated satellite scheduling software such as Newtec's SATLink Manager, a multi-level deterministic QoS model allowing similar flexibility as terrestrial networks is key. Newtec Dialog features this technology.

Efficiency: The Key to the Door

An area which requires continued focus in the light of UHD uptake is the efficiency of space segment usage for distribution over satellite. One method of doing this is to make use of the latest transmission standard, DVB-S2X, of which Newtec is very proud to have played a part in developing it. Using DVB-S2X gives the satellite industry the opportunity to increase profitability by delivering improved efficiencies without investing in additional, costly, space segment.

DVB-S2X Channel Bonding is one such optimization, allowing the transport of a single Direct-To-Home (DTH) stream over as many as three transponders and treating them as one logical transponder. Programs are then recomposed by a next-generation set-top box (STB). Transport efficiency is significantly improved, thanks to statistical multiplexing improvements that enable the delivery of UHD content to the viewer's living room.

Roll-out of 4K resolution-capable STBs enable the deployment of advanced technologies such as HEVC and DVB-S2X System-on-Chip.

Understanding the Future

Whether the viewer's demand for spectacular picture quality, or the rise of drones and mobile journalism as content collection methods, the broadcast market will continue to see disruption for some time to come.

However, in a competitive commercial landscape, cost-effectiveness will always be the key consideration for broadcasters who must embrace these changes by having the appropriate technology working for them in the correct way.

Those providers that can manage this successfully will find themselves in a prime position to take advantage of the next-generation technologies that are driving the broadcast market forward, all the while remaining cost-effective and commercially viable.

www.newtec.eu

A Newtec Update

A satellite technology pioneered in Africa by Liquid Telecom and Newtec was the winner at the Global Telecoms Business Innovation Awards held earlier this year – the company accepted the award for Enterprise Service Innovation. These prestigious Innovation Awards recognize the industry's most innovative and successful project partnerships between operators and vendors over the previous 12 months.

Last year, Liquid Telecom and Newtec deployed the first Mx-DMA satellite links in Africa in response to increasing demand from enterprises wanting always-on satellite connectivity with channels always open and immediately available.

Mx-DMA is the dynamic bandwidth allocation technology from Newtec that is featured on the company's innovative Newtec Dialog platform and adapted by Liquid Telecom for the African market. Mx-DMA provides high quality, dedicated connectivity to enterprises at a massively reduced cost by allowing bandwidth to be moved to where it is being demanded, exploiting the 'bursty' nature of an IP network – and providing TDMA-like on-demand variable bandwidth allocation with SCPC-like efficiencies. This provides enterprises in Africa with dedicated always-on bandwidth allowing use of big data apps and constant corporate VPN links to HQs and other offices.

Gem Diamonds, a mining company in Botswana, was the first Mx-DMA deployment in Africa. Liquid Telecom and Newtec worked with VBN Services, an enterprise service provider in Botswana which manages the networks of Gem Diamonds.

The Newtec Dialog platform with Mx-DMA technology is available across Africa and suitable for all types of enterprises in the continent, including banking, oil and gas, SMEs and enterprise networks, broadcast cellular backhaul, Government and defense.

At IBC2017 in Amsterdam, please visit Newtec at their Booth #1A49

The Ever Increasing Use of Satellite Broadcasting for Live Events

An ETL Systems SatBroadcasting™ Focus

by Andrew Bond, Sales and Marketing Director, ETL Systems

Broadcasters are under increasing pressure to provide a constant flow of content to viewers on a multitude of platforms. Breaking news and other live events need to be covered instantly — the industry is awash with talk of Over-The-Top (OTT) video — many are predicting the death of satellite broadcast. However, there are many reasons why that is simply not the case and, in fact, satellite broadcast has a highly positive future.

Broadcast Under Pressure

There is no denying that the broadcast marketplace is evolving — broadcast is no longer simply the remit of broadcasters via a single channel, as anyone who can create and distribute content can deliver OTT content to eager viewers. This is making the competition fierce and is also putting broadcasters under increasing pressure to lower subscription costs or even offer content at no cost.

In the newsgathering scenario, as soon as anything occurs, not only are there a plethora of broadcasters competing to cover the incident but there will be masses of people at the scene with their smartphones who are capturing and instantly streaming the news occurrence. Broadcasters who are not present at a major event to instantly obtain their own coverage will find viewers heading elsewhere to obtain the breaking story.

The same holds true for major occurrences, such as sporting events, concerts, festivals and the like. These are increasingly being streamed from phones across the Internet and they are attracting numerous viewers — just look at the number of videos resident on YouTube. Of course, broadcast content is going to be of a much better quality and would be generally preferred by consumers — if there is a viewing option.

In this increasingly competitive environment, attracting viewers when considering all of the tools they have at their disposal requires broadcasters to consider how they deliver content more cost efficiently. Therein lies a problem, as it is all far too easy to cut corners and buy equipment that is under par in order to compete on price. Unfortunately for those that do so, the result can often be a poor quality feed.

The Satellite Reputation — Are We Over It?

Satellite broadcast has had a rough ride over recent years. Many years ago, when the first satellite broadcast happened, the public was wowed. No matter that at that time the picture was a bit grainy. The very fact that satellite broadcasting was possible was amazing.

Technology has moved on at great speed and these days no one really knows or cares about how the video is getting to their screens as long as that content is available and the quality of the transmission is good. Nowadays, there seems to be a certain stigma with satellite, which is often considered to be a legacy technology. For those working in this field, the understanding is that such beliefs are nonsense — there are a wealth of applications that totally rely on satellite and the attendant technology.

With all the talk of cord-cutting, satellite broadcasters, along with other traditional broadcasters, are naturally concerned. Many are embracing change and adopting more hybrid approaches. OTT options from satellite broadcasters

are appearing on the market, such as Sky's offering, Sky Go. However, despite these challenges and the apparent satellite stigma, this author believes the future is bright for satellite broadcast, especially for live coverage of events from the field.

Staying Connected

The most obvious argument for the importance of satellite is the need for connections everywhere for content delivery... everywhere. While it is true that we live in a much more connected world, it remains unlikely that there will be a ready-made fiber connection at every breaking news event or live sporting event. In the case of disasters, any existing connection infrastructure is more than likely to have been impacted. In many of these cases, satellite is the only way to obtain a reliable connection, and quickly. Being able to arrive on site with a portable Very Small Aperture Terminal (VSAT) terminal ready to go has obvious advantages for a number of applications, including for the broadcast world, where these pressures are quite apparent. Thankfully, technology is getting far easier to use, with many auto-pointing antennas making it easy for anyone to setup the equipment, automatically lock-on to a satellite and be ready for video capture in mere moments.

VSATs — Are They Getting Better?

While it is true that getting live coverage is critical, neglecting quality is not an option. Consumers, who are used to receiving content from multiple sources and have much less channel loyalty than ever before, expect a certain level of quality from all of their content sources. If there is any visual degradation, they simply obtain their coverage elsewhere.

One of the biggest challenges with VSATs is obtaining consistent quality throughout the capture and delivery process. Not all VSAT terminals are up to the task. The market has, unfortunately, been flooded with some poorly made antennas. When a satellite broadcast feed is not up to par, not only does that make the consumer move away from that particular feed, but it also potentially damages the reputation of satellite broadcasting as a whole—that has the potential to impact all who are operating in this field. As an industry, all need to ensure superb content quality all of the time.

Equipment That Can Cope

VSAT equipment also needs to be able to cope in some rather unique conditions. In the world of outside broadcast (OB), the trucks could be in remote locations with tricky driving conditions that could cause equipment damage if the appliances are not up to the task. In other applications, this is even a bigger issue.

The military, for example, needs to be assured that their equipment can really be pushed to the limits and be able to transmit data, perfectly, on each occasion of use. Absolutely critical is that all VSAT equipment in all parts of the chain be viable and reliable.

The Future Of Satellite

Satellite for broadcast will remain extremely important for the foreseeable future as this technology is a highly efficient way to deliver coverage to viewers no matter where they are located or from wherever the event is occurring.

That fact is why satellite is far more crucial across multiple applications than given credit for and also why satellite will become even more important as the demand for coverage everywhere will continue, from cars to fridges.

With increasing demands, satellite will be more important than ever before and broadcasters need to ensure that all of their equipment is up to the challenge.

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Innovation: Smallsat Autonomous Formation Flying

A Space Flight Laboratory of Toronto Focus

by Kevin P. Corbley

Space Flight Laboratory (SFL) of Toronto is on a mission to expand the utility of smallsats in a variety of commercial, government and research sectors.

Among the organization's current focus areas is the exploitation of its successful heritage in autonomous formation flying, a technology that enables multiple satellites to work together and to perform functions that are not typically possible with just a single satellite.

SFL is reputed to be the only organization to have accomplished precise, autonomous formation flight with centimeter-level knowledge and sub-meter level control accuracy in LEO on two nanosatellites: CanX-4 and CanX-5. This space-proven compact technology is now available at low cost, enabling commercial exploitation previously not possible.

"*The most significant benefit of this technology is in commercial geospatial services*," said Dr. Robert E. Zee, Director of SFL. "*Certain remote sensing and geolocation applications become viable when two, three or more satellites are flown in precise orbital configurations.*"

Autonomous formation flying means the satellites are orbiting in a constellation with their relative positions predetermined, with their spacing precisely maintained without assistance from ground-based commands. Autonomy refers to the fact that onboard hardware and software allow the satellites to communicate with one another to keep their positioning exact.

"*For space-borne sensing and localization missions, autonomy is the key because the real-time position determination and control continuously preserves the precise configuration, which establishes a more accurate positional baseline to process the measurements and data being collected*," said Zee, who then added that not all satellite constellations use, or need, autonomous formation flying.

For example, clusters of small Earth Observation (EO) satellites now being launched have a primary objective of collecting large volumes of imagery on frequent revisit cycles — these missions do not necessarily require the technology. SFL, on the other hand, is focused on enabling a different set of applications that would not be possible, or would be prohibitively expensive, with single satellites or with uncontrolled constellations.

Proof of Concept Completed

Established at the University of Toronto Institute for Aerospace Studies (UTIAS) as a self-sustaining specialty lab servicing the world, SFL builds smallsats on tight schedules and at low cost.

Over the past two decades, the organization has developed 25 nano-, micro- and small satellite missions that have totaled more than 68 years of orbit time. The SFL has spanned the full spectrum of space-borne applications, including EO, environmental sensing and communications.

Image is courtesy of HawkEye 360.


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During the course of these diverse missions, the SFL has innovated precise attitude control, modular power systems, and numerous subsystems designed specifically for smallsats, which have contributed to development of autonomous formation flying capabilities.

Others who have accomplished formation flight to date have done so with larger, more expensive satellites, or with much less accuracy, which makes commercial implementation and utility virtually impossible. Formation flying capabilities exist for traditional satellites, but operational deployment in many applications, especially related to commercial geospatial and location-based services, has been impractical due to the cost of building multiple large satellites. These other technologies do not scale well to smaller satellites because of both the size and expense of the components and subsystems involved.

SFL, however, achieved a microspace breakthrough in technology and cost-effectiveness with the development of the CanX-4 and CanX-5 demonstration mission in 2014. Funded by SFL and the Canadian government, the two 7 kg nanosatellites flew autonomously in five planned orbital configurations with separations varying from 50 meters to one kilometer. Their positional accuracy was less than a meter, and relative position knowledge was within a few centimeters.

"We believe SFL is the first to demonstrate autonomous formation flying of nanosatellites at a cost that is feasible for commercial operation," said Zee. "And the innovations we developed to make this possible scale up from nanosatellites to microsatellites and smallsats. It's easier to make something big if it is small, but much harder to make something big, smaller. We did the hard part so that our customers can fly any size of formation flying mission without breaking their budgets."

While CanX-4 and CanX-5 are nanosatellites — under 10 kg — bigger satellites such as microsatellites (10-100 kg) and small satellites (100-500 kg) are also direct beneficiaries of the SFL technology.

Practical Benefits of Autonomous Formation Flight

Now that autonomous formation flying is a technical and practical reality for smallsats, SFL believes one of the most common uses will be in geolocation services. This involves three or more satellites receiving radio frequency (RF) signals from transmission sources on the ground (either active or passive) and using triangulation to precisely calculate their locations in three dimensions.

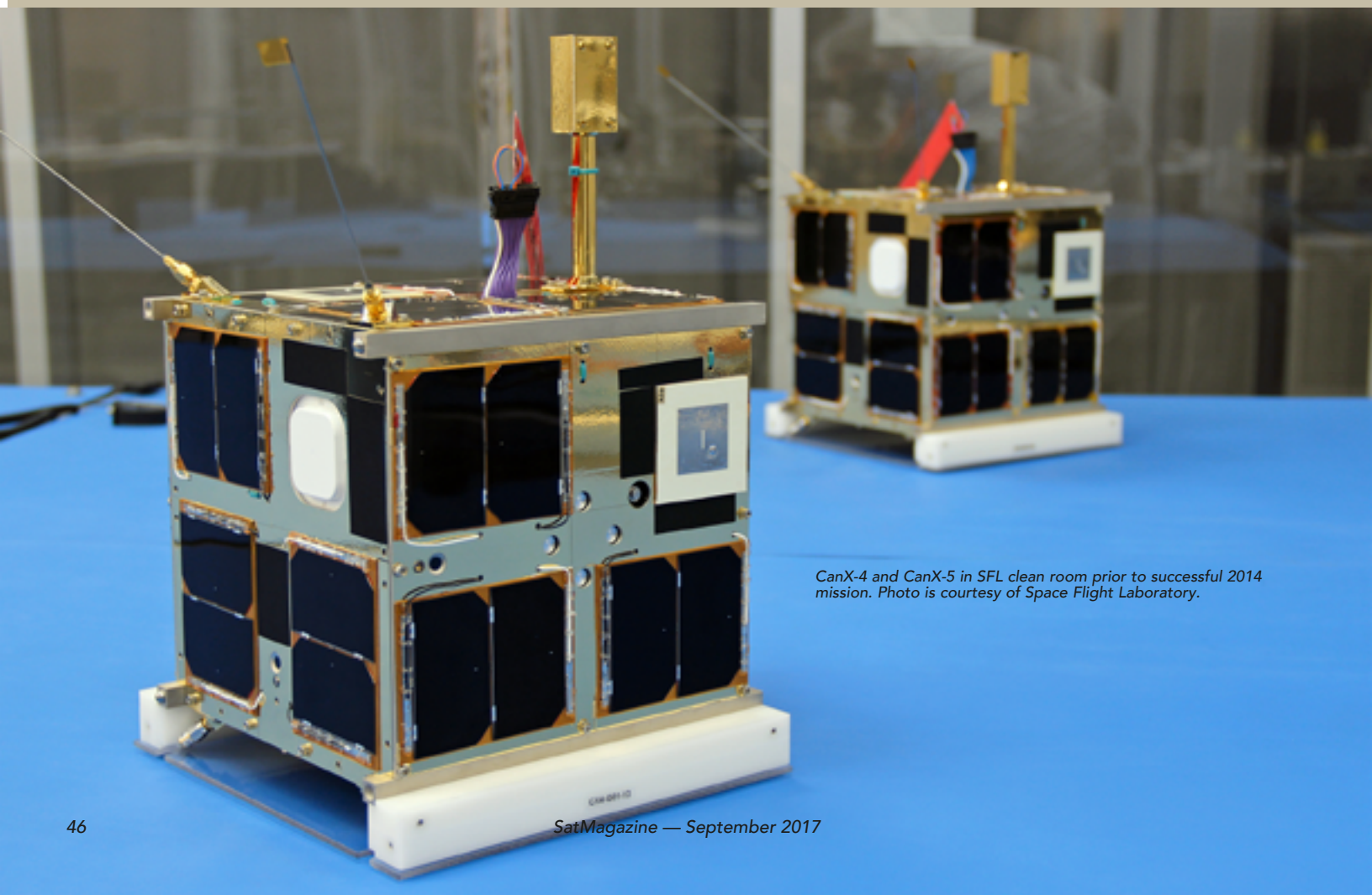
"The accuracy of the location calculation depends on how precisely the separation of the satellites is known and controlled," said Zee.

One of the first companies to create a commercial business around satellite-based geolocation is HawkEye 360 in Herndon, Virginia. Primarily due to the success of CanX-4/CanX-5, the HawkEye 360 development team, led by Deep Space Industries, selected SFL to build a demonstration constellation that was comprised of three 15 kg microsatellites that is scheduled for launch in early 2018.

HawkEye 360 is creating an RF survey-based geospatial information network that will map and analyze RF signals coming from numerous communications and transportation sources, including air, sea and land vehicles. Among the applications will be identifying wireless broadcast interference sources for communications companies and expediting the location of emergency beacons in search-and-rescue operations.

"Automated formation-flying makes our mission both possible and differentiated," said Chris DeMay, Founder and Chief Operating Officer of HawkEye 360.

Another application enabled by autonomous formation flying is sparse aperture sensing. In this application, a cluster of satellites equipped with small sensors capture data that is then combined to provide the effect of a single instrument with a larger aperture than individual satellites in the cluster could independently carry. For example, Synthetic Aperture Radar (SAR) images from different satellites in formation flight can be processed and combined for higher resolution imagery. This enables the use of smaller antennas and smaller satellites.



CanX-4 and CanX-5 in SFL clean room prior to successful 2014 mission. Photo is courtesy of Space Flight Laboratory.

Other SAR applications include Interferometric SAR (InSAR), where an interferogram of two SAR images is made from SAR images captured by formation flying satellites to provide real-time change detection.

"*As with triangulation, the accuracy of combining these multiple data sets into meaningful information relies on knowing the precise baselines, or relative positions, of the sensors on the satellites,*" said Zee.

Clusters of electro-optical sensors might leverage formation flight to identify and track movement of objects on the ground or to capture overlapping image pairs for use in stereo photogrammetry.

Integration of Software and Hardware

The autonomous formation flying technology developed by SFL is a complex choreography of hardware systems and software algorithms. They work together to keep the satellites in their intended orbital configurations with predefined baseline separation among them.

SFL devised closely coupled sets of algorithms for attitude control, navigation and formation control of the satellites. These software solutions interact primarily with three onboard hardware systems: propulsion, carrier phase differential GPS and S-band inter-satellite radios.

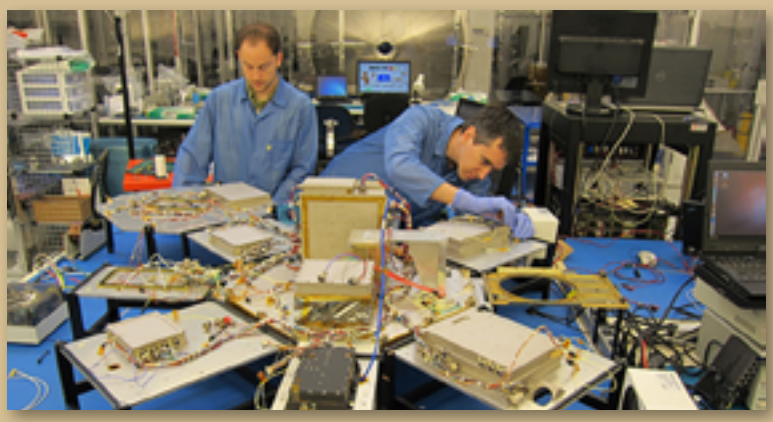
Navigation is provided by the GPS receivers, which SFL has adapted from terrestrial units to minimize cost and size. The data from the GPS units are then analyzed to determine the relative phases of reception among the formation flying satellites that in turn determine relative separation distances.

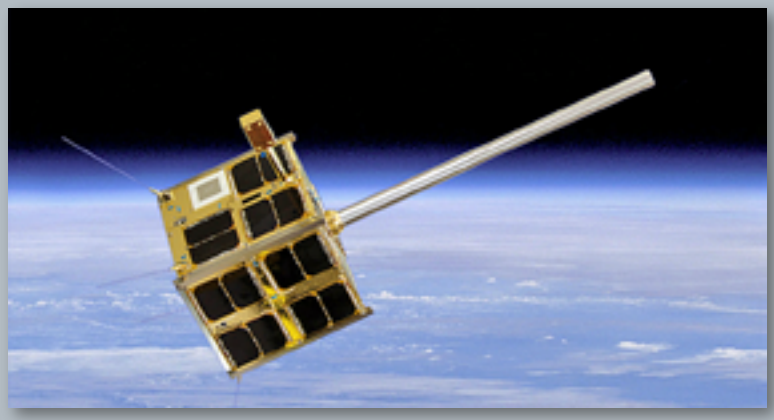
The GPS hardware and navigation algorithms determine relative position to within a few centimeters on orbit. With this information, the on-board formation control algorithms then actuate satellite propulsion systems to counteract orbital perturbations and control relative position in the chosen orbital configuration to sub-meter accuracy.

"*The satellites receive signals from the same GPS satellite but at slightly different times,*" said Zee. "*The phase difference between the signals is key to determining the baseline separation between the satellites.*"

CanX-4 and CanX-5 were particularly challenging, given their small 20x20x20 cm size. For the individual satellites to receive signals from the same GPS satellites, they had to mirror each other in orientation to point their GPS antennas in the same direction. SFL developed an extremely precise attitude control system for their nanosatellite buses, taking into account that thrusters can only be placed on one of the exterior surfaces of each satellite due to the spacecraft's small size. Thrust commands were coupled with the attitude and formation control systems to maintain orientation and position.

"*In operational formation flying missions, more thrusters and more GPS antennas would be used in order to enable the attitude control system to point instruments while in formation,*" said Zee, "*In many ways, the CanX-4 and CanX-5 mission was so challenging that the success has opened the door to much easier formation flying missions that would be implemented in practice.*"





SFL has developed several different propulsion system technologies to maneuver satellites in orbit. For the CanX-4/-5 mission, cold gas was used for the sake of simplicity; however, SFL has developed warm gas, monopropulsion and cylindrical Hall thruster systems for smallsat missions that require higher efficiencies and longer durations in orbit.

Critical for the control algorithms to operate in a coordinated fashion is the inter-satellite communications link. The CanX-4 and CanX-5 satellites carried S-band radios that shared data, most importantly their attitude and GPS location information. The sharing of information is a key enabler that allowed the satellites to stay in a precisely controlled formation.

"*The control algorithms on the CanX-4 and CanX-5 satellites are identical, giving each the ability to assume the role of chief or deputy,*" said Zee. "*The deputy controls its position relative to the chief. In the case of more than two satellites, there would be multiple deputies all controlling their positions relative to the chief. Having identical satellites allows the roles of the satellites to be swapped if necessary to provide for maximum flexibility, redundancy and lifetime. This illustrates the benefits of formation flight which include satellite redundancy and graceful degradation.*"

For CanX-4/CanX-5, onboard radios receive commands from the SFL ground station in Toronto to move the satellites into specific configurations, but once there, the satellites maintain formations on their own. Most operational formation missions are likely to use only one particular configuration depending on the mission applications, but the formations can change in flight.

What's Next for Formation Flying

SFL believes autonomous formation flying will become a mainstay capability for the majority of smallsat constellations in the near future, primarily because the affordability of the technology now makes many multi-satellite missions financially viable that simply were not so in the past, especially in the commercial sector.

There is strength in numbers. Individual satellites in a constellation can fail or be replaced, often without mission degradation, and the constellation itself can be upgraded incrementally over time with new additions. Large clusters of multiple satellites are also difficult to jam from the ground, and hence provide electronic protection against denial of service threats.

"*Affordable formation flying satellites are now a reality because of the pioneering work of SFL,*" Zee said. "*By following a true microspace approach that leverages miniaturization, modern component performance, and low cost without sacrificing quality, formation flying technology is now available for worldwide commercial applications. We are excited about the future possibilities.*"

www.utias-sfl.net/

Kevin Corbley is the President of Corbley Communications Inc. in Castle Rock, Colorado ,USA. For nearly 25 years, his firm has provided business development and communications services to geospatial, aerospace, energy and big data organizations. Corbley served as public relations manager for EOSAT, the commercial Landsat operator, and worked as a journalist in Washington, D.C. He holds a B.S. in Geology from the University of Notre Dame.
(***www.corbleycommunications.com***)

Innovation: There's Something Fishy Going On in Norway

A Bridge Technologies Focus

by Simen Frostad, Chaiman, Bridge Technologies

It's not just TV networks that benefit from monitoring to ensure the delivery of high quality images: Norway's aquaculture industry benefits from it too.

If healthy eating is of interest, then the chances are that omega-3 is a supplement under consideration for consumption. Extensive research has confirmed that omega-3 is extremely beneficial for the human heart and circulation system.

The main source of omega-3 is oily fish — and one fish in particular. As people focus increasingly on their diet, the last few years has seen the sales of salmon rapidly increase. That's been good news for Norway — that nation is the world's biggest producer of Atlantic salmon and the second largest seafood exporter in the world.

Last year, the country exported — to 130 countries — two million tons of seafood worth NOK74.3 billion (8.1 billion euros). That included 800,000 tons of salmon valued at NOK49.2 billion (5 billion euros) — up 29 percent over the previous year. When noting Norwegian exports, aquaculture is second only to oil and gas.

Norway's pre-eminence in this market segment is a function of the nation's environmental suitability. Norway has a long (80,000 kilometer) jagged coastline and the resulting fjords creating an ideal combination of almost limitless, pure, clear, cold sea water — in relatively sheltered and accessible conditions.

As well as providing a livelihood for an estimated 21,000 Norwegians, there is a lot of money at stake in aquaculture — especially in farming salmon. Aquaculture is also a sensitive environmental issue. It's unsurprising, therefore, that the industry has been quick to implement technologies that can make salmon farming more efficient and to maximize return on investment, all the while attempting to make the industry more acceptable to environmentalists.

Perhaps the biggest single threat to the industry are the sea lice which can infest the salmon and cause the premature death of young fish. Here, 'skirts' within the nets have been developed to shelter the salmon from the lice. Remotely operated vehicles are deployed for inspection of the nets within which the salmon are maintained — any damage can allow fish to escape, with catastrophic financial (and environmental) results. Acoustic deterrents are used to keep the predators away from the fish.

One company looking for technology solutions was Linga Laks (trans: Linga Salmon). Founded in 1978 by Rolv and Åsta Haugarvoll with an initial stock of 5,000 fish, the company now farms 2.5 million salmon each year, creating 11,000 tons of gutted fish and a turnover of NOK600 million (650,000 euros) at Hardangerfjord where 40 people are employed.

Key Challenge

One of the key challenges in salmon farming is the feeding of the fish, which is a 24/7 process. In an enterprise the size of Linga Laks, feeding is carried out automatically by a series of tubes. Feed too little, and the salmon won't grow as quickly as they should. Feed too much, and the water beneath the farm quickly becomes polluted, not to mention the waste of money.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Salmon monitoring screens.

How to discover the correct amount of food to deliver to the salmon? The answer is video cameras, placed around each net, that are trained on the fish. An observer watches the salmon's behavior to assess their level of interest in eating. However, in the rocky, mountainous terrain that is characteristic of Norway's coastline, getting those video images from the nets to the control room is a challenge.

Linga Laks turned to Bridge Technologies' long-time customer, Steinar Foss Andersen, the founder of KvamNet. KvamNet was originally established to bring a modern, high speed communications infrastructure to the local community, delivering TV programming and Internet access. Over a number of years, the network has been developed to provide fiber optic communications to many homes in the area. Where such is impracticable, homes are served by a network of around 20 antenna masts.

What Linga Laks needed was a way of taking the video output from the cameras installed at some eight net locations and to then deliver that video to the surveillance monitors at the company's headquarters some 30 to 40 kilometers away. A key design consideration was that the cameras had to transmit images of high quality, essential if the interaction of the salmon with the feed is to be accurately observed, as well as to be able to precisely determine the condition of the nets. This meant creating a network capable of high bandwidths: with each camera transmitting at 100 Megabytes/second, the ultimate link to Linga Laks HQ needed to be capable of Gigabyte speeds.

Working with long time supplier Ubiquiti Networks, Steinar devised a solution that combined wireless communications from the camera servers into a single Gigabyte link to the Linga Laks control room, taking advantage of the existing network infrastructure.

High Quality Images

While the available bandwidth is certainly sufficient to deliver the high quality images necessary, Linga Laks also benefits from KvamNet's implementation of a Bridge Technologies network analysis solution.

Playing a key role in the management of KvamNet is the Bridge VB288 Objective QoE Content Extractor, which performs objective video and audio monitoring of MPEG-2, H.264/MPEG-4 and H.265/HEVC streams and offers a unique web browser-based remote video-wall capability providing full visual status from any location. This means that Steinar can view the performance of the entire network, know exactly what's going on and quickly identify potential problems from his office or wherever he may be located.

The VB288 is complemented by a number of Bridge microVB network analyzers — soon to be further augmented — and a number of VB1 Series probes, which are still delivering reliable performance almost a decade after they were initially installed.

The Bridge solution was primarily installed to ensure that the TV pictures being received by domestic customers were of the required quality; however, this solution also ensures that the images the Linga Laks observers receive are of a high enough quality to deliver information that can cause any appropriate remedial action to be undertaken quickly.

Linga Laks are delighted with the solution KvamNet designed for them — and it's caught the attention of other salmon farms in the area, with whom Steinar is now in discussion.

Normally, the business at Bridge Technologies is about improving the health of media networks. On this occasion, it's true to say the company is making a small, yet highly noticeable, contribution to the health of the world.

www.bridgetech.tv/

Simen K. Frostad is Chairman and co-founder of Bridge Technologies. With 22 years of industry experience, Simen founded Bridge Technologies in 2004, after creating the world's first IP/MPLS contribution network for Scandinavian sports coverage. Simen had previously built the first multi-camera hard disk recording system for episodic drama production in 1998, and the first nonlinear sports editing facility during the 1994 Winter Olympics.


Panoramic view of Norwegian salmon farm.

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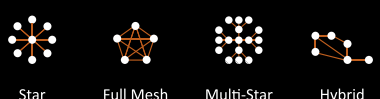

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The Evolution of Uplink Amplifier Technology

A SpacePath Perspective

by Newton Burnett, Chief Technical Officer and Co-Founder, Spacepath

To quote a slogan that has been effectively adopted by the UK Export Trade body, "Technology is great."

Telecommunications play a significant role in social and political relationships as well as in the economic growth of nations. The rate of technology change is exponential — the human desire to distribute and consume information increases proportionally with the technology that enables services at affordable prices. The world's desire continues to grow for information and entertainment content delivery.

The SATCOM industry provides essential industrial infrastructure to feed the need for global data consumption. The demand for greater bandwidth and lower cost services has fueled significant changes in technology for the SATCOM industry. The industry has innovated and improved on the efficiency of modulation and coding of information. That has resulted in higher density and greater bandwidth RF signals for transmission via SATCOM systems. The industry has also improved the capacity efficiency of satellites, flooding the market with available bandwidth and driving the need for greater power and bandwidth transmitters within the SATCOM network. The SATCOM high power amplifier market has also significantly evolved over the last three decades, with the appetite for increased transmitted power, bandwidth and efficiency driving this service expansion.

Indoor klystron and traveling wave tube (TWT) based amplifiers fulfilled the need for SATCOM systems in the 1980s. The application of TWT amplifiers in outdoor formats significantly changed the landscape of SATCOM systems in the 1990s.

The growth of technology in GaS and GaN devices made significant impacts in the market in the 2000s. Early devices had clear limitations with respect to frequency and power. Higher power solid state amplifiers were designed by banking up multiple power modules, meeting the overall output power specifications, but these amplifier designs were big and very inefficient compared to TWT technology.

Solid state amplifier product appeal on the outset looks far more sexy than TWT technology and, unless further investigation into the performance and specifications of that technology, users may not change their minds. The real truth is that there is room for both technologies in today's SATCOM market — the selection of which technology to select will depend on power, frequency, size and efficiency decisions.

The klystron power amplifiers (KPA) were robust high power solutions for SATCOM up-linking systems in the 1980s and the 1990s. The devices achieved high powers with multiple channel narrow band tuning of 40 to 80 MHz. These amplifiers served the purpose of powering complex, multiplexed, combined systems, which required the high power of a klystron to overcome the system losses.

In the late 1990s, the klystron witnessed an evolutionary change as size was decreased by 50 percent with the application of operation and power control technology. The introduction of the one-half height KPA made a market impact thanks to significant improvements in operational expenses such as power consumption and HVAC demand.

The improvement in Size, Weight and Power (SWaP) performance changed the KPA market; however, the timing was too late — the advent and application of the outdoor TWTA changed the game and amplifiers of 750W power level, introduced at C-, Ku-and DBS-band, made this a short-lived solution. The KPA products are nearly obsolete in the market today. The KPA market has devolved into the maintenance and support of legacy equipment.

In the 1990s, many changes were introduced to the TWTA market. The application of conduction cooled TWTs vs. traditional forced air cooled TWTs was applied to indoor products in the industry. This was followed by the first outdoor SATCOM power amplifiers, which were then followed by more available TWTs in broader bands and high power levels in C-, Ku-, DBS- and Ka-band.

The TWT is often viewed as an old and obsolete technology because of the use of vacuum tube technology. Mention vacuum tube to anyone unfamiliar with a TWT and they often think of the old glass tubes used in the first radios and televisions, old and obsolete, yet still produced. TWT technology is alive and thriving along with many vacuum tube technologies.

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These are the workhorses of RF power conversion devices that have yet to become obsolete by solid state technology. The TWT is the most efficient broadband RF power conversion technology available for high power amplifier applications

Solid state technology has made significant impacts with improved power and efficiency. GaN technology has made important improvements in solid state RF power conversion devices. They are more thermally robust and offer increased RF power conversion over standard GaS devices.

Application of GaN technology has been great for providing alternate cost effective solutions at low frequencies. As the device manufacturers continue to evolve product technology, the power and performance at higher frequencies continues to improve.

C- and Ku-band GaN devices make for cost-effective solutions for low and medium power amplifiers. At higher frequencies, such as Ka-band, GaN technology improvements have enabled low cost, entry level products to be widely adopted. As further improvements are made in device design, output powers will increase.

Traveling wave tubes are robust, broad band RF power conversion devices. The TWT can achieve greater than 1 octave bandwidth and can easily be optimized for telecommunication applications with 20 percent bandwidth. The RF conversion efficiency can exceed 50 percent. There is no other technology of RF conversion device used in SATCOM applications that can achieve this performance. Efficiency drives power consumption, which in turn drives the size and the weight of an amplifier. The more efficient the RF conversion device, the less prime power and thermal power dissipation are required to operate the amplifier, which can lead to reduced size and weight.

Modern SATCOM TWTs are designed and tuned to optimize power consumption. These are operated in what is known as a "peak" mode. This means that a CW RF signal can be applied to operate within the entire linear operating range of the TWT. The TWT is tuned for efficiency and, when integrated into an amplifier, a limiter is used to prevent operating at power levels greater than linear. This allows for highly improved RF conversion efficiencies, yielding lower power consumption and thermal power dissipation. This technology enables the application of other lesser but important technologies to help reduce the size and weight of amplifiers.

Each technology visited — klystron, solid state and traveling wave tube — has evolved with the ever-increasing demand for additional communications power amplifier solutions. Selecting the correct technology for the application is a matter of cost and performance.

There is an area of power performance in any SATCOM frequency band where each technology has cost advantages, as illustrated in ***Figure 1***, as well as an area of performance where the costs are equitable in the cross over region.

SATCOM amplifier technologies continue to evolve. Unfortunately, TWT manufacturers have not been quick to defend the advantages of their applied technology. Like all markets, SATCOM is also prone to fashion demands — the GaS and GaN device manufacturers have done an excellent job at promoting their technology, leaving the tube based amplifiers as unfairly being seen as yesterday's technology.

TWTA technology is alive, healthy and continues to evolve. Highly efficient TWTs, the inclusion of advanced materials, the application of modern electronics in power conversion and control systems, as well as refined design techniques, have all resulted in a TWTA product that is the perfect solution for SATCOM transmission systems. The SWaP performance of TWTAs is continuously improving for high power applications and is untouched by other SATCOM power amplifier technologies.

As a manufacturer, SpacePath uses both TWT and Solid State technology and designs amplifiers using the most appropriate technology for each application.

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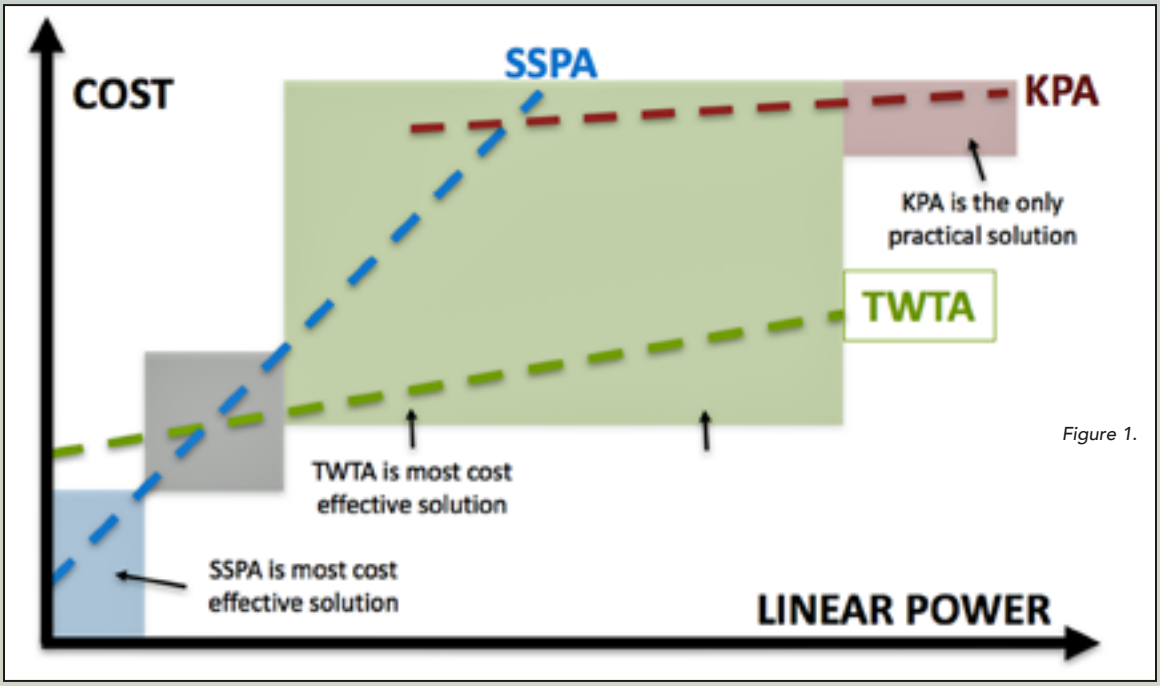

Figure 1.

Newton Burnet founded Powerlink, Europe's leading satellite amplifier repair and service company in 1994. During his time running the organization, Newton noted all types and makes of HPAs and SSPAs and built a wealth of experience and knowledge of uplink amplifiers — this background would prove invaluable in designing new amplifiers and sub-systems.

Prior to this, Newton held a number of engineering and manufacturing positions at EEV (now e2v). His track record and expertise provides SpacePath with a solid industry related engineering base and a strong focus on customer relationships.

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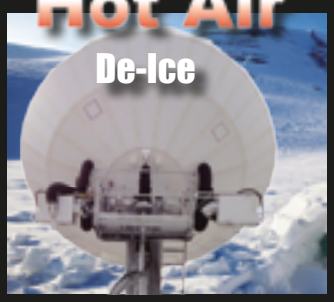

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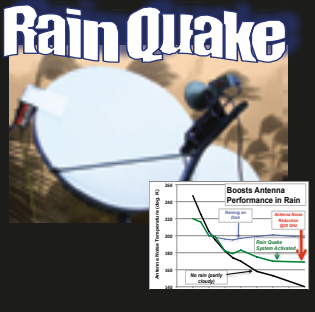

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Innovation: How Satellites Will Revolutionize 5G

An Arralis Perspective

by Mike Gleaves, Group CTO, Arralis

The next-generation of mobile communication, known as 5G, could easily be mistaken as a set standard that will shortly be introduced to offer even faster data and services to customers.

However, there is considerable confusion and uncertainty as to what the next-generation in mobile communications will actually be — while some frequencies have been allocated and a few trials have been completed, there is no set standard in the same way that 2G, 3G and 4G are understood. The next-generation will be an entirely new concept for digital communication in terms of frequencies, modulation and access. Most importantly, satellite services will play a significant — if not domineering — role and be for the masses, not just the business or specialist user.

Perhaps it is best to visualize the fact by imagining the following scenario: Starting with the future pocket digital terminal and moving from place to place, country to country and building to building, each communication medium will change and optimize according to use.

In the countryside, the data will be delivered from overhead satellites, thousands of them; moving into urban areas, then the portable device switch to local terrestrial access points (many fed by satellites). In buildings, whether at work or commercial, the mobile locks onto what is known today as Wi-Fi. Fly to another country and at the other end the data provider, perhaps Facebook, Google, SpaceX or even Boeing, instantly connects the pocket terminal to what is now a global network.

There will be no roaming, as the next-generation of service suppliers will own the satellites as well as the data — global, not parochial. All of this access will be automatic and there will be no need to log into different networks or enter new passwords. Anywhere in the world, there will be instant access to fast, uninterrupted service.

If this sounds like the Utopian dream for mobile networks, get prepared — this has to happen — subscribers will no longer tolerate poor service. Moreover, the 'Internet of Things (IoT)' will drive the need for more data in more places and more reliably; drop outs and poor signals have been suffered for too long by customers and at a high price.

This achievement will not be simple, which is why the progression to the magic 5G didn't happen as fast as it did from 3G to 4G, which was essentially a modification to the modulation techniques used. Multiple standards, very high data rates and global rather than national integration are needed.

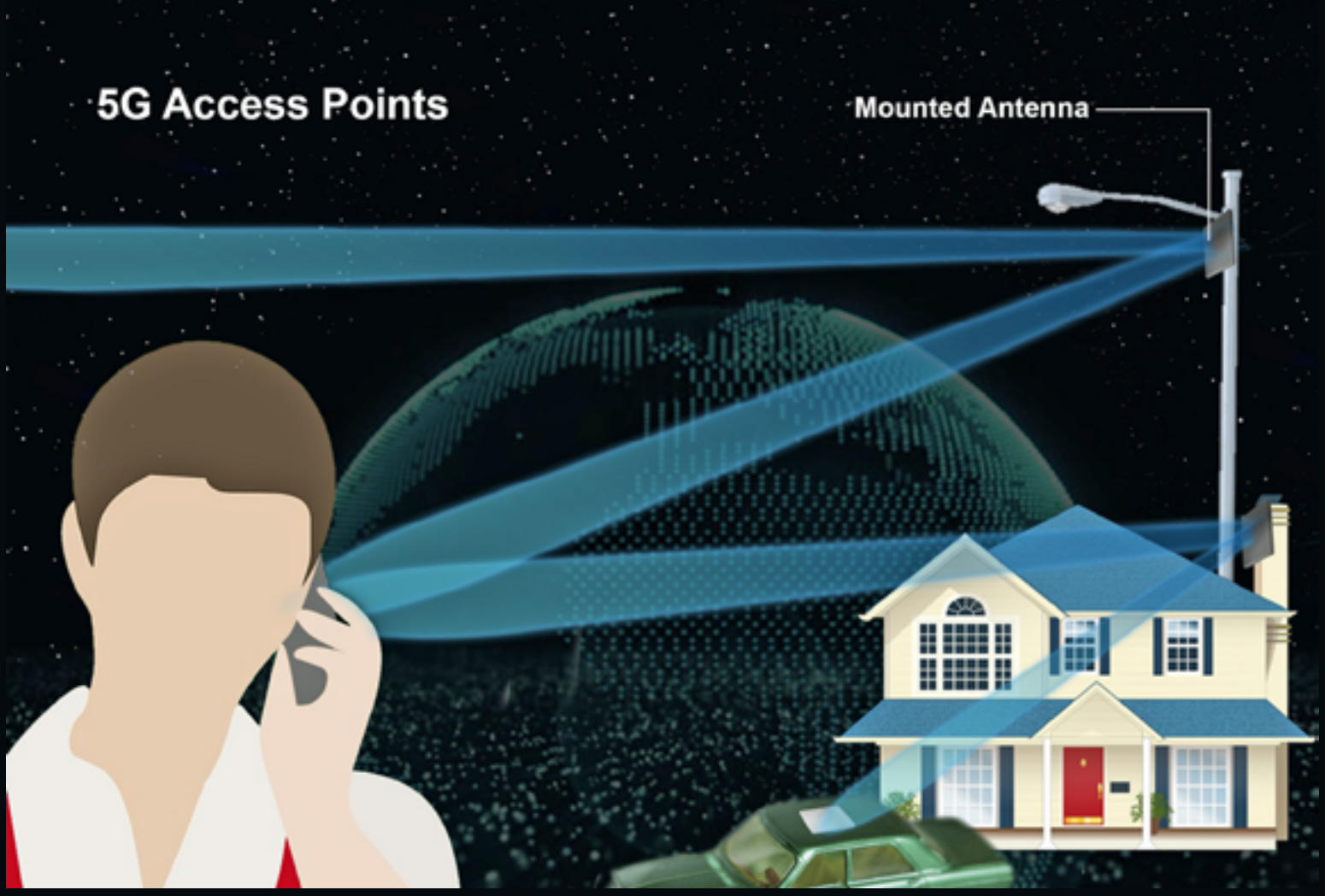

Figure 1. The next terrestrial infrastructure.

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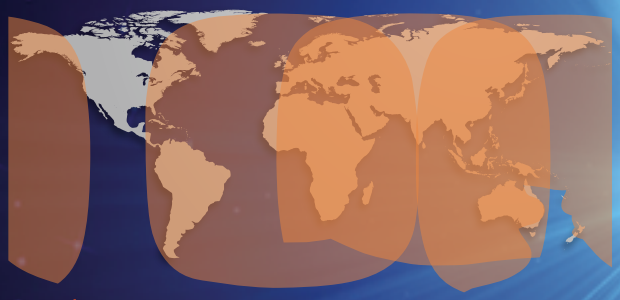

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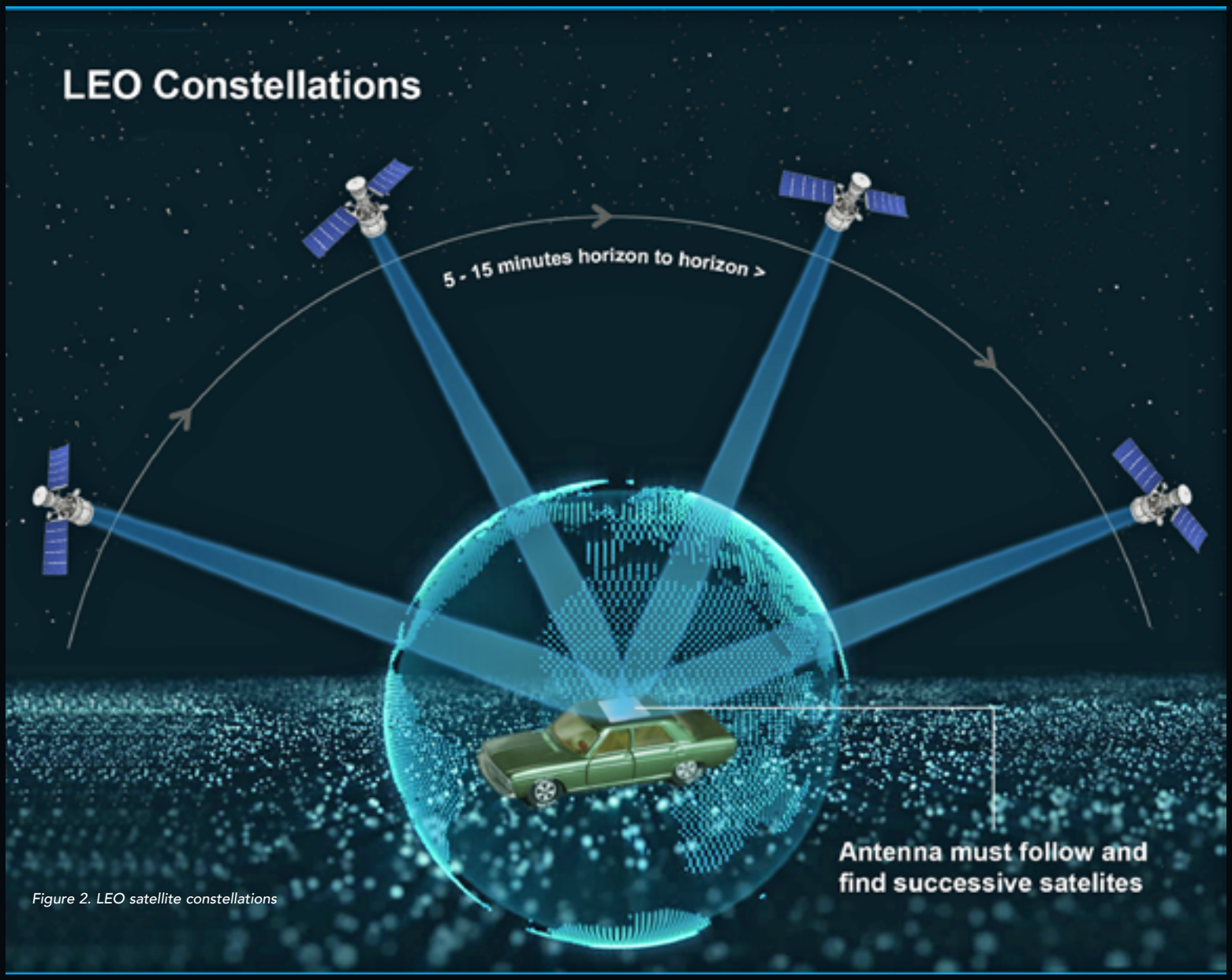

Figure 2. LEO satellite constellations

Certain nations, who restrict the content that their users can access, will be dreading this future development. To have such an integrated network, high data rate satellites, terrestrial access points and Wi-Fi terminals are needed. In addition, some serious technical challenges have to be overcome for the ground terminal to be available to everyone at an affordable price.

Bring on Millimeter Wave

The current terrestrial networks operate around 2 GHz (GSM 900 MHz) and have relatively narrow bandwidths that limit the best usable data rates to around 15 Mbs, although much higher rates are claimed; Wi-Fi is similar due to the bandwidth being shared with multiple users. Satellite data rates, mostly at Ku-band, are in the kHz range as anyone who has tried to use in-flight Wi-Fi knows all too well. Simply stated, if high data rates are needed, then wide bandwidths are an absolute must, all being adaptive (to the conditions) — modulation techniques will maximize this requirement.

At millimeter wave, and that could be considered as anything above 20 GHz in practical terms, the need is for new technology. Millimeter waves, because of their short wavelength (as the name suggests) tend to travel in straight lines, can use much smaller antennas, are subject to higher atmospheric attenuation and, most significantly, can possess much wider bandwidths. This seems obvious, but 10 percent bandwidth at 2 GHz is 200 MHz, at 28 GHz its 2.8 GHz. The straight-line property means beam steering antennas, the smaller aerial implies tiny base stations, the higher attenuation raises the requirement for multiple access points and the wide bandwidths will bring all super-fast data rates. Major infrastructure projects will be needed to facilitate this revolution in terms of satellite, terrestrial and Wi-Fi.

Changing Terrestrial Infrastructure

Current mobile base stations are situated on hilltops and buildings, have powerful transmitters and are linked together with high gain point to point links, known as backhaul. These are in the form of relatively high towers with large antennas and microwave dishes.

The generation of high power at millimeter wave is difficult, so the antenna towers will disappear and, in urban areas, be replaced with multiple and inconspicuous access points, which will be small, directional and interlinked by fiber. In rural areas, as at sea today, terrestrial access points, where installed, will be connected by satellite; however, more likely users will receive their data directly from the spacecraft themselves. (*See Figure 1 on the previous page.)*

Satellite is the Key

This is the most exciting and 'game changing' part of the 5G concept; masses of Low Earth Orbit (LEO) satellites will be launched in the coming decade that will

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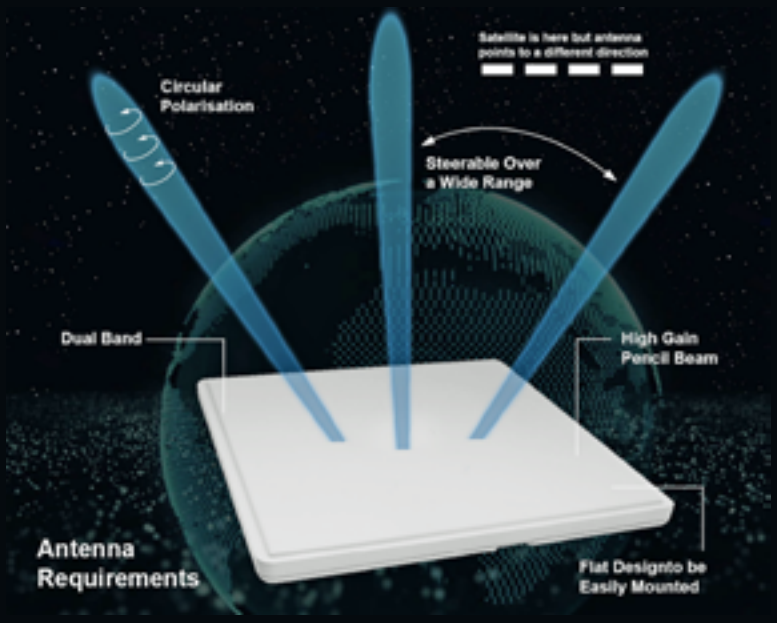

Figure 3 – The ground terminal antenna challenge

enable the vast majority of users to no longer receive a 'no signal' or 'E' on their handheld device — such messages will become a thing of the past.

These satellites will, more than likely, operate at Ka-band and with 500 MHz channel bandwidth, implying theoretical data rates of 2 Gbs or more. As stated previously, Ku-band satellites (~12 GHz) will not deliver the high data rates that will be required, V-band satellites (~45 GHz) will suffer high atmospheric absorption, meaning that Ka-band is probably going to be the best compromise for data delivery.

Currently, there are a few Ka-band satellite services, such as Viasat and Inmarsat (Global Express), but these are GEO services with relatively low data throughput and they suffer from high degrees of latency due to their distance from the Earth. Numerous organizations have proposed LEO constellations such as OneWeb, SpaceX, Google, Samsung as well as some several lesser known firms. Most are Ka-band, although OneWeb has a significant number of Ku-band proposals, and Space X recently applied for additional V-band services.

As stated above, the advantage with LEO services is their low latency due to their distance from the Earth; the disadvantage is that to provide a mass market service with the further complication that they only remain in view for approximately ten minutes or so, means thousands of these satellites will be required to maintain communications.

Satellite Enabling Technologies

How will so many satellites be launched in time to provide a global service? This is a subject of much discussion and beyond the scope of this article. However, that is the main driver of SpaceX and Virgin Galactic.

What is required, though, is some sophisticated antenna technology that can follow the satellite across the sky, irrespective of user movement, with automatic hand-over to the next satellite as the signal fades. This will require retrodirective technology, an antenna that can receive from all directions simultaneously and then point and retransmit back in the direction of one or more signals.

If the antenna is mounted on a moving vehicle as it twists and turns, goes up and downhill, this becomes a formidable task. For such dynamic antenna performance, solid state is probably the only answer and the antenna would need to be flat or slightly curved to be mountable on vehicles and aircraft.

Currently, no such commercially available antenna exists, although there are some trials underway. As these satellites will be only visible for, say, ten minutes or so and appear no more than a few times per day, as stated, thousands will be required in order to maintain the very high data rates on the ground that would be required.

A slightly easier task, but no less expensive to develop, is a complete chipset with high speed Gigabit modem that operates at Ka-band, 17-21 GHz for the downlink and 27-31 GHz for the uplink. This is a serious and difficult technical challenge for satellite terminal builders

Other Considerations

The FCC recently introduced a range of frequencies that would be available for 5G use. The most likely of these frequencies to be used is at 28 GHz. For terrestrial devices operating at this frequency, access points can be fairly widespread and beam steering arrays highly achievable once decent semiconductor phase shifters become widely available. The handset will need to be capable of MIMO performance, meaning that the unit can receive, error correct and process signals from multiple access points, thereby ensuring very high data rates.

For Wi-Fi, much talk has been given to so-called WiGig; this operates at around 60 GHz and is capable of, in theory, Gbit data rates. Point-to-point chipsets at this frequency are widely available and this is perhaps the most realizable of the 5G enhancements; however, 60 GHz suffers from the worst possible atmospheric attenuation — that means a typical house may require one Wi-Fi box per room. In addition, as 5G access points will be so widely spread around urban areas and inside buildings and shopping malls, it could be argued that Wi-Fi will eventually disappear, being one standard too many; for example, who remembers CT2?

Satellite Rules

Apple revolutionized the mobile market when the company introduced their first iPhone; suddenly, the screen and look became more important than the performance of the phone. 5G will mean that high resolution touch screens are old hat — the radio features of the device will once again take precedence.

The most important, and probably most expensive and desirable phones, will be satellite enabled. Satellite technology means that new global mobile players will enter the market; this calls for rapid and quite difficult technological developments in flat retrodirective antennas, high speed modems and phased array chipsets. The best revenue streams will come from selling the data — the people who will build the satellites, such as SpaceX, will then also market data services globally.

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Mike Gleaves is Chief Technical Officer at Arralis Limited, a company he co-founded and built to become a major player in the latest satellite technology. He was a contributory member of one of the original ETSI GSM standards committees and has held various senior positions in microwave and radio manufacturing and service companies. He holds a BA in electronic systems and an MBA in International Business Development.

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Innovation: Optical Communications Ground Network

A BridgeSat Perspective

by Joseph Campagna, Senior Vice President, Operations, BridgeSat Inc.

BridgeSat has broken ground on a global Optical Communications Ground Network (OCGN) that is ideally suited to meet the needs of upcoming LEO satellite operators.

The OCGN consists of multiple Optical Ground Stations (OGS) that are remotely monitored and controlled from BridgeSat's Network Operations Center (NOC) and connected through a network/cloud domain to the satellite operators. BridgeSat is working in partnership with Swedish Space Corporation (SSC) and a host of leading suppliers to develop this network in time for Final Operational Capability (FOC) in early 2019.

BridgeSat's OCGN was initially sized to meet the needs of LEO Earth Observations satellites that generate more data than can be downlinked, due to power limitations, a general paucity of available (RF) spectrum, variable pass durations and limited access to ground stations. Currently, 27 percent of smallsat Earth Observation (EO) missions generate more data than they are able to downlink and this problem is only going to get worse, according to a study by Northern Sky Research.

RF systems only offer data rates in the Mbps, while optical comm systems offer data rates of 10 Gbps or higher. For smallsat operators looking to deploy EO or sensing missions, this improved capability offers the potential to downlink all of their data generated on orbit, without on-board compression or complex priority tasking. However, ground station site diversity is essential for optical communications to be a viable operational system, which is the inspiration for the BridgeSat OCGN.

The BridgeSat OCGN is structured around a minimum of ten Optical Ground Stations (OGS) that are strategically located in secure, low cloud, high elevation sites around the world with good access to terrestrial data lines. These sites use spatial diversity with high latitude and equatorial locations to provide maximum availability for both ISS and polar orbiting spacecraft's.

Each Optical Ground Station (OGS) provides the ability to receive data from a LEO satellite with a laser communications terminal that provides up to 10 Gbps data rate. This ground network consists of:

- *Optical Ground Stations (OGS) that support 1550 nm wavelength optical communications with a half meter diameter aperture telescope*
- *Ground infrastructure at ten sites around that world that will host the optical ground stations, including the SSC sites*

An artisitc rendition of the completed BridgeSat Optical Ground Station in Kiruna, Sweden. Image is courtesy of BridgeSat.

Ground Breaking at BridgeSat Sites in Australia and Sweden. Photo is courtesy of BridgeSat.

- *A data modem designed to handle downlink data rates of up to 10Gbps from satellites that host a compatible laser communications terminal, including an Advanced Optical Link Protection (AOLP) system designed to minimize atmospheric effects.*
- *A data cache storage and management system that receives the data downlinked from satellites through an Ethernet stream protocol, and provides the data line connection.*
- *A Network Operations Center (NOC) that will remotely monitor and control the optical ground stations*
- *A scheduler engine that creates validated, de-conflicted, optimized schedules for any type of tasks, resources and physical or virtual constraints.*
- *A BridgeSat scheduler application programming interface (API) will be used to integrate scheduler with other subsystems via a proprietary Weather Interface Module, Data Buffer Interface Module, Laser Deconfliction Module and Automation Module.*
- *A network/cloud domain that utilizes a Ground Terminal Server (GTS) with the Aspera client software, which will be scheduled with inputs from the Resource Management Server (RMS) and transfers data to Amazon Web Service (AWS).*
- *Web and app-based interfaces that will be delivered to BridgeSat's customers and provides status of their satellite's operational state, buffer utilization, transfer rates and downlink history and metrics (start time, stop time, data transferred, completion time, and average data rates).*

BridgeSat's first major milestones were completed this summer with the ground hardware and software design reviews, as well as ground breaking at the initial sites. The first OGS installation is underway at the first site high in the Sierra Nevada Mountains of California.

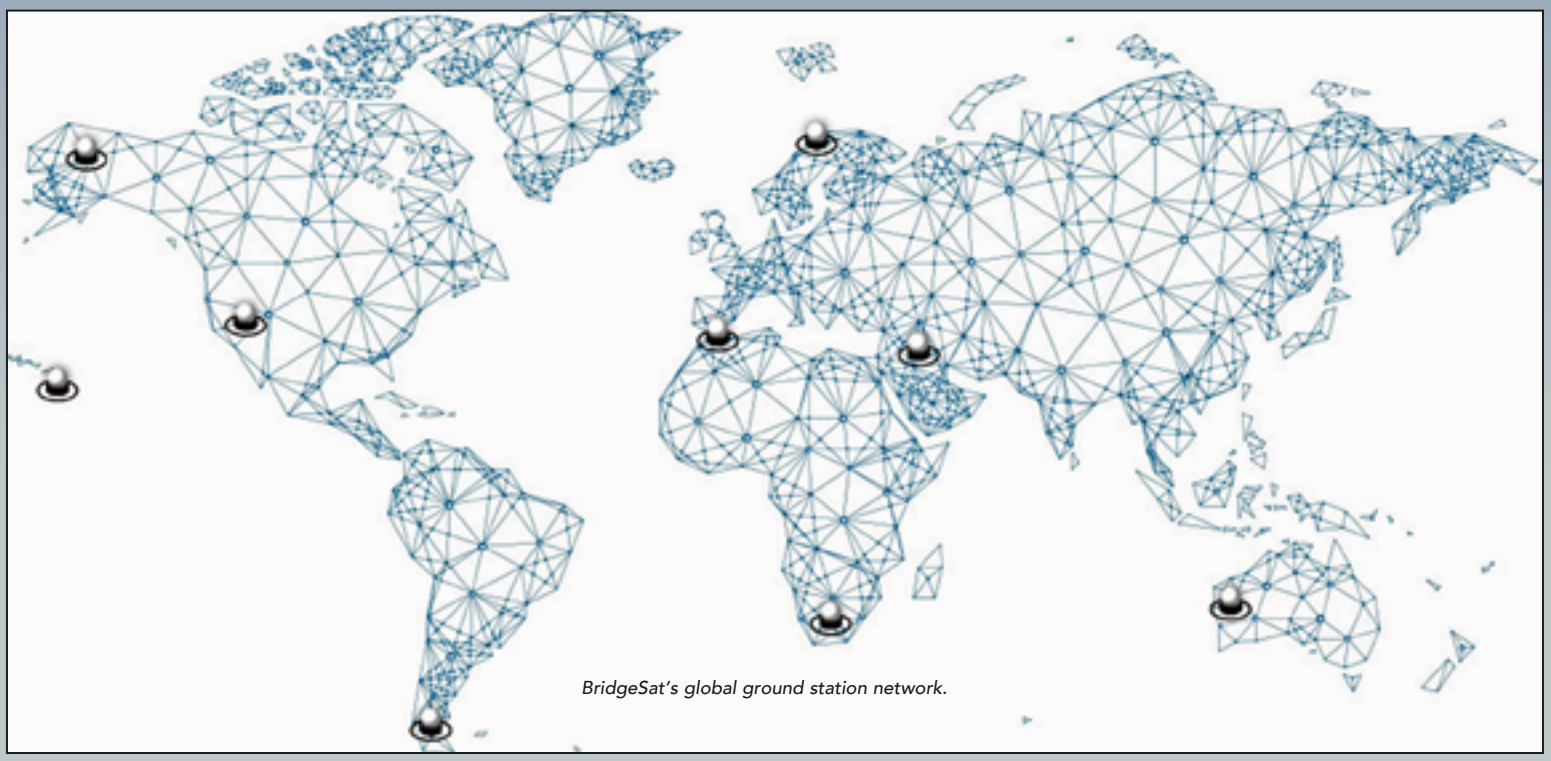
The next major milestone is to complete a satellite-to-ground-to-cloud storage end-to-end test, which is scheduled for late 2017. This network is planned to be operational in time to support satellite missions launching in 2018.

When Final Operational Capability is achieved in 2019, this network is expected to provide a minimum of 2 TB of data downlink per day for satellites in a LEO polar orbit, with much more capability believed to be possible. From there, BridgeSat aims to deploy continual ground network expansion and upgrades that will allow much higher data downlink capabilities over time, as demand dictates.

www.bridgesatinc.com/

Joseph joined BridgeSat in 2016 with more than 25 years of experience in Commercial and DoD satellite operations, ground system engineering and remote terminal construction. Prior to BridgeSat he led Global Ground Systems as CEO and Chief Engineer, focusing on ground system design and systems analysis for both commercial and classified DoD customers. Before that, he was the Director of Ground Systems Engineering at Orbital Sciences, overseeing ground systems, program management, design and installation and long term support for GEO & LEO missions.

Joseph was a key member of the initial operations team for the Iridium Satellite Constellation and also served in the USAF specializing in operations and intelligence. Joseph holds Bachelor's Degree from University of Maryland in Aerospace Engineering Management and a Leadership Certificate from University of Virginia Darden School of Business.



BridgeSat's global ground station network.

The Future: Where Do Independent Teleports Fit In?

An STN Perspective

by Tomaz Lovsin, Chief Technical Officer, STN

This is an era where rapid technological advancements are witnessed on an almost daily basis, a constant cycle of evolution in every part of our technological lives.

The satellite, teleport and broadcasting industries are no exception to these changes and this article takes a closer look at how they are affecting the industry.

First, take a look at the broadcasting segment and take a step back in time to the very beginnings of television, when TV was rather blandly defined as "*radio with pictures*." The viewing area was extremely small and the monochrome lines were hardly what one might call visually overwhelming.

As screens became larger and color was introduced, television claimed to be a visual medium. Fast forward 50 years and the question is now asked, "Why HD? Where is the market?"

HDTV represented a significant leap forward for the industry. HDTV was a technological milestone, no matter that such took more than 30 years, from original development to actual implementation.

Teleport to today (couldn't resist that choice of words). Yet again, all stand on the precipice of a visual (r)evolution. The questions that were asked in the past are exactly the same questions that are posed today — "*So, why UHD? Where is the market*?"

There is an old adage that the past tends to repeat itself. This certainly seems to hold true for the broadcasting industry. Forget the 3D fiasco of the past, as any of the broadcasting fairs that can be attended can attest to that technology as a passing fancy. Fortunately, most of the issues that held back 3D are not applicable or do not impact UHD.

Leaving the evolving UHD aside for now, what opportunities await an independent teleport in regard to High Throughput Satellites (HTS). For mobile operators who are already exploiting traditional satellites for expanding or accelerating their 3G/4G network, HTS brings more bandwidth at a fraction of a cost of a traditional satellite.

However, after sitting on a number of panels and listening to various discussions by satellite fleet operators, this author has a feeling that the trend being witnessed is to establish their own gateways. In the best case scenario, an independent teleport can hope to simply host their equipment. Of course, at the end of the day, it does not matter who purchases the hardware, but at the same time, the entire concept diminishes the importance of an independent teleport in this game by excluding any active services that an independent teleport usually provides.

Requests to provide 1 Gbps of direct public Internet access to one or two tier 1 ISPs and to host third party equipment is hardly worth the combined engineering skills that an independent teleport has access to and can accommodate.

Moving on to the advancements in modulation schemes, the appearance is that traditional broadcasting services remain stuck between DVB-S QPSK and DVB-S2 8PSK standards. This makes sense, as traditional broadcasting is quite limited by the decoders that the end viewers are using.

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What remains to be seen is whether the migration to UHD and the accompanying h.265 encoding standard will "force" the viewers to switch to higher-order modulation schemes — the notion that such availability might become a show stopper is rife with skepticism.

Yet, look at the data segment — the advancements there are substantial. Today, the bits per megahertz ratio has increased drastically. By using the DVB-S2X standard along with the higher order modulation schemes, such as 64 or 128 or even 256APSK, the data rates can reach and even exceed 400 Mbit/s per transponder. Operators can additionally lower satellite costs by using carrier-in-carrier modes of transmission by combining the forward and return transmissions in the same satellite bandwidth.

Moving onto the teleport segment, one could easily be misled into thinking that this is the most "static" one of the three environments. The traditional Earth station antennas with their associated transmission equipment remain the same, correct?

Well, not exactly. While an Earth station antenna still looks pretty much the same as it did before the world moved on, there have been advancements in this area, as well. By simply running out of traditional Ku-band frequencies and moving to the higher frequency range of Ka-band, the antenna manufactures have had to refine their production lines as extreme reflector and feed precision are required.

An example of how to tackle the issues that come with transmitting in Ka-band is with sub-reflector tracking. At STN, this solution for Ka-band has been successfully used (it really makes no sense to have it installed on Ku-band antennas) for the last four years and its usefulness can certainly be verified.

SRT (Sub-Reflector Tracking) provides reduced mechanical wear and increases reliability on the one hand, and on the other also provides for thermal beam steering — that reduces thermal defocusing — effectively killing two birds with one stone (no actual birds were harmed in the process).

STN has also witnessed an increase in TWTA (Travel Wave Tube Amplifier) output powers. While 750 watt TWTA's used to be the most powerful HPAs (High Power Amplifier) on the market, for Ku-/DBS-bands today that power has doubled (or more) to 1500 or 2000 watts. The same is true for Ka-band, where 100 watts was initially the maximum, yet today, 500 watts is widely available.

Why is higher power needed? The days of 32 meter antennas are an element of the past and adverse weather conditions are becoming more frequent than ever before experienced. If this trend continues to worsen, more technical enhancements will be required in this field.

There is another opportunity for teleports to expand their offerings and their services. Though not directly related to satellites, Over-The-Top (OTT) services can certainly complement the services of a traditional broadcast teleport. While satellite is associated with linear broadcast, today's viewers expect to be able to watch their favorite shows, movies or events whenever it suits them and not just when the program airs. The viewer has become the final editor and is no longer bound to linear television schedules or traditional TV screens.

While OTT brings new commercial opportunities, it also comes with a few new technicalities that were not needed by traditional teleports. However, the novelties are not drastic and, if a teleport has a team of good and out-of-the-box thinking engineers, it is certainly not a problem to incorporate and add OTT in its portfolio of services.

Delivering media content over the Internet requires huge bandwidth capacities. Fortunately, the headend can be in the teleports hands while the edge servers and infrastructure can be rented from various content delivery network (CDN) providers. The synergy in analogous to the "teleport/satellite owner" relationship.

All of the above briefly describes a few (but far from all) technological advancements in three closely related and bound industries, but there are also some existing and potential technical challenges ahead.

A traditional broadcast infrastructure, based around coaxial cables and the HD-SDI interface, is slowly in demise — a teleport that uses this existing infrastructure will probably not be able to carry UHD, unless the cabling has been recently upgraded.

Moving into the IP domain makes much more sense. However, UHD cannot be accommodated by 10 Gbps Ethernet, and 40 Gbps ports are still too expensive for mass adoption. The question is whether content could be lightly compressed in order to fit in a single 10 Gbps cable. While solutions do exist to tackle this problem, it is still too early to go all-IP, unless the challenge of becoming a pioneer in this field and all the dangers that go with it is accepted by the implementer.

At STN, a live UHD transmission encoded in h.265 using a software-based, GPU-accelerated real-time video and audio high performance encoding solution has been performed and… it worked. The market for UHD is not yet there, apart from a premium channel here and there for major DTH platforms such as SKY or DirecTV as well as a number of test channels. At the moment, 4K over satellite is more a matter of prestige than anything else.

One element is certain — technological advancements will not stop. In fact, quite the opposite — these advancements will arrive faster and faster. Eventually, when the Ka-band becomes saturated, the satellite industry will have no option but to expand to Q- and V-bands and teleports will follow suit.

With ever higher frequencies, hardware vendors will need to adjust to the increasing precision-demanding production processes. Unless the need for satellite communication will cease to exist — the "satellite will die" comments have been listened to for the past 10 years or more — clearly, that has not occurred. In fact, the opposite has happened, and ever more demand for satellite capacity is being witnessed.

While the traditional broadcast market may be generally saturated, there are still many regions that are only now starting the transition to HD, plus the Internet of Things (IoT) is only in its infancy. That, combined with the ever increasing demand for more and more bandwidth in mobility and other areas of communication, assure all — especially the industry — that the satellite is far from extinction.

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SatBroadcasting™: Encoder Enhancement Eases DVB-S2 Switch Over

A 2wcom Case in Point

by Anke Schneider, Sales PR & Marketing, 2wcom Systems GmbH, and Frédéric Bourgeais, Technical Director, SAS Radiou Alouette

In 2017, satellite transmissions are undergoing a monumental change — the switch over to the DVB-S2 standard — the technology is more open and is designed to be interoperable with all of the current and future media protocols, no matter if satellite-based or IP-based — and 2wcom is working to ensure such switch overs are accomplished with aplomb.

One example is Alouette that is based in Herbiers, Vendée, France. Since 1981, Alouette has become a leader in regional radio in France and also happens to be the largest and most popular broadcaster in the western region of that nation. Operating 43 of their own frequencies, Alouette now covers 15 local departments. The key to their success is their regional focus and closeness to their listeners. Alouette is known for a wide variety of popular formats and the use of cutting-edge technology.

Alouette quickly expanded into becoming a genuine, regional network. The company President, Bertrand de Villiers, has given the radio network a unique, local, musical style.

Since 1996, Alouette has been managing their own MCPC satellite uplink with their partner in the space segment, Globecast — Eutelsat. That is the main reason why the company is not participating in the NSTR project for the change over to DVB-S2 standard, which is a merger of several French broadcasters using a common satellite uplink.

Nevertheless, the technical team of engineers had been interested why the NSTR project team had selected a system solution from 2wcom. The positive feedback from the NSTR team, in combination with the visit of Werner Drews (CEO of 2wcom) in the summer of 2016, as well as a highly competitive bid, were the main reasons why the DVB-S2 project team of Alouette decided to work with 2wcom.

The system operators of Alouette quickly realized that the professional and high-quality products of 2wcom were keeping pace with the needs of a strong, regional orientated, broadcaster. As a further stroke of good luck, 2wcom had just completed the design of their own eight channel audio MPEG encoder — MM08E. The main differences Alouette noted between this encoder and the devices from alternative manufacturer was cost-efficiency and simplicity of configuration and installation. The Alouette project team had four major goals:

- *Best possible flexibility regarding transmission sources and coding algorithms*
- *Keeping technology as simple and as cost-efficient as possible*
- *Optimize quality via a well-constructed redundancy concept*
- *A solution tailored to the requirements of regional broadcasting*

To ensure an unproblematic switchover to the DVB-S2 standard, Alouette initiated a test phase in February of 2017. The company acquired, on loan, one of each device that was planned to be a part of the new system. The technical team had an extremely close look at all of the functions and interoperability of this equipment with the on-site system. This was particularly important in regard to one of the main requirements — local content broadcasting. The detailed descriptions that follow explain quite clearly why the selected 2wcom equipment perfectly met the stated requirements of Radio Alouette.

Alouette engineers received the first manufactured MM08E device at their station and initiated discussions with 2wcom regarding the test results of the equipment. The MPEG encoder, flexible in use for IP and satellite system requirements, also offered a wide selection of excellent quality codecs (Enhanced apt-X, AAC, MPEG I/II Layer 2/3, PCM) as well as RDS data — plus, MM08E also generates independent multiple streams.

With the use of MM08E, transmission of ancillary data and switching contact information (GPIO) could be forwarded via integrated interfaces. If more hardware channels are required, activation can be easily and conveniently managed via software updates.

After several weeks of working intensively with the device, all of the Alouette engineers were impressed by how dependably the prototype equipment performed. The technical staff came to the conclusion that the device is a complete and competitively priced product, rounded out by offering functions for quality management (MPEG FEC and DualStreaming to avoid IP packet losses), controlling (HTTP, Telnet, NMS and SNMP) and monitoring (IP and MPEG parameters via SNMP v2c and relay, headphone output and alarm, source switch and event logging).

Combined with the eSIRC Server and DSR02+ receivers, this solution enables Alouette to distribute and broadcast local programs and fully control the entire channel using a hybrid satellite IP solution. Selecting eSIRC (Satellite Inband Remote Control) was due to this web-based software for remote control precisely meeting the needs demanded for daily work, cost reduction and economy of time.

Equipping FlexDSR02+ with the SIRC option and an SD card makes it possible to use the entire range of enhanced functions of eSIRC. As a result, the technicians were able to completely access eSIRC management system via the web interface from any computer within the network for uploading data files to the internal memory of integrated FlexDSR02+ receivers (such as firmware, audio, reports and configuration). This was important for immediate use with an up-time close to 100 percent as well as for broadcasting content at a later point of time.

All content stored on internal memory of remote devices is mirrored within the eSIRC. Therefore, the network operators at Alouette can always track the state of internal memory on all integrated devices without the need for a physical connection.

If a certain file is scheduled to be uploaded, that file will also be stored in the local mirror of the concerned device. As storage space of each device is accessible via web interface, and also via FTP, network operators are able to

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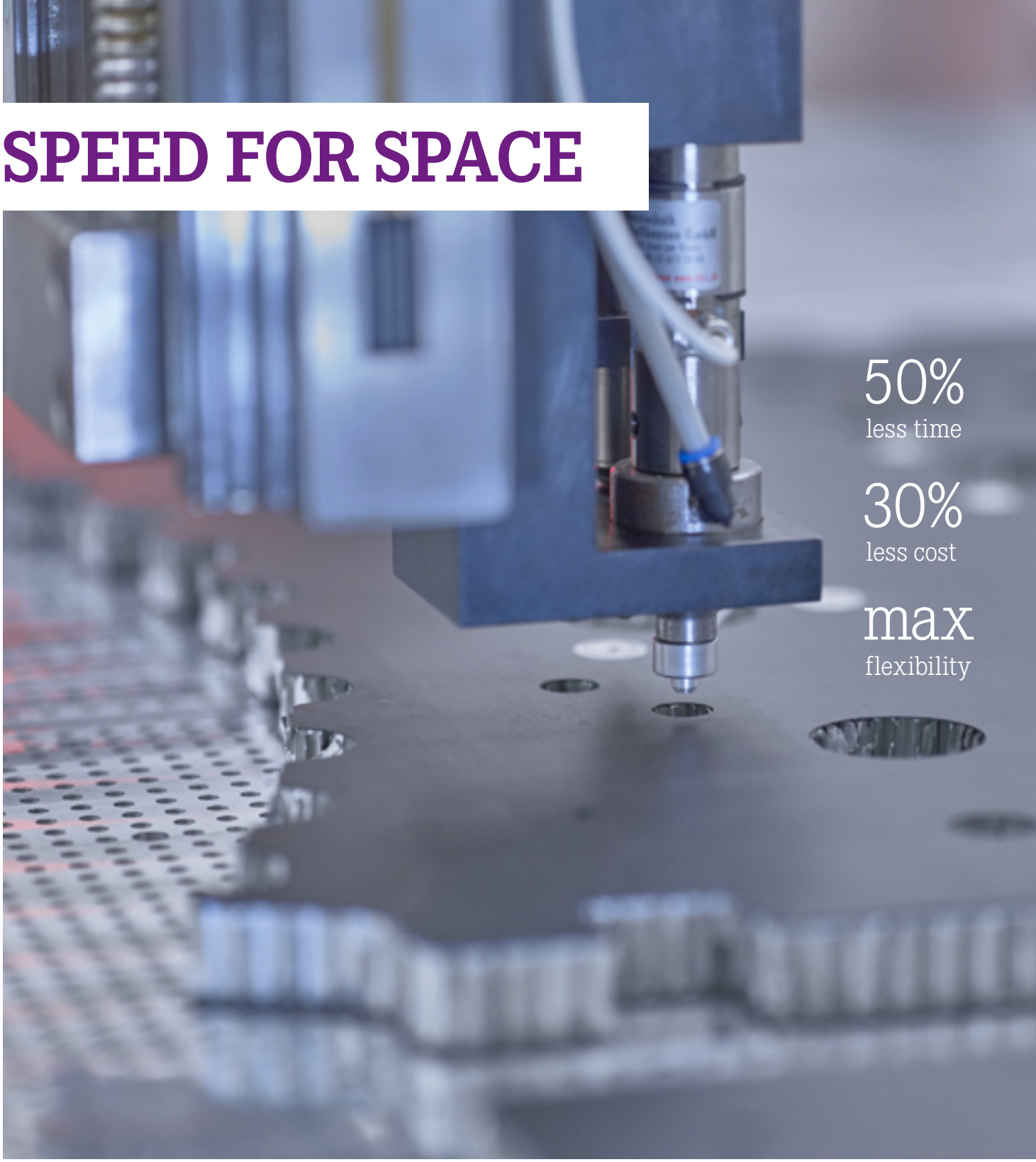

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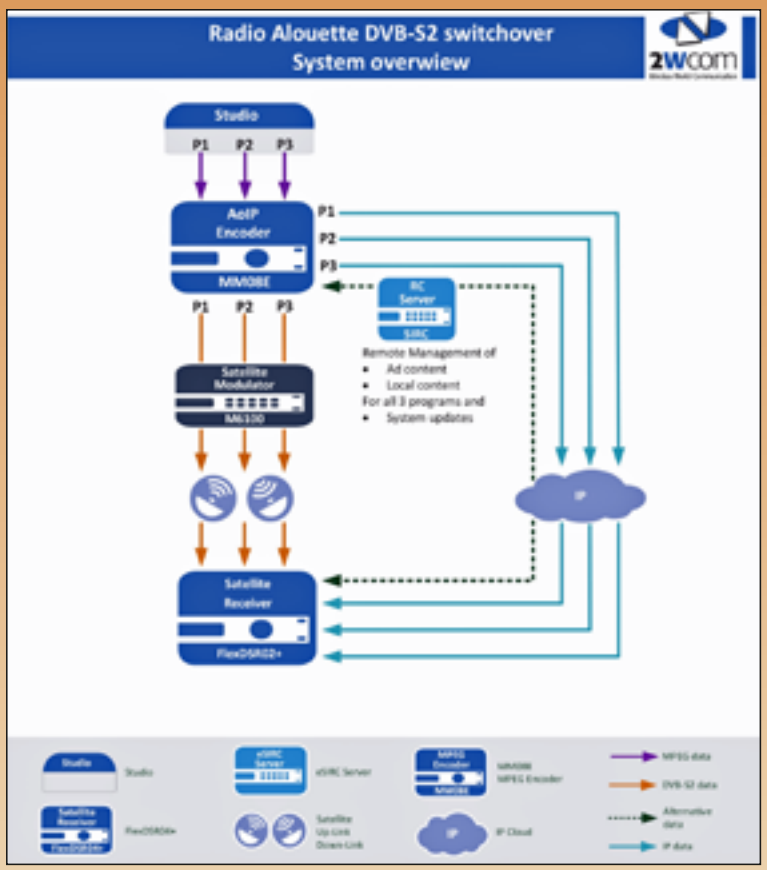

upload files directly to the system for distribution via satellite. In case a greater volume of data needs to be processed and there is no satellite capacity left for such to occur, eSIRC can synchronize content stored on the internal memory cards with the eSIRC mirror by using FTP.

Currently, Alouette has 38 industrial computers on each of the company's sites to manage the local news. Daily content and programming specific for every city is received and connected by an ADSL line to the master server located at the head office. The self-developed software allows every computer to be started in sequence by one or several contact relays coming from the current satellite receiver. This technology is reliable, but requires regular maintenance. Numerous kilometers of optical fiber have to be checked at least once a year. Remembering that Alouette covers a large area in the west of France, the company did not wish to use only a terrestrial IP technology — the firm wanted to optimize their content delivery by using satellite. Some towns within the Alouette coverage area simply did not have enough ADSL quality.

For obvious financial reasons, Alouette opted for a hybrid product that effectively allows for the management of 43 FM frequencies. After evaluating a range of possible products, Frédéric Bourgeais and his team selected the FlexDSR02+ satellite receivers to handle transport streams via satellite (DVB-S/S2), ASI input and IP, while also managing elementary audio streams and Icecast streams via IP.

The Alouette satellite platform.

The device is able to process all common coding algorithms, such as Eapt-X, AAC, MPEG I/II Layer 2/3 or PCM. Hence, the device matches up perfectly with one of Alouette's major aims — flexibility. Regarding the requirements for quality, this multipurpose device offers a sophisticated concept for audio quality and redundancy with options such as Pro-MPEG FEC and DualStreaming to avoid IP packet losses. Also included is highly effective link redundancy between the satellite and terrestrial IP by providing advanced functions that make it possible to pass over automatically from satellite reception in one flow to a global TS-IP.

The Alouette technical room with the 2wcom MM08E present in the hardware mix.

Frédéric Bourgeais provided insight into his experience with the collaboration efforts with 2wcom. *"From the beginning, cooperation between the sales teams and the engineers of both companies had been based on respect and trust. We also had the chance to check the quality of 2wcom's customer service. Because of the new system's importance to us for the present and for the future, this was a crucial question for us.*

"Apart from all of the technical features, one of our most important requirements is a constructive and respectful relationship between the engineers of Alouette and 2wcom. To that end, it was key to us that the people involved could work quickly and efficiently together to interface our Zenon Media computerized broadcast systems with 2wcom's broadcast solution."

This major switch over involving at least three MM08E MPEG Encoder, one eSIRC Server and 38 DSR02+ satellite receivers, has already been started and will be completed by September of this year. The new internal structure will ultimately enable Alouette to immediately multiplex three programs simultaneously. Alouette manages 16 of their own frequencies; the additional 27 frequencies are divided between Towercast and TDF.

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Anke Schneider is responsible for sales, PR and marketing at 2wcom Systems GmbH. Anke has 20+ years of marketing experience as well as CRM. She most recently worked at Bauer Media Group Sales & CRM prior to joining 2wcom in 2016. Frédéric Bourgeais is the Technical Director of SAS Radio Aloutte.

The Alouette technical team.

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Streaming Video — How It Works

A Vimond Media Solutions Focus

by Andreas Helland, Chief Commercial Officer, Vimond Media Solutions

Broadcast was once the exclusive domain of experts. Then came the Internet. Having worked in the broadcast and OTT (Over-The-Top) industries for the past few decades, Vimond has witnessed how IP technologies have democratized the ability to produce and distribute video.

This sounds simple. You shoot the video. You edit the video. And then you upload the video to the cloud for publishing — and then come the questions. How can you make sure the video is available for everyone? What about the numerous devices you need to ensure the video reaches? Where is the content published? How is content secured? The list goes on and on, and Vimond has faced such inquiries for a long time.

If the need to know more about streaming video, either to keep up with the OTT competition or to understand what is happening a company or organization, here is a quick tutorial on this process, starting with some basics.

Compression, Formats, Codecs, and Containers

Video is a sequence of images where the color for each pixel is defined in each image. However, if every image was fully stored, the video would end up being far too large for streaming within acceptable time limits.

A full-length, uncompressed, progressive HD movie, with 10-bit color, 1920x1080 pixels, and at 25 frames per second (fps), translates into a 1.4 terabyte file. To view such a video without buffering, viewers would need to be able to receive extremely high-speed data of about 2 Gbps in size. The answer to such a dilemma is compression, which comes in two basic flavors:

- *Lossless compression allows the images to be fully restored after decompression, but are CPU-intensive*
- *Lossy compression reduces the size of the original file dramatically, by simplifying the image or removing detail*

Video formats are specifications for compressing video to a stream. Examples include the MPEG family (1, 2 and 4), H.264 (MPEG-4 AVC) and H.265 (HEVC).

Codecs (coder-decoders) are the methods for implementing a specific video format. They use algorithms to shrink the size of the video file and to decompress that file when asked. Examples include x264, x265, ffmpeg, DivX, Xvid, WME, VP3 - VP9, Sorenson, Blackbird, Dirac, libtheora, Huffyuv and 3ivx.

Video formats and codecs are constantly being improved and updated as better hardware is developed and new devices come to market, and most of all because the viewing public demands faster and higher resolution imagery.

Video container (or wrapper) formats define how elements coexist in a stored file, but not what kinds of data can be stored. Containers usually contain multiple, interrelated video and audio tracks. Individual tracks can have metadata, such as aspect ratio or language. The container can also have metadata, such as the video title, cover art, episode numbers, subtitles, and so on.

Because the same codec is used to play back the stream with which the material was coded, many video containers also embed the codec. Examples include MP4, Microsoft (AVI, ASF, WMV), Google WebM, Apple (m4v, MOV), Adobe Flash FLV, Matroska MKV, Ogg, 3gp, DivX and RM,

Transcoding and Streaming

In a multi-screen world, the video must be scaled to fit different devices. With transcoding, video is adapted to the size of the device and the bitrate (bits per second of video) is adjusted in order to cap the amount of data to be transferred. The different streams are then packaged into the same container.

Streaming today uses adaptive bitrate (ABR) techniques — the stream is broken down into a sequence of small HTTP-based file downloads. Each download contains a short segment of a transport stream and also includes a manifest, which contains timing data, quality and a list of other available streams.

At the start of the session, an ABR stream downloads the manifest, an extended playlist containing the metadata for the various sub-streams that are available. As the stream is played, the client may select from a number of different quality streams to adapt to the available connection speed. Examples include Google's MPEG-Dynamic Adaptive Streaming over HTTP (DASH), Apple's HTTP Live Streaming (HLS) and Microsoft Smooth Streaming.

In addition to the standards and software, hardware is required that can take the original video file, fragment that file and then smoothly deliver that content. This is done by a streaming (aka, origin) server. Examples include devices from Unified Streaming, Wowza, Adobe Media, Apache, Nginx Plus and others.

Distribution, VOD vs. Live

In a standard Video on Demand (VOD) pipeline, the video is prepared beforehand and is not time critical. For example, content and metadata are ingested from various sources and stored in the cloud. The content is archived in the selected format. Content is then distributed to the CDN, while the online data-storage or hosting service ensures availability.

In a VOD scenario, there's the video, the container, format and everything needed for delivery to customers. For live video, the customer is attached to a potentially endless stream of data. In either case, customer access lines vary enormously. The goal of the service provider is to balance the amount of buffering and availability of content with acceptably high video quality.

But for live events, timing and synchronization are extremely important. Content must reach the end-user as soon as possible, and redundancy in the system must be designed so that any failover happens without notice by the end-user. The importance of synchronized time codes to redundancy cannot be over-emphasized: customers typically pay a premium to watch live video and are unhappy with interruptions to the video stream.

Continue to Learn

In satellite content distribution, the video expert has typically been someone with deep knowledge of industry standards, such as DVB or MPEG. In the streaming video world, the technology domain is broader and more dynamic. The new expert must understand multiple and evolving formats, codecs, containers, transcoders, streamers and CDNs — and, moreover, must know how these and other technologies are deployed to deliver on-demand and time-sensitive live video.

Becoming a streaming video expert may not be necessary; however, given the proliferation of OTT video, even within the satellite industry and how OTT cuts across traditional video, networking, IT and business silos, satellite OTT providers do need to become more familiar with this category.

A little learning, in this case, is certainly a good thing.

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Earth Observation via Smallsats — Major Moves

An Orbit Communications Overview

by Stav Gizunterman, Vice President R&D, Orbit Communications Systems

Today, more than ever before, Earth Observation (EO) has become an essential part of our daily lives.

The Earth is constantly monitored, analyzed and measured by government agencies, defense forces and the private sector. From weather forecasting to disaster control and oil & gas exploration, EO data is vital to a host of applications that profoundly affect our lives. Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites are constantly encircling the globe, providing optical and radar imaging for analysis of our planet.

EO Satellites

Similar to spy satellites, EO satellites are specifically designed for global coverage, but are intended for non-military purposes, such as environmental monitoring, meteorology, cartography, etc. Many EO satellites carry instrumentation whose functionality is suited for operation at low altitudes of between 450 and 800 km. Nearly global coverage is achieved in polar orbits, where a typical LEO satellite circles the planet every 100 minutes or so.

For example, below is a list of NASA satellites and their primary tasks, currently supported by the Alaska Satellite Facility (ASF). The ASF is part of the NASA-managed Near Earth Network (NEN) system of satellite-tracking ground stations around the world.

Satellite	Launch date	Altitude (km)	Primary objective – studying Earth's:
AIM	25 Apr 2007	600	Icy mesosphere
Aqua	04 May 2002	705	Water cycle
Aura	15 Jul 2004	705	Atmosphere
IRIS	27 Jun 2013	620	Sun
GRACE	17 Mar 2002	456	Gravity
OCO-2	02 Jul 2014	705	CO^2 levels
QuikSCAT	19 Jun 1999	800	Winds
SCISAT	12 Aug 2003	650	Atmosphere
SMAP	31 Jan 2015	685	Soil moisture levels

NASA's NEN provides telemetry, commanding, ground-based tracking, data and communications services to a wide range of customers. NEN provides these services to a customer base that is both U.S. and international, governmental and commercial, NASA (Earth Science, Space Science and Human Explorations missions) and non-NASA.

Many believe that most satellites can be found in LEO as it is less expensive to get them there — while this end result is true, there are two additional, compelling reasons. The first is Kepler's Law, which states that an orbit's period is determined by its altitude. In other words, the closer the orbit, the more frequent the updates. The second is optical physics, in the sense that the closer the satellite is to the Earth's surface, the better the imaging.

Mind you, there is one serious drawback with LEO. The lower the orbit, the greater the atmospheric drag. To keep those satellites in orbit, each one requires an engine and fuel. Hence, the somewhat conflicting trend of producing smaller and smaller satellites of bigger and bigger mass. More on that issue in the next section.

The Smallsat Market

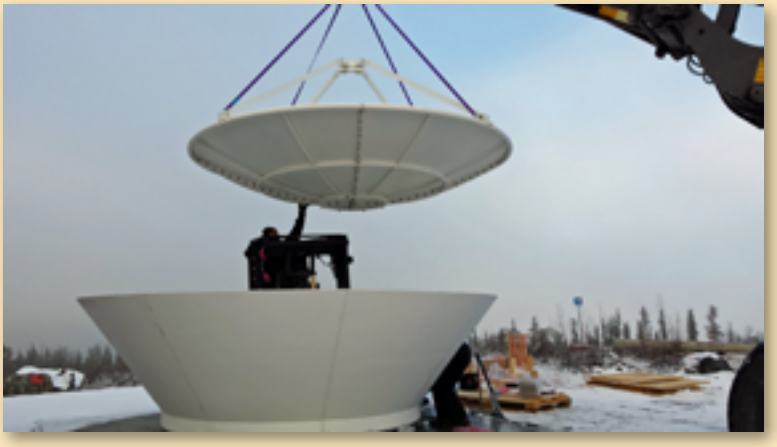
Small satellites, or smallsats, are of low mass and size, usually under 500 kg. The key reasons for the development of smallsats are to reduce the high cost of satellite construction and launch vehicles and to increase efficiency in certain fields. For instance, a network of miniature satellites, especially in large numbers, is proving to be more useful than fewer, larger ones for purposes of scientific data gathering and for use as signal relays. The technical challenges associated with smallsat construction — such as lack of sufficient power storage or room for a propulsion system — are being overcome with ongoing, innovative solutions.

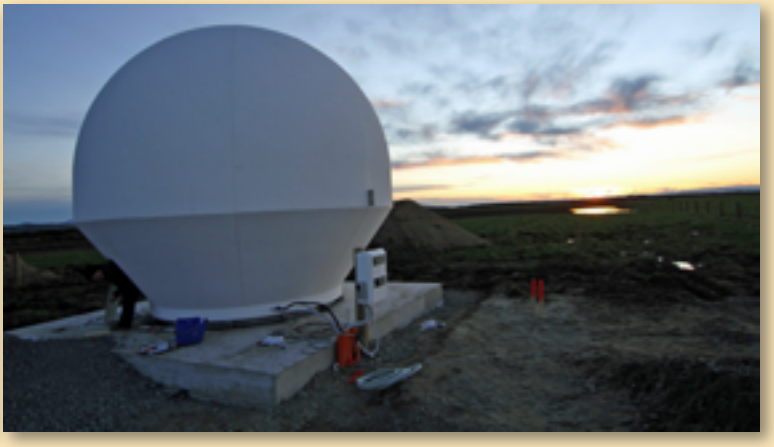
As mentioned previously, the key rationale for miniaturizing satellites is to reduce their cost: heavier satellites require larger rockets with greater thrust and higher price tags. In comparison, smaller, lighter satellites require smaller, less expensive launch vehicles and can sometimes be launched in multiples — or 'piggybacked — by taking advantage of excess capacity on larger rockets. Finally, miniaturized satellites allow for cheaper designs and a simple path to mass production.

Another major reason for developing small satellites is the opportunity to enable missions that a larger satellite could not accomplish, such as:

- *Constellations for low-data-rate communications*
- *The use of formations to gather data from multiple points*
- *On orbit inspection of larger satellites*
- *University-related research*

According to Rich Smith's Dec 2016 Motley Fool article, "***Small Satellites Explode in Popularity — and Size***," of the 4,250 satellites in orbit today, 291 (7 percent) can be termed as smallsats. The International Academy of Astronautics defines a range of smallsats, based on mass, including:





Satellite group name	Mass (kg)
Minisats	100 to 500
Microsats	10 to 100
Nanosats	1 to 10
Picosats	0.1 to 1
Femtosats	Less than 0.1

Smallsats are typically launched into orbit by cost-effectively hitchhiking them onto rockets that are carrying larger payloads. According to Northern Sky Research (NSR), approximately 80 percent of all smallsats launched between 2011 and 2015 had a mass of less than 10 kg. However, by 2021, NSR predicts that smallsats of more than 10 kg will account for 45 percent of the market. This trend can be explained by the simple fact that the cost of building larger smallsats been dramatically reduced. For example, just a few years ago, the cost of specialized components for a 20 kg smallsat might have been $2.5 million — today, all the necessary parts can be obtained for around $25,000.

Smallsat-Tracking Ground Stations

The smaller the satellite, the less the deliverable performance. To benefit from the data captured by smallsats, a quick and reliable communications link must be established between the fast-moving satellites and the Earth. Communication can only be established when there is line of sight between the satellite and the ground station. For LEO satellites, this communication "time window" typically lasts only a few minutes, so the goal is to squeeze the most data of the small spacecraft.

Important decisions depend on the reliability of such communications links and there are no second chances. That is why high-performance, high-accuracy ground stations are needed for tracking LEO satellites. The ideal ground station should be economical and scalable to match the budget of any satellite-based remote sensing project and should further support a range of antenna sizes as well as deliver maximum performance with a minimum footprint.

The 10 items to look for in a smallsat-tracking ground station solution include:

1. *No "key hole", for continuous tracking*
2. *3-axis system – EL, Tilt and AZ – for higher availability and reliability*
3. *Built-in Advanced Control Loop, step-tracked for optimum performance*
4. *Remote operation capabilities*
5. *Total control and scheduling software, for maximum agility*
6. *A radome, for anytime/anywhere/all-weather operation*
7. *Multiple configurations (from L- to K-band) in a single platform*
8. *Field-proven reliability, with reference installations in a range of topographies*
9. *Easy maintenance*
10. *Cost-effectiveness, for the flexibility to support everything from low-budget, academic research projects to government-sponsored ground stations downloading massive amounts of data on a continuous basis*

End-to-end ground station solutions should fully integrate into existing infrastructures and be capable of scaling from rooftop high-performance tracking antennas, used by GIS experts, to a complete turnkey ground station solution that includes high data-rate receivers, control software and more.

Emerging Smallsat Trends for EO

Imaging satellites are getting smaller and more sophisticated, thanks to the rapidly growing field of optical technology, with smaller and better cameras being developed and deployed all the time. What was once an almost exclusively military domain is rapidly being overtaken by research and commercial ventures. Today, although 60 percent of smallsats are defense-related, that market share is dropping fast due to quicker and cheaper solutions.

These days, smallsats are being launched at an unprecedented pace. For example, while today a well-known space launch provider sends up a payload of smallsats every two weeks, that company projects that by next year, that rate will be every week — by the following year, every day.

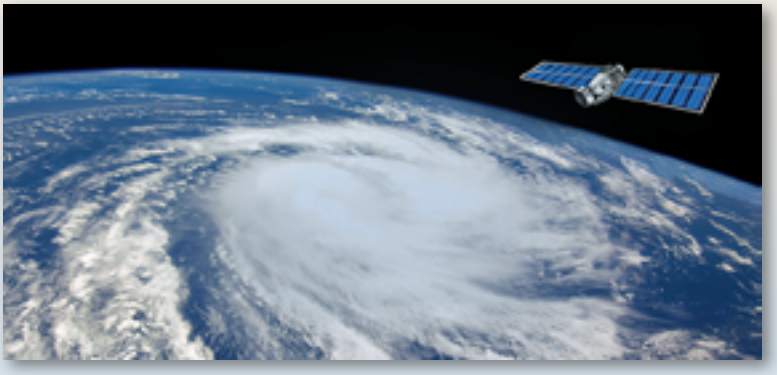
Just as satellites are diminishing in size, so are ground-station antennas. Where one EU operator used to use 7 to 13 meter antennas for smallsat tracking, two 5.5 meter antennas are now being used.

Editor's note*:*

The images on the opening page of this article show the Installation of a smallsat tracking ground station in a polar environment. The photos are courtesy of Orbit Communications Systems, Ltd.

Stav Gizunterman is the Vice President of R&D at Orbit Communications Systems Ltd. He was appointed to this position in 2017, after holding senior management positions in R&D and Product Marketing at the company since 2012. Prior to joining Orbit, he served in a variety of engineering roles at Elbit Systems, a global solution provider focused on the defense, homeland security and commercial aviation markets.

Stav holds a BSc in Communication Systems Engineering from Ben-Gurion University of the Negev, in Israel, and an MBA from Heriot-Watt University. He can be reached at ***stav.gizunterman@orbit-cs.com***



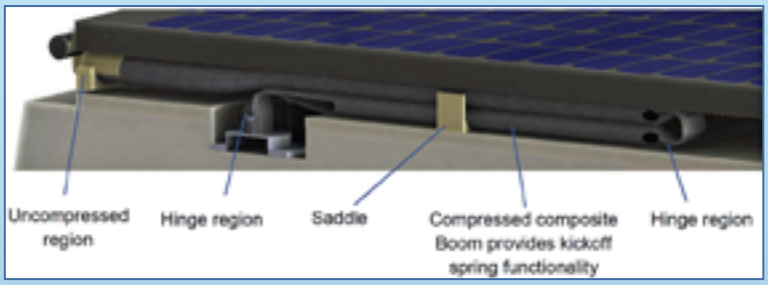
The Future of Smallsat Antennas...

A Roccor Perspective

by Chris Pearson, Vice President of Space Products, Roccor

The geo-communications and spaced-based remote sensing industries are being disrupted by a new generation of satellite constellations and their greatly expanding commercial communications capabilities, geospatial data availability, and defense signals intelligence architectures.

Buried deeply within these emerging satellite constellations, High Strain Composite (HSC) antennas are poised to touch people on a global scale as the new orbiting gatekeepers of information technology. The HSC industry has grown from laboratory experiments on composite carpenter tape springs to mission-critical components on satellite constellations in just over a decade.



Roccor HSC SADS system for 900 satellite constellation.

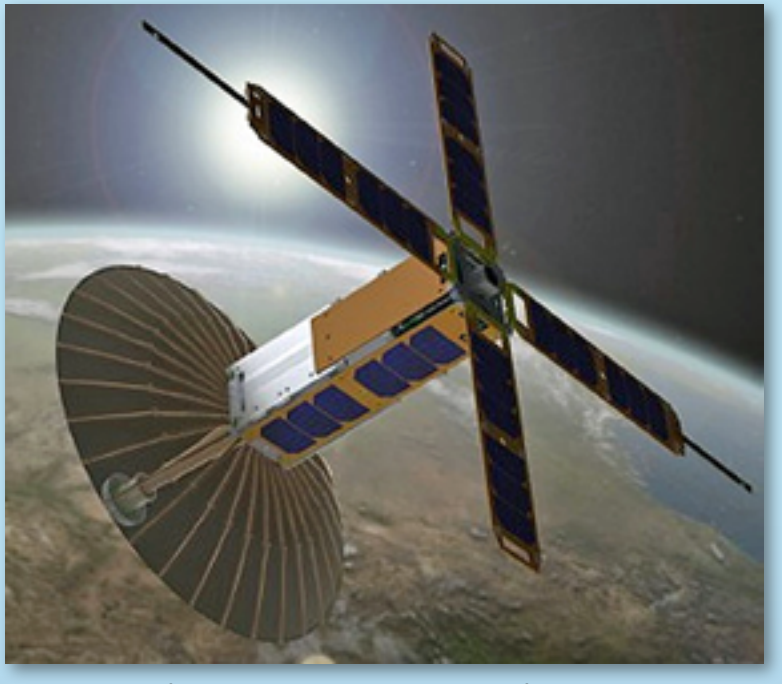
Roccor, the global leader in HSC deployment systems, has already secured a contract with an undisclosed satellite operator to provide HSC Solar Array Development Systems (SADS) for that firm's fleet of more than 900 satellites. The deployable structures are incredibly simple with few parts and are derived from technology exclusively licensed from the Air Force Research Laboratory (AFRL) .

The technology was further developed under the U.S. government's Small Business Innovation Research (SBIR) program. More importantly, the technology is proving critical to the challenge of designing high-performance, low-cost deployable antennas for these satellite constellations.

In 2012, researchers at the University of Southern California (USC) launched a 3U CubeSat called Aeneas to prove the concept of tracking cargo containers on a global scale using a cubesat constellation. Supported by the DoD Operationally Responsive Space Office and AFRL, Aeneas included a 0.5 meter in diameter deployable mesh antenna pointed to within a 2 degree accurate ground track. While Aeneas was the first-ever demonstration of cubesat attitude control and pointing to this level of accuracy, unfortunately the antenna — a mechanically complex design derived from traditional large-scale folding rib antennas — may not have fully deployed as the system failed to demonstrate the desired data link-up on orbit.

As mega-constellations inch closer to becoming reality, the industry is closely analyzing recent antenna technology demonstrations such as Aeneas and learning valuable lessons that are leading toward simpler and more-robust designs for small satellite antennas that can be produced in high volume.

The team at Roccor is working diligently through partnerships with top-tier antenna system companies to deliver such designs. In fact, Roccor is currently working with one commercial partner to flight qualify a more robust cubesat mesh antenna design than Aeneas, which will be deployed using HSC components.



Artistic rendition of the Aeneas satellite. Image is courtesy of USC.

To be practical, these small-scale antennas must have much simpler mechanical designs than larger, traditional, satellite antennas. HSC structural elements — which can provide deployment actuation and damping, deployed stiffness, and integrated electrical/RF functionality in one multifunctional part — open an entirely new design space, which can lead to different antenna architectures and structural designs.

To exploit this design freedom, Roccor has found that co-engineering of the HSC components with the antenna system is key and the best solutions evolve when the HSC engineering team works in tandem with the antenna and spacecraft engineering team to co-engineer starting at the point of requirements definition and through to final product realization. Designing deployable structures with HSC elements is quite different from using traditional mechanisms and experienced mechanism engineers can find it difficult making the transition. Traditional designs with fixed hinge lines give way to more flexible configurations using "floating" hinge lines or furlable, rather than rigid, members. The result is an antenna that packages and deploys more like a flexible camp chair and less like a rigid card table chair.

The HSC element in Roccor's SADS system has integral hinges and wire harness and packages for launch in a very compact volume without any moving mechanical parts (other than launch tie-down and release mechanisms). On orbit, deployment is triggered with a simple release firing signal, and driven by the strain energy packaged within the deformed HSC boom. Once deployed, the carbon-fiber boom straightens to provide substantial stiffness and strength while being relatively insensitive to thermal loading from the sun.

With flight heritage being proven on solar array systems, HSC laminates have evolved from relatively simple constructions to highly engineered designs capable of meeting conflicting requirements for deployable antenna applications. For example, latest-generation HSC laminates accommodate high packaging strains while having a near zero-CTE and extremely high deployed stiffness to remain dimensionally stable after deployment while supporting high compression loads as they tension critical antenna elements.

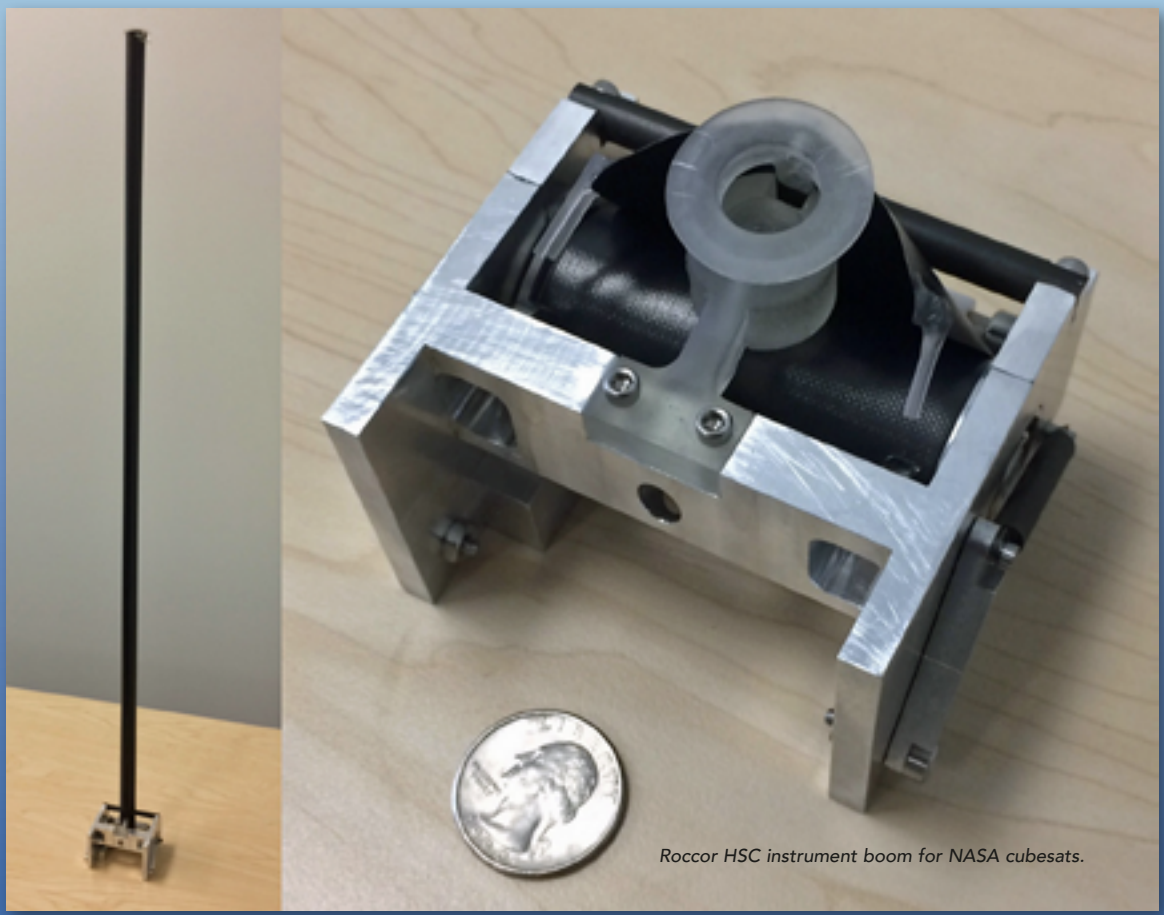
Creep of these polymer matrix composites and the concern over how they will perform on orbit after months or years of storage is perhaps the greatest concern among antenna system engineers. As such, years of development have yielded clear standards that are now being systematically applied for flight qualification of designs that accommodate these effects.

In the recent Decadal Survey of Space and Solar Physics, the National Research Council urged NASA's heliophysics community to consider whether future space weather missions, such as the Geospace Dynamics Constellation, might best be done with lower-cost cubesats.

Since then, Roccor has worked closely with NASA engineers to adapt HSC technology to very simple high-precision, low-cost deployable instrument booms and systems capable of measuring precisely the variations in Earth's ionosphere due to solar flares. These geomagnetic storms can block space-based radio communications, and degrade the performance of these new constellations of information technology.

So, flying among the armies of HSC antennas will be HSC space weather sentinels to sound the alarm when the high-flying information grid goes down.

roccor.com/



Roccor HSC instrument boom for NASA cubesats.

Innovation: Keeping the Rainforests of Guatemala Safe

An Astrosat Perspective

by Dan Ghatoray, Business and Innovation Analyst, Astrosat

The space perspective, proudly embedded in the ethos of the Scottish space technologies company Astrosat, is keeping watch on criminals halfway across the globe, providing those who protect vital rainforest systems with an ever-watchful eye in the sky.

The dense, dark jungle of Guatemala is one of the most biodiverse locations on the planet — and is also the birthplace of the ancient Mayan civilization. Guatemala is home to 1,246 known species of amphibians, birds, mammals and reptiles, as well as 8,681 species of plant life. Both the flora and fauna of the region exist in a delicate balance; a vibrant and dynamic ecosystem with significant global importance — nearly 15 percent of all these species are endemic, meaning that Guatemala is the only country on Earth wherein they exist.

More than a third of the land mass of Guatemala is made up of extensive forest systems, and more than half of these are classified as primary forest — the most significant and biodiverse forestry classification possible. However, these forests are at risk of being despoiled and eventually destroyed by the threat of illegal logging.

Years of civil war and political unrest in the region have resulted in three quarters of the population living on, or below, the poverty line, with over half living in rural areas. The lives of these people are heavily dependent on the fair use of the natural environment around them. Unfortunately, this is far from the current situation.

What motivates illegal loggers? Simply put, the profits for the perpetrators are very high when compared with the low risk of detection. The World Bank and Interpol list timber as a commodity, no different from weapons, narcotics, vehicles or any other internationally traded goods which can generate profits.

The fact that timber is easy to launder and readily appears as a 'clean' business compared with human or drug trafficking implies the notion that it is not a seriously immoral activity or a 'victimless crime.' The reality is that illegal logging has extremely serious and detrimental consequences.

Guatemala suffers from widespread environmental damage and rapid primary forest loss, which leads to loss of many environmental services that forests provide, including water regulation, soil formation and stabilization. Deforestation also exacerbates the threat of catastrophic flooding. In 2005, floods and mudslides that were attributed to tropical storm Stan killed thousands of people in the country.

The economic losses due to tax evasion, fees and other revenues are significantly impacting the nation, as well. According to Interpol and the UN, global illegal logging is worth between $30 and $100 billion (10 to 30 percent of the entire global timber trade).

The social impact must also be considered. It has been argued that illegal logging increases poverty and breeds uneven power relations. Local communities and indigenous groups are often directly dependent on forest resources for subsistence needs.

Between 1990 and 2005, Guatemala lost almost one-fifth of the nation's entire forest system. Official figures assert an annual deforestation rate of 80,000 hectares (a hectare is equal to 10,000 square meters, which is equivalent to 2.471 acres), although some organizations place that figure at almost 100,000 hectares, with recent surveys highlighting the extensive destruction in the Mayan Biosphere Reserve. Since the millennium, deforestation rates have continued to climb by 13 percent.

Given the size and density of the forests, the ecological and critical economic importance of forestry to the country and the lack of available law enforcement manpower to tackle illegal logging, a technological leap is required that allows sufficient intelligence and situational awareness to be collected in one place in order for counter logging efforts to be coordinated and focused for maximum effect.

Field work underway in Guatemala. Photos are courtesy of Astrosat.

This technological leap is FMAP, or Forest Management and Protection — basically, a 'CCTV in the sky' that has been developed by Astrosat.

Astrosat is a Scotland-based, leading-edge, satellite-as-a-service provider. Building on the firm's experience working with and delivering space-based solutions to governments, large scale infrastructure and energy operators in Europe, Astrosat is internationally renowned for working consistently to understand the needs, practices and current limitations of its end user and client communities.

Less formally, however, and aligning with the spirit of the company's CEO and founder, Steve Lee, Astrosat is the physical result of the shared belief that space, and the space perspective, can solve or assist any Earthbound problem.

Astrosat has built a solid technical, commercial and delivery team that is dedicated to answering this challenge and delivering on the potential of their systems. The team is composed of a wide range of space scientists and engineers who range in specialties from situational analysts, field responders, physicists and technical and operations specialists, as well as innovative strategists that ensure the solution delivered in Guatemala will be useful, usable and sustainable for end-users.

With the capacity to track individual logs from lumber site to saw-mills, Astrosat's technology is assisting the Guatemalan government and related environmental agencies to monitor effectively large areas of land, such as the rich 'Mayan biosphere reserve' and a host of other important national parks along the border.

Working with cutting edge Earth Observation (EO) technologies, FMAP monitors specific jurisdictions to ensure that only permitted timber is allowed

The Astrosat team members.

to move freely, creating a legal market for sustainably managed forest products. Steve Lee said, "*What we are working on here could be described as a CCTV system which operates from space. With the data and information we can garner, we can help countries and communities which are at the mercy of unscrupulous operators.*

"*This, in effect, bring space — and space companies and organizations — into the FairTrade arena, by helping local farmers and villagers to manage their sustainable timber reserves. Illegal logging undercuts markets and has a devastating effect on vital ecosystems.*"

FMAP is designed to work end-to-end, keeping close tabs on individual logs from start to finish via new methods of electronic transference and using satellite data to monitor canopy loss over larger regions to build the clearest picture ever of illegal logging in Guatemala.

To this end, Astrosat has recently coordinated the first of many task force workshops in Guatemala, attended by governmental, environmental and law enforcement agencies alike, including the non-profit wildlife conservation NGO known as ARCAS, the national forestry institute (INAB), the National Council for Protected Areas (CONAP) and MAGA, the Ministry of Agriculture, Livestock and Food of Guatemala.

The workshop was attended by technical staff of CONAP and INAB (both field and office staff), as well as the Rainforest Alliance and representatives from university and industry bodies. Together they collated information on the organizations, the challenges faced by each, and ideas for improving existing processes and systems.

Members of the Astrosat team and representatives from collaborating partners visited the sites which are most at risk and followed the timber journey from cut site to lumber mill in order to ensure a full understanding of the process, before delivering training events for local police who will eventually be widely using this technology in the field.

The hope is that the technology Astrosat has developed will not only reduce illegal logging across the country and increase the number of illegal loggers captured, but will also protect and create sustainable forestry jobs, reduce forest degradation and also boost biodiversity.

The aim is to increase the wholesale value of sustainably harvested forest products from the region due to the long term use of FMAP and integration of the system across Central America and beyond.

www.astrosat.space

Dan Ghatoray is the Business and Innovation Analyst at Astrosat with an academic background in Astrophysics from the University of Glasgow. Dan is now focused on space commercialization; bringing space down to Earth - showing the world how powerful, applicable and necessary space applications and technologies are to everyday life. Contact Dan at ***Dan.ghatoray@astrosat.space****.*

Making Home Feel a Lot Closer for Expats Across Europe

A bobbles.tv Broadcasting Insight

by Arthur Kulbatzki, Chief Executive Officer, bobbles

An innovative service from bobbles media, based in Hamburg, Germany, relies on a unique combination of Direct-To-Home (DTH) satellite and Over-The-Top (OTT) to enable expats in Europe stay in touch with home.

Many in the broadcasting industry consider DTH and OTT as rival distribution platforms; however, bobbles CEO Arnold Kulbatzki believes that viewers, and his media business, are getting the best of both worlds.

"*Ideas come when personal experience tells you that there is a need for something new, something different. I've traveled a lot during my career and I'm familiar with the feeling of being abroad, but wanting to know what's going on at home.*" That statement is what is received from company CEO Arnold Kulbatzki when he is asked what gave him the idea for bobbles. "*Among my own friends are people from other parts of the world who miss familiar — and loved — TV services*," he added.

Kulbatzki notes that he and his partners imagined there must be a way to create a business built around delivering multiple packages of programming to those who have decided to call Europe "home." When his research revealed there are more than 15 million people originally from Asia, Latin America and Africa living in Europe, he knew this kind of offering would delight a huge viewing population. "*We also knew we had a great business opportunity*," he added. And so, the concept of bobbles was born.

Early on, the bobbles team knew that reaching as wide an audience as possible was essential. "*In Europe, if you want to truly engage with people located directly across the region, pan-European satellite is really the only way to go*," said Kulbatzki. In order to enable additional subscribers to join bobbles online, and to ease access via mobile devices, the bobbles.tv OTT streaming service was deemed a fundamental part of the service mix.

Convenience and Quality Service

In 2016, bobbles.tv went live with Chinese and Korean packages via SES' 19.2 degrees East ASTRA satellite position as well as online for OTT. The spring of 2017 witnessed the debut of Europe's largest package of Indian programming available on satellite, with bobbles offering viewers the convenience of viewing live or via catch-up.

Kulbatzki knows how to give customers what they want. A long-term broadcasting industry professional, hiss résumé includes advising some of Europe's biggest cable and satellite TV service providers. He also has years of board membership on high-profile retail brands that leverage his expertise. Overseeing subscriber management for 2.4 million customers has taught him a thing or two about what people want from their TV services.

A New Offering for International Communities

For decades, diaspora populations — people of the same nationality or culture located in countries other than their homeland — have been able to access programming from their birth nation in a variety of ways. However, these language-based TV channel bouquet services were often not professionally managed or attractively packaged. Additionally, such services were frequently associated with piracy.

The broadcasting industry has a new vocabulary and people now have a better understanding of digital TV, Kulbatzki said. "*Words such as streaming and over-the-top are widely understood*," he explained, then continued, "*But in parallel, consumers now have much higher expectations when it comes to delivery, quality and convenience. Amazon has raised the consumer's standards for service and speed, and today everyone has much higher expectations for retail services across the board.*" Together with his partners, Kulbatzki set out to make bobbles easy to use in every way possible.

"*Pay-TV has changed dramatically*," said Kulbatzki, "*and the success of Netflix in recent years has been a game-changer. We realized that combining OTT with DTH would yield the best of both worlds and enable us to build our business based on Europe-wide reach, including areas where there is no or limited broadband. Selecting SES [as our satellite partner] was a no-brainer, as that company is the worldwide leader when it comes to beaming top TV programming directly into millions of homes.*"

In addition to offering the best possible reach and viewer convenience, bobbles.tv was to also have maximum appeal and user-friendliness. Bobbles' ambition was to be much more than an à la carte menu of linear services. Catch-up TV complements linear TV, with true PVR functionality such as search and backwards EPG, enabling a subscriber to access a program even when missed.

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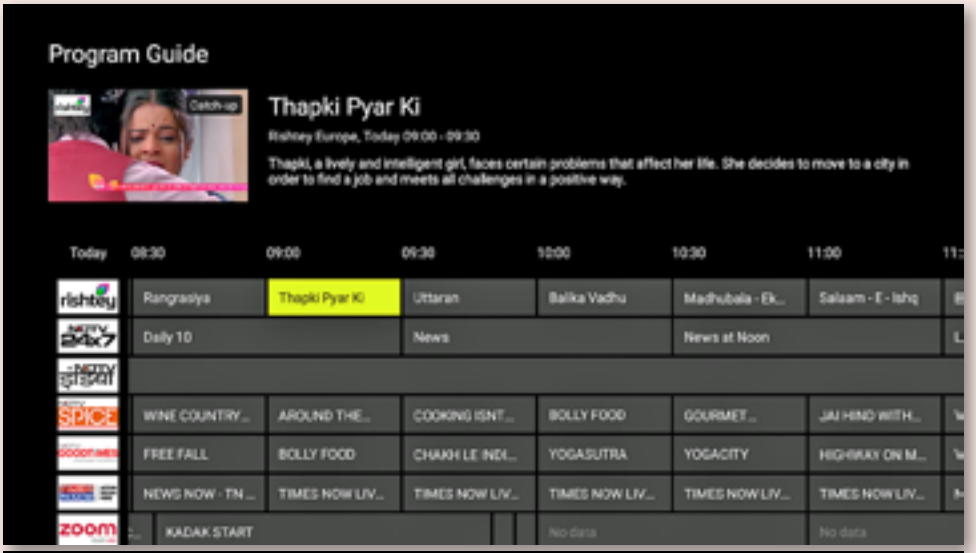

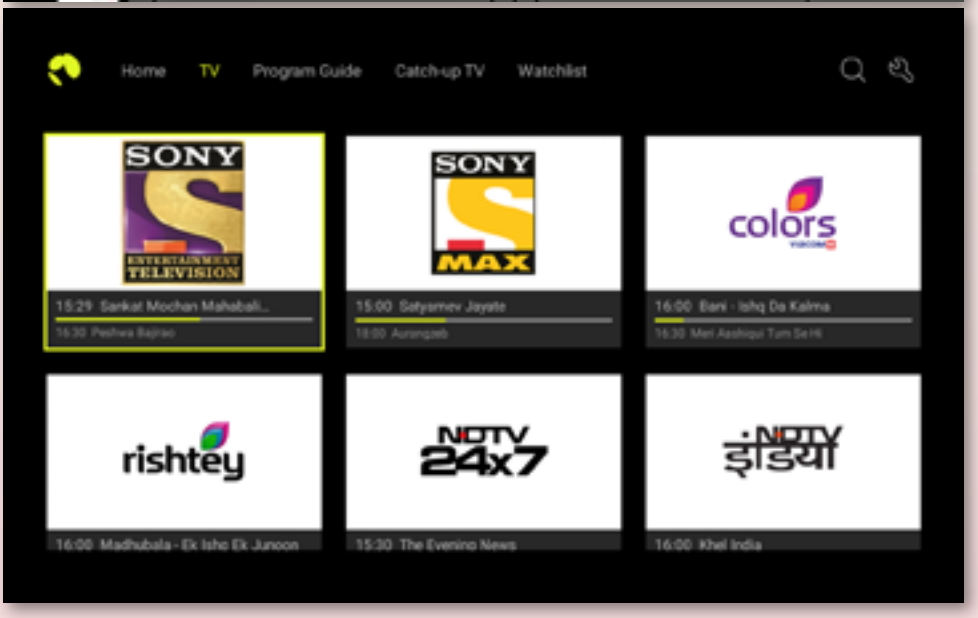

"*We really wanted to deliver a world-class personal TV experience. It was critical to determine a price point for a new service like bobbles.tv that would make choosing the alternative route of piracy uneconomic*," he said.

One of the biggest challenges that any TV provider faces, particularly in today's highly competitive landscape, is a consumer's reluctance to be tied to a long-term contract. Viewers want an easy sign-up process and a hassle-free unsubscribe option. They get all this with bobbles, Kulbatzki noted, adding that this commitment to usability sets bobbles apart from the competition.

bobbles.tv subscribers only pay for the programming they wish to receive: A single subscription enables viewers to access the most popular channels from their home country. Depending on the desired package, bobbles.tv monthly prices start from just 6.95 euros online and 14.95 euros for satellite.

Partnering with Broadcasters

Bobbles works closely with broadcasters in Asia who are drawn to the company's business model and the firm's ambition to reach new audiences across Europe. "*For some channels, our platform is their first foray into the European region,*" he shared.

Joining a platform such as bobbles.tv is a powerful, yet highly resource-efficient opportunity, to reach the millions of people who comprise the various diaspora groups. "*Via our bundled channel offerings, we give broadcasters a chance to reach new audiences without expensive marketing campaigns or complex licensing operations,*" said Kulbatzki. Revenue opportunities going forward include video-on-demand. When the subscriber base reaches a critical mass, Kulbatzki believes it will be a unique business opportunity for advertisers.

Launching a multi-language international service on a pan-European satellite system simultaneously alongside OTT was an amazing accomplishment in terms of the technology involved and process co-ordination. Pre-launch, regular international project team conference calls involved engineers, designers, satellite and online distribution technicians as well as other specialists from technology partners, as well bobbles' own in-house team.

"*Typically, 15 or more participants dialed in from various countries — all worked together, shared their expertise and creativity, and all possessed the common goal of making bobbles.tv satellite and OTT service a success for our audiences and for us,*" Kulbatzki said.

Innovation is Key

Bobbles is committed to continuously innovate and to enhance the service offering. Social media networks, like Facebook and WhatsApp, play a vital part in the informal relationships and communities expats populate when they relocate. Bobbles recognized early on the importance of social networks — they form a core part of the user experience for many subscribers. New social media features are in continuous development by the company.

Kulbatzki said, "*the social media tools we've integrated into bobbles.tv help users be more involved in our product while enabling them to connect with each other.*"

In June of 2017, bobbles launched two new HUMAX reception devices for subscribers — the HUMAX B1 HEVC compliant digital set-top box (STB) delivers bobbles via satellite, while the Android-based HUMAX H3 media player delivers wireless, multi-room TV that enables bobbles online/OTT subscribers to watch their favorite content anywhere in the home or office.

Kulbatzki stated that the positive feedback from subscribers has been remarkable. "*We instinctively knew that people who relocate to another country don't want to lose touch with home, or to lose links with its culture – bobbles subscribers tell us how much they appreciate watching their favorite shows and movies in their mother tongue.*" He added that customers even offer suggestions as to what channels to add, all of which encourages greater user engagement and retention.

Does Kulbatzki have any advice to offer other prospective OTT service providers? "*If you think that you have an idea worth trying,*" he said, "*something that will enrich people's lives, try it. I guarantee it will take more time, energy and imagination than you expect. But then, the rewards and personal satisfaction make every moment worthwhile — plus, it's also a lot of fun.*"

www.bobbles.tv

Image, left to right: HUMAX B1 STB and HUMAX H3 STB.

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Innovation: A Satellite Ground Station In a Box

A GateHouse Telecom Focus

Test and validation is crucial to ensure robust satellite communications (SATCOM) equipment, including user terminals, applications and solutions.

However, traditional on-air test activities come with several challenges. Access to SATCOM equipment may be limited due to equipment costs, air-time costs or service availability. SATCOM terminals cost thousands of dollars or even more, especially in niche markets such as aeronautical SATCOM services.

In addition to the economic challenge, service may not be easily available. Testing activities are often desired a long time before the satellite communications service is launched. Even then, the service may or may not be available at the specific physical location of the test engineers. The testing activities have further requirements, such as having to set up the terminal with good line-of-sight to the communications satellite and the routing of cables with power and connectivity to a convenient testing facility.

Finally, with access to the SATCOM service, and when the test equipment is set up, the users are subject to the conditions of the network that are occurring at that exact time and place. Bandwidth may or may not be limited by the service plan and the amount of congestion in the network, depending on how many other users are using the same channels. These conditions make for an uncontrollable test environment, which can complicate, or all together obstruct, a planned test procedure.

The practicalities of on-air testing call for other methods by which to test applications and solutions.

To alleviate these challenges, work arounds can be considered by looking for options that require moving all or part of the testing effort into the lab. Simulation or emulation equipment can be used, just like in the cellular world where test equipment exists that provide some level of connectivity on the bench. A similar solution has been developed by a SATCOM software house for Inmarsat BGAN services.

The Build

When developing the first generation of user terminals for the Inmarsat BGAN satellite service, GateHouse Telecom A/S and the firm's partners experienced the SATCOM testing challenges first-hand. Access to the service was limited. Rigorous testing was time consuming and costly — a better solution was required.

BGAN Application Tester (BAT) interface.

Leveraging already available RF and modem hardware, GateHouse Telecom was in a unique position to reuse their mobile protocol stack IP to develop a comprehensive network emulator for the Inmarsat BGAN system.

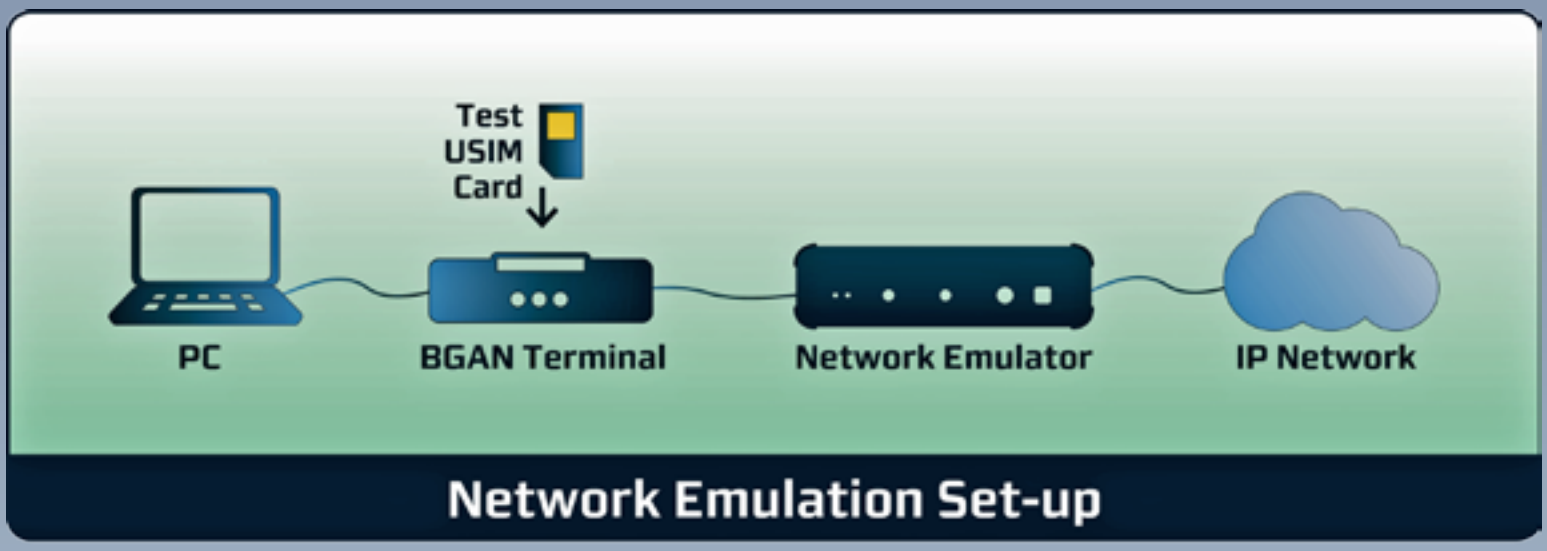
The existing hardware platform was originally developed by Square Peg Communications Inc. to support physical layer and protocol stack conformance testing of BGAN user terminals as a key part of the terminal type approval process. The current generation of the modem hardware is a compact and fully integrated 3U unit supporting four uplink and downlink channel pairs — more than enough capacity to simulate multiple satellites and spot beams.

GateHouse developed the Network Emulator product, which augments the Square Peg hardware with the emulation of an Inmarsat BGAN ground station. Together, these technologies enable end-to-end test of solutions on the bench, directly in the lab.

The Network Emulator implements the Inmarsat air-interface protocol that allows a user terminal to logon to the system and to activate services. Both IP services (standard data and streaming data) and circuit-switched services (voice and ISDN) are supported.

The current generation platform is the Application Tester for the Inmarsat BGAN service — combining the Square Peg Communications hardware with the GateHouse software into a fully integrated ground station in-a-box.

Toward the user terminal, the emulator is connected via a regular L-band RF interface over a coaxial cable. The appropriate broadcast information is sent to the terminal to simulate a full satellite constellation, allowing the terminal to acquire the signal and logon.



Network Emulation Set-up

A special Test-SIM card is used in the user terminal instead of the normal subscription SIM.

Toward the Internet or LAN, the network emulator is connected via a normal Ethernet cable. When the user terminal activates an IP service, data can be transported from the mobile side to any server accessible via this connection. Any IP-based application or solution can then be tested and validated.

Core Functionality

On the inside, the network emulator simulates a complete I4 satellite constellation. Given the position of the user terminal, the emulator will turn on the signals from the global and regional beams of the satellites visible at that testing location. When a service is activated by the user via the terminal, the required narrow beam channels are activated.

Mobility Test On-The-Bench

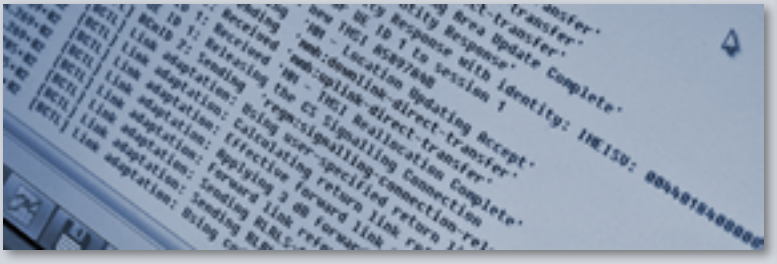
Satellite service performance often varies with location, giving different levels of service, depending on the elevation of the communications satellite. Effects from handovers or satellite switches may affect the application.

Such scenarios are quite challenging to reproduce in the real world; however, with an emulator, this concern becomes trivial. The user terminal uses GPS to obtain a position resolution that is then used to select the satellite and spot beam to use for the satellite service.

Faking this position can be done by using a GPS signal generator, or by overriding the position via a debug interface. Changing the position makes the user terminal operate as if located anywhere on Earth.

As the terminal reports the position to the emulator, the service level is adjusted accordingly. Depending on the pointing elevation of the antenna, adjustments are made based on the assigned link margins in each elevation band.

When the terminal crosses a spot beam boundary, handovers are performed. When the edge of coverage is crossed, satellites turn off and on, allowing realistic simulation of the switch between each satellite and ocean region.



BGAN Network Emulator (BNE) screen closeup.

Test On A Rainy Day

The satellite service level may vary depending on network condition, number of users and even be subjective to environmental effects such as weather fade. Such conditions are not under the user control, but in an emulated environment they can be applied. An emulator can simulate degraded performance, error conditions and user data congestion. This allows for realistic testing under a wider range of scenarios, fully under the user's control. The robustness of the application when facing a highly congested network can be validated verification can be made that the application gives proper feedback to the user or performs appropriate error handling when errors occur.

The Future

By bringing the ground station and all of the other parts of a SATCOM network into the lab, test environments are controlled. That enables a more robust and better performing product far faster than such would have ever been possible on a live network. With a world that is constantly in search of ways to secure and guarantee connectivity and up-time, wherever and whenever, testing in the lab has an integral part to play in the future of satellite communications.

gatehouse.dk/

	BAT BGAN Application Tester	BNE BGAN Network Emulator
User-friendliness	User-friendly GUI - no training required	In-depth system knowledge required
Functionality *	Selected BGAN, FBB & SBB functionalities available	All BGAN, FBB & SBB functionalities available
Network features	Supports all system features - compatible with latest SDM	Supports all system features - compatible with latest SDM
Network emulation	Preconfigured with network defaults for black-box testing	Configurable for white-box terminal testing
Operation	Manual testing	Automated and manual testing
Customization	Profile based testing	Configurable - customized testing

Innovation: Tackling the Waste Crime Wave — Space Super Sleuths

An Air and Space Evidence Focus

by Ray Purdy, Director, Air and Space Evidence

Air and Space Evidence, the world's first Space Detective Agency, are initiating a new service using 'spy in the sky' satellite technologies to detect waste crime. This new service — called Waste from Space — is based on the company's development of a semi-automated detection model that uses satellite data (and machine learning algorithms), which enables the company to offer an effective and commercially viable geospatial intelligence tool that can detect serious waste crime.

Waste crime is increasingly causing significant damage to society — for example, in the UK alone, that cost is estimated to be more than a billion pounds a year and for all EU countries, that estimate ranges from 72 to 90 billion euros per year.

In 2016, the head of the Environment Agency in England called waste crime the "*new narcotics,*" commenting that "*it feels to me like drugs felt in the 1980s: the system hadn't quite woken up to the enormity of what was going on and was racing to catch up.*"

Interpol, Europol and the UN have identified waste crime as one of the fastest growing areas of organized criminal activity and is increasingly recognized to have the potential to rival drug trafficking in terms of scale and profits. One Italian mafia gang is estimated to make as much money annually from waste crime as the global revenue of the McDonalds fast-food restaurant chain.

More than 1,000 illegal waste sites spring up in England each year. A single site discovered in Northern Ireland is believed to contain 1.5 million tons of illegally deposited waste, which is significantly more municipal waste than the entirety of Northern Ireland's production in one year (i.e., 969,157 tons in 2015 to 2016).

In 2016/2017, Air and Space Evidence received funding from the European Space Agency, Open Data Incubator for Europe (ODINE) and the Scottish Environmental Protection Agency to conduct research and trials examining how this problem can be tackled using space technologies. Air and Space Evidence are now launching a much-needed waste crime monitoring service to governments.

The ASE team.

Air and Space Evidence was named as the winner by the EARSC as the *European Earth Observation Product of the Year.* (*See additional information later in this article.*)

Ray Purdy, a Director of the company, said that waste crime is highly lucrative — and can also be hard to detect. Governments need new investigatory approaches because at the moment they are several steps behind waste crime gangs. Air and Space Evidence will offer a much needed, innovative intelligence gathering and analysis service to governments, whereby the company can identify waste crime that Governments are not aware of, bringing immense value to their work and enabling them to catch more waste crime gangs in the act.

Professor Ray Harris, also a Director of the company, noted that waste crime can cause environmental damage to surrounding land, air and water and poses a risk to human and animal health. Living near an unlawful waste site can also ruin people's lives. The company is aiming to use cutting edge space technology to significantly reduce the scale of the waste crime problem.

Some key questions that prompted Air and Space Evidence to become involved include…

Why is waste crime happening?

Criminals are short-changing economies by exploiting the high costs of legal waste management (e.g. landfill tax avoidance).

An ASE identified illegal waste site. Image is courtesy of ASE.

Another ASE identified illegal waste site. Image is courtesy of ASE.

How does the firm's detection product work?

Finding illegal waste sites is a bit like finding a needle in a haystack. They can be concealed, be different shapes and sizes and be in a wide variety of locations. To tackle this, the company combined a variety of techniques from radar and optical satellite sensors, aided by mapping data, to discriminate standard land use types, concentrating on anomalies. Air and Space Evidence effectively focused on finding the needle by eliminating the haystack. This technique discards the vast majority of items in the search area and allows the company to isolate a realistic number of suspicious areas for further close-up satellite investigation. In the product trials, 71 percent of sites identified as potential illegal waste sites were proved to be so.

The EARSC Award

The EARSC competition "*European EO product of the year*" rewarded a company which has developed a product that will support the implementation of the Sustainable Development Goals (SDGs) at national, regional and/or local levels, and the monitoring and reporting against the global indicator framework.

The SDGs are being launched with an emphasis on collecting data that will be extensive and specific enough to serve these needs. European Earth Observation industry can help achieve the SDGs by providing critical information on natural resources, government operations, public services, and population demographics. That's why EARSC decided to focus its 2017 Product award on the industry contribution to SDGs. During the process, 15 companies became interested in the award and seven of them forwarded to the EARSC the required documentation.

The EARSC recognized Air & Space Evidence's Waste from Space as winner of the context of the commercial product of the year, which support the monitoring and reporting against SDGs in the most innovative way. This is a new geo-information product which offers a much-needed intelligence gathering and analysis service to governments, investigating and providing evidence of one of the most significant global environmental problems, unlawful waste dumping sites.

The product is based on a semi-automated detection model using Earth Observation data, enabling the company to offer an effective and commercially viable geospatial intelligence tool that can detect serious waste crime.

ASE receiving the EARSC award.

This product serves several SDGs indicators. Waste from Space successfully drives down the size of the waste crime problem by combating organized crime (SDG 16.4), ensures that much more waste/hazardous waste is subject to environmentally sound management in its life cycle (SDG 12.4) pushes more waste to be treated properly and sustainably within the circular economy (SDG 12.5), and means much less waste is not released illegally into the environment (SDG 6.3, 11.6 , 12.4). — ***www.earsc.org***

Air and Space Evidence is an academic spin-off company, set up by two former colleagues at University College London – Ray Purdy (a lawyer) and Ray Harris (an Earth observation expert). Other group members have military intelligence, business and environmental career backgrounds. The Company have undertaken investigations using satellite imagery for individuals, companies and governments since late 2014. They have worked on property, environment, crime and insurance cases. The company was named by the leading US business and innovation magazine, Fast Company, as one their 12 World Changing Company Ideas for 2015.

www.space-evidence.net

Resources

*A European Commission study estimated that illegal waste operations cost EU countries €72 billion per annum – **http://europa.eu/rapid/press-release_IP-12-18_en.htm**. Other research has put that figure at €90 billion per annum — **http://www.ieep.eu/news/2012/05/eu-waste-law-and-better-compliance-a-journey-into-the-unknown***

*Guardian, 2016 — **https://www.theguardian.com/environment/2016/sep/22/ea-chief-waste-is-the-new-narcotics***

*UNEP, 2016 — **https://wedocs.unep.org/rest/bitstreams/11507/retrieve; Europol https://www.europol.europa.eu/crime-areas-and-trends/crime-areas/environmental-crime***

*GlobalSecurity.org — **http://www.globalsecurity.org/military/world/para/ndrangheta.htm***

*In 2015, the Environment Agency shut down more than 1,000 illegal waste sites in England, and estimated that, per illegal waste site in operation, £150,000-200,000 is lost. UK Parliament, 2017 — **http://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0547***

*Irish Times, 2016 — **https://www.irishtimes.com/news/environment/stormont-struggles-with-millions-of-tonnes-of-dumped-waste-1.2856625***

Is the Satellite Imagery World Ready to Welcome the Commercial World?

A Black Sky Perspective

by Rakesh Narasimhan, Chief Operating Officer, Spaceflight Industries

The personal computer, Internet and mobile devices have had a dramatic impact on our lives and spurred significant new innovations since their introductions.

Satellite imagery is on the cusp of making a similar impact, helping companies and people better understand the planet. The question is whether the satellite imagery industry itself is ready for this to occur.

To serve commercial customers, satellite imagery providers need to address five key market needs:

- *Making satellite imaging affordable*
- *Rapid iteration for continuous improvement*
- *Improving the user experience by upgrading delivery times and processes*
- *Developing better data analytics capabilities*
- *Broadening access to space for increased competition*

Making Satellite Imagery Affordable

To effectively reach commercial customers, including enterprises, scientists and NGOs, satellite imagery providers must make their offerings affordable. Price is often a function of cost and desired profit margins: Satellite imagery providers will need to cover their costs and make money. Given this, the industry's biggest challenge in terms of cost reduction is that satellites and their related equipment are still too expensive and have not reached economies of scale.

To provide satellite imagery at an affordable price, the industry must have commercial scale production for the continued development of telescopes, components and product delivery.

For example, look at the PC market — today there are many providers of PC components, increasing competition and making those components inexpensive for manufacturers. The space industry can learn from this. While progress is being made, imagery providers need more affordable equipment and component options to make certain the business model is viable in order to attract large-scale commercial customers.

Considering Rapid Iteration for Continuous Improvement

There is an opportunity for satellite imagery providers and other players in the space industry to improve upon iterative and incremental development. Satellite imagery providers can learn from companies, such as Apple with their development and progressive iteration of the iPhone. With each new phone it introduced, Apple incorporated improvements, which then forced the other players to also innovate their product lines.

Commercial scale and iteration haven't yet happened in the satellite industry, but such is getting closer. Take Black Sky's Pathfinder program as one example. Pathfinder was the first generation spacecraft with its own level of componentry, payload, flight computers, power and propulsion. The second iteration, which launches this year, will be much improved in terms of the spacecraft's telescope, computers and storage and will reflect a complete generational upgrade. Next year, a third generation will ship, with additional enhancements in processing speed, camera and software functionality as well as telecom connectivity.

Similar to the iPhone and mobile phone industry, as this industry moves toward iteration and scale, competitors will also be forced to upgrade components and products to keep pace, improving innovation for all.

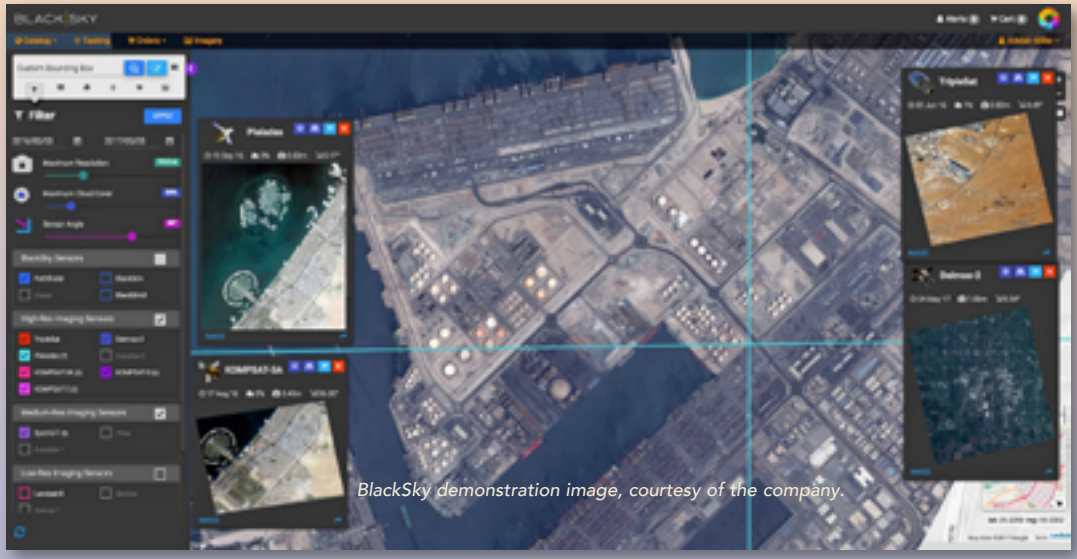
Improving the User Experience

The second step toward the commercialization of satellite imagery is to make it easy for businesses, NGOs and scientists to purchase, access, and use this imagery. Businesses expect tools to be easy to use. Consider the consumerization of enterprise software and the proliferation of easy-to-use, cloud-based tools in the business world today.

To make it easier for commercial customers to buy satellite imagery, the industry needs to get rid of antiquated processes. Today, many customers still fax or make phone calls to order images or select imagery from an archive. The retail experience for satellite imagery is subpar; searching and perusing inventory is clunky, purchasing is slow and order fulfillment is lacking.

Commercial customers will demand an improved experience. Imagery customers will expect a shopping experience much like Amazon.com, where a customer clicks to an online portal, logs in, discovers what's available, tasks a satellite in real-time, pays for them online, and has them delivered.

As we continue to demonstrate iterations of the Black Sky platform, using other organization's satellites and soon our own constellation to capture images, the company's customers



BlackSky demonstration image, courtesy of the company.

are increasingly impressed as the technology provides a better way to obtain the data they require. Historically, that acquisition of data has been a far more arduous process. Indeed, the "one-click" retail model that consumers take for granted is simply not yet available in this industry. Meeting the needs of commercial customers will require enormous adjustments in business models for the satellite imagery industry, including the processes of discovery, purchasing, delivery and imagery, but it must happen.

Developing Better Data Analytics Capabilities

No longer can satellite imagery be thought of simply as "taking pictures." Satellite imagery unlocks information, adding deeper layers of insight and data that illuminate other, potentially bigger issues that require the world's — or a business' — attention.

Imagine a satellite image of a glacier suspected of melting. What if the same basic image of that glacier could be captured over time with attendant data analysis software deriving the actual measurements of that glacier's melting rate? This would remove any speculation and avoid a guessing game. After all, who can afford to make a trip to a glacier every month, or every year even, to gather data?

With satellite imagery, data analysis and machine learning, it is now possible to scientifically report exact measurements and rates and other data, rather than subjectively postulating as a human with an opinion. The same detection analysis can be applied to port traffic, storm damage, urban development, pipeline security, or a panoply of other uses not yet imagined.

The satellite imagery industry is starting to leverage the large amounts of data being produced. However, to glean new insight, satellite imagery service providers will need to partner with software developers and experts in artificial intelligence to harness this data and improve its analysis.

Broadening Access to Space via Increased Competition

Competition is critical and is a sign of industry health and vitality and ultimately benefits the end customer. Competition will drive service providers to innovate and technological development is thereby forced into the open, upping the value factor for businesses, scientists and NGOs. With competition, the broader industry ecosystem becomes stronger. The result will be a more robust industry, fueled by innovation, with the flexibility to offer lower pricing and better value for commercial customers.

This increasingly competitive landscape means reaching space can no longer be controlled by only a few businesses or nations. Access to space must be far more broad based.

To do this, capital will need to be available. Vital capital infusions for companies such as Rocket Labs, Vector Space Systems and SpaceX have recently been made, enabling new players to reach space in an unprecedented manner. Had Elon Musk not invested his own money and persuaded the U.S. government to grant him access to launch facilities, the emergence of the launch industry would not have happened. The satellite imagery sector requires the same sort of investment.

Venture capitalists must often choose between promising options: Invest in a small software company that can grow to a billion dollars in three years, or invest in a space company that will need to build 20 satellites for huge capital with no ROI for seven years.

Those VC firms wanting to fundamentally innovate and seriously change the landscape are playing the long game today, because they see enormous opportunity in the future.

Further, the satellite imagery industry needs to advocate for smart policies and standards. Policies — as important as they can be for the industry — have the potential to impede the average venturesome company. Fostering competition will require a strong governmental influence to help spur more innovation. Government policy needs to enable timely approvals and licensing that is realistic for serving commercial interests. There also needs to be forum or a framework for enterprises to bring grievances when there is disagreement among commercial vendors.

The Flight Path to Success

The resulting network effect of increased competition and investment will help to spawn new and innovative ways to employ and exploit satellite imagery technology. The identification of ways to use satellite image data to benefit mankind has only just begun.

To be clear, the satellite imagery industry must take significant steps to ready itself for commercialization; however, rest assured that none of the challenges ahead are insurmountable. By addressing the evolving commercial market demands, the industry is poised to serve a market sorely lacking in cost-effective satellite imagery and data. When enterprises and other commercial customers are presented with a robust, affordable and easy model to help them leverage satellite imagery, they will no doubt dream big and innovate in ways never before imagined.

www.blacksky.com/

This article's opening photo is of Black Sky's Pathfinder satellite undergoing the final integration process by Senior Technician Jim Bowes.

Rakesh Narasimhan serves as the Chief Operating Officer for Spaceflight Industries, responsible for all product and development operations for Spaceflight and Black Sky. In addition, he's responsible for the evolution of the Black Sky platform and its roadmap to understand the world's information in time and space.

A tech veteran, Rakesh has more than 25 years of executive experience in high-growth technology industry with past experience including a range of senior executive roles at Oracle Corporation, Microsoft Corporation and Citrix Systems.

Advancements In Transportable Earth Stations: The Driving Forces Of Change

An AvLTechnoloiges Perpsective

by Bryan Kerns, Director of Strategic Business Development, AvL Technologies

Do you remember watching TV before the existence of live, on-the-scene newscasts? This author doesn't, anymore than teenagers remember communications before the Internet.

In the U.S., early remote Satellite News Gathering (SNG) from the late 1970s required large trucks with huge 2.4 to 5.0 meter C-band (4 to 8 GHz) reflectors (or dishes, as they were sometimes referred to) to transmit analog audio and video back to a studio for broadcasting. Because these lower frequencies interfere with microwave links, the FCC required a site survey prior to each transmission from a mobile SNG truck.

The uplink vehicles typically required a dedicated and highly trained crew to complete the site setup and lots of power to operate the systems and cooling equipment. The full transponder bandwidth requirement to uplink was quite costly and that meant that the uplinks were not often used. Those early days of expensive uplinks were reserved for major planned events, such as political conventions, elections and major sporting events.

Later, in the early 1980s, along came satellites with transponders in Ku-band (12 to 18 GHz), which continue to remain prevalent today. The higher frequencies did not interfere with microwave ground equipment — FCC site surveys were no longer required and reflector aperture size could be smaller.

Many broadcasters moved to antennas typically sized at 1.2 meters and the FCC created the term VSAT to designate Very Small Aperture Terminal for antennas ranging in size from 75 centimeters to 1.2 meters. During this time period, digital compression technology arrived and completely changed everything.

Equipment costs were still expensive; however, by the early 1990s, the overall costs per uplink were lower because compressed digital used only a quarter of a transponder — plus no site coordination was needed and "live on the scene" broadcasts began to spread and normalize. As news media outlets competed to be first on the scene, they became dependent on their satellite trucks to quickly provide reliable uplinks.

Through most of the 1980s, antenna performance was lightly regulated in the U.S. There were few issues as GEO satellites were originally spaced 4 degrees apart to protect against causing adjacent satellite interference for transmitting Earth station antennas. However, as many new Ku-band satellites went into service — and they could be spaced at 2 degrees apart — and the number of Ku-band satellite uplink vehicles grew, adjacent satellite interference became a significant issue.

The main causes of adjacent satellite interference originating from VSAT antennas are excessive side lobe radiation due to multiple factors that include poor antenna design and manufacturing or overpowering the transmit amplifier. The FCC promptly tightened regulations and required that off-axis energy for transmitting antennas be reduced by 50 percent and the agency mandated using off-set antennas with minimum blockage to meet the new specification.

Accurate pointing of the main beam is essential to minimize or eliminate adjacent satellite interference, but misaligned cross polarization is a source of inference on the target satellite. Most Ku-band satellites transmit and receive using linear polarization, and cross polarization interference can occur between users when operating on the same frequencies in opposite poles, either vertical or horizontal.

If each of the linear transmission signal waves has not been properly tuned to opposite phase alignment, then one signal can leak into the other. Cross polarization tuning is usually conducted between the satellite operator and the VSAT operator to eliminate this type of interference.

Automating optimized cross polarization alignment was introduced by AvL Technologies in 2008, and today, sophisticated modem protocols require communication between the antenna controller and the Earth station at the NOC or network operations center. Modern digital satellite modems with modern auto-acquire antennas, such as those produced by AvL Technologies, will perform auto-cross-polarization and auto-power uplink control without user intervention.

Returning to those late 1980s through 1990s when U.S. journalists were using satellite communications to broadcast live on the scene, covering events in local markets and major markets was relatively easy using SNG trucks. However, when international events had to be covered, news stations could not easily ship their trucks to the event site — an example of this is when it took three days to move an SNG truck to Mexico City to cover the earthquake of 1985.

Broadcasters needed an antenna that could be packed into transit cases and then flown to any location in order to bring news directly to the media outlets in America. To build such an antenna terminal required segmenting the reflector into multiple pieces for packing into small cases. The individual reflector pieces had to be constructed from lightweight, yet extremely strong, materials. The reflector had to be able to withstand repeated assembly and disassembly without tools, all the while maintaining a highly accurate reflective surface to comply with adjacent satellite interference and cross-polarization specifications that have been discussed earlier in this article.

This was a puzzling problem at the time because nothing like

this existed in the U.S. Meanwhile, in the UK, a small company called Advent was using a material more common to Formula 1 racing at the time — carbon fiber composite — to build the world's first manually pointed flyaway VSAT with a 1.9 meter aperture reflector. This was a wildly successful antenna design and the inventor was Steve McGuinness, the founder of Advent who has now been with AvL Technologies for 14 years. McGuinness received an ***Emmy*** award for ***Outstanding Technical Achievement and Engineering Development in Satellite News Gathering*** in 1993 for the development of that flyaway antenna.

Jim Oliver founded AvL Technologies in 1994 after a friend requested that he design a compact, rugged and stiff antenna positioner for SNG trucks. Oliver was well-known in the industry as the co-founder of Satcom Technologies and as an innovative antenna designer. Within a few years, Oliver was building complete SNG antennas with 1.2, 1.5, 1.8 and 2.4 meter reflectors. By 2002, Oliver recognized the need for an auto-acquisition transportable antenna that could be operated by anyone — including volunteers — when he was contacted by the American Red Cross. During and after disasters, armies of Red Cross volunteers jump into action providing help and communications. Therefore, an auto-acquire transportable satellite antenna was absolutely necessary — and that antenna needed to be simple to operate.

Oliver contacted another industry friend, Dave Provencher, who co-founded a small company called TracStar. Provencher had designed and built an antenna control system for digital video broadcasting, or DVB, receive-only antennas for the recreational vehicle industry, and Oliver had a concept for using DVB technology to obtain very accurate azimuth headings to locate satellites.

Oliver and Provencher, along with TracStar CTO Chris Hadley, jointly developed a new DVB-based satellite locating method, which led to the first fully auto-acquisition antennas. This new auto-acquisition method worked extremely well and a mutually beneficial symbiotic relationship between AvL Technologies and TracStar was formed. Provencher later transitioned the ownership of TracStar to Cobham, then took a year off before joining AvL in 2015.

An AvL Model 9066 from 2006 with the auto acquisition green button.

Oliver did not stop with auto-acquire SNG and VSAT antennas. The terrorist attacks of September 11, 2001, and the resulting invasion of Iraq brought a need for high bandwidth communications built to withstand rugged and harsh environments and operated by non-technical war fighters. Oliver's team, with Mike Proffitt at the helm of operations, quickly designed and built a 1.0 meter aperture reflector, segmented in four pieces, and a 2.0 meter antenna with nine segments, and outfitted both transportable positioners with a fully auto acquire TracStar controller. This design used carbon fiber composites similar to that of the flyaway antennas from Advent.

After extensive testing, Oliver took the antenna on the road, first to the Navy Research Lab in Washington, DC, then by invitation to the White House Communications Agency. When asked by one of the senior government officials at the demonstration if he could train him to use the antenna, Jim replied, "***Certainly. Push the green button. Okay, you're trained.***"

Every AvL antenna has always had a green and a red button and everyone in the company knows the phrase, "green button means go, red button means stow." Both demonstrations in 2003 were successful and the orders soon flowed in from prime defense contractors needing easy-to-operate, robust communications (single to multiple T1 lines) in the Middle East by all of the DoD forces for tactical, logistics and intelligence activities.

Recent years have brought satellite advancements in Ka-band (26.5 to 40 GHz) and new High Throughput Satellites, or HTS. Ka-band HTS using spot beam technologies deliver much higher data rates than traditional Ku-band satellites but are more susceptible to degraded performance in rain, dense clouds or fog. Rain attenuation in this band can often be remedied with higher transmit power but this requires a more accurate reflector and higher precision pointing due to the narrow wavelengths of the much higher frequencies as compared to Ku-band.

Today's users of VSAT technologies are familiar with small and easily transportable antennas — either mounted to trucks or transported in small cases — as well as the simplicity of the green and red buttons that enable easy-to-use satellite communications on the go. However, VSATs have transformed and innovated over time — just as satellites and other segments of the industry have — and few remember the days when an engineer was required to point a large antenna.

Thanks to innovators and industry pioneers such as Jim Oliver, Steve McGuinness and Dave Provencher, the industry has changed and the tools have greatly improved. These advancements have contributed to the proliferation of VSAT antennas atop the modern-day uplink van, which is easily supported by a crew of only two: the camera operator and the news journalist.

Editor's note: The opening photo is of Jim Oliver at the U.S. Capitol Building with an early AvL flyaway antenna.

www.avltechnologies.com

Bryan Kerns is the Director of Strategic Business Development at AvL Technologies. Prior to joining AvL in 2010, Bryan was Director of Business Development at CapRock Government Solutions. He previously held roles at LBiSat, Verizon Business and the U.S. Air Force.

Understanding and Improving the ROI of VSAT Networks

by Robert Bell, Executive Director, World Teleport Association (WTA), and Juan C. Sanchez, CEO, Integrasys

Very Small Aperture Terminal (VSAT) Networks provide an extremely valuable and much needed resource for an entire range of different applications, many of which would simply not be possible without VSATs, as they are operated in remote environments where no other connections are available.

Since the first VSAT systems emerged in the 1980s, they have proven to be extremely durable and flexible, having evolved as speeds, throughput, and applications have all grown. However, the VSAT environment is a very unique one and certainly not without its challenges.

A teleport may manage dozens or even hundreds of individual networks, each comprising anywhere from 20 to 2,000 nodes with their own specific configuration, bandwidth requirements and mission criticality. At the same time, providers are under increasing pressure to deliver all of this functionality at low cost, all the while maintaining high quality of service — that is no mean feat.

VSAT Challenges

VSAT is, without a doubt, a challenging environment — but what, exactly, keeps teleport operators up at night and how do they go about resolving those challenges? To answer that and other teleport questions, the ***Understanding and Improving the ROI of VSAT Networks*** report was produced by the World Teleport Association and Integrasys to provide some insights.

Developing this report revealed some extremely interesting understandings into the challenges faced by teleports. One element was clear — all of the Teleport Operators interviewed struggle with the labor time and the increasing costs to install and maintain VSAT systems. These operators are all either integrating methods to reduce those factors, or seeking ways to do so.

The major costs and challenges of network deployment vary, depending on the type of network, size, application, and vertical market being served. For example, in the cruise ship industry, the biggest challenge is reported as the logistics of getting systems onto vessels. Days of travel and months of advanced scheduling is required for installs to be performed while a ship is in dry dock or a shipyard. However, across all markets, there is strong agreement that the faster a system can be deployed, the sooner revenue can be earned, and that means that no matter what the application, fast and efficient installation is absolutely crucial to the health of a company.

At the same time, however, the VSAT environment is one wherein installation is not always as simple as many may believe. Take the cruise ship example, for instance, where months of pre-planning are required. In most circumstances, VSATs are in remote locations where traveling to them can take considerable time, effort and even resources. Sometimes this may involve traveling along unpaved roads, boat, via airplane, or using off-terrain transport.

In the Government arena, additional complications arise, with some of those surveyed reporting the possibility of being sent back from an installation trip if the proper clearances and credentials have not been secured. The requirement to use individuals who are authorized for access tends to increase the installation labor costs, as there will generally be a much smaller pool of employees who have the necessary clearances.

The Real Cost

When estimating the cost of VSAT systems, most operators immediately think of satellite bandwidth, which is certainly a factor and one that can be optimized through better technology. Multiple technology vendors regularly release new advances for their products. The capex costs at the hub can also be optimized and those costs are easy to calculate. What is not so straightforward is calculating

the running costs of a network, which include a whole host of factors that are often overlooked, such as field installers, satellite phone costs, travel, and hub support staff. According to the survey, for a 50-site VSAT high performance network, capital expenditure represents 45 percent of the total investment, while operating expenses comprise approximately 55 of the cost. One operator stated, "*We have experienced challenging financial models, from design to implementation and on-going operation.*"

This survey found there is an average travel cost per remote installation of a staggering $1,100. Multiply that cost for numerous VSAT terminals and it is easy to see how these expenses can quickly add up for operators. Around 9 percent of that cost is for labor, with the remainder being attributed to travel, subsistence and materials. Such costs shouldn't be surprising, given that installers spend — on average — 12 hours working on the installation and approximately 12 hours in travel time.

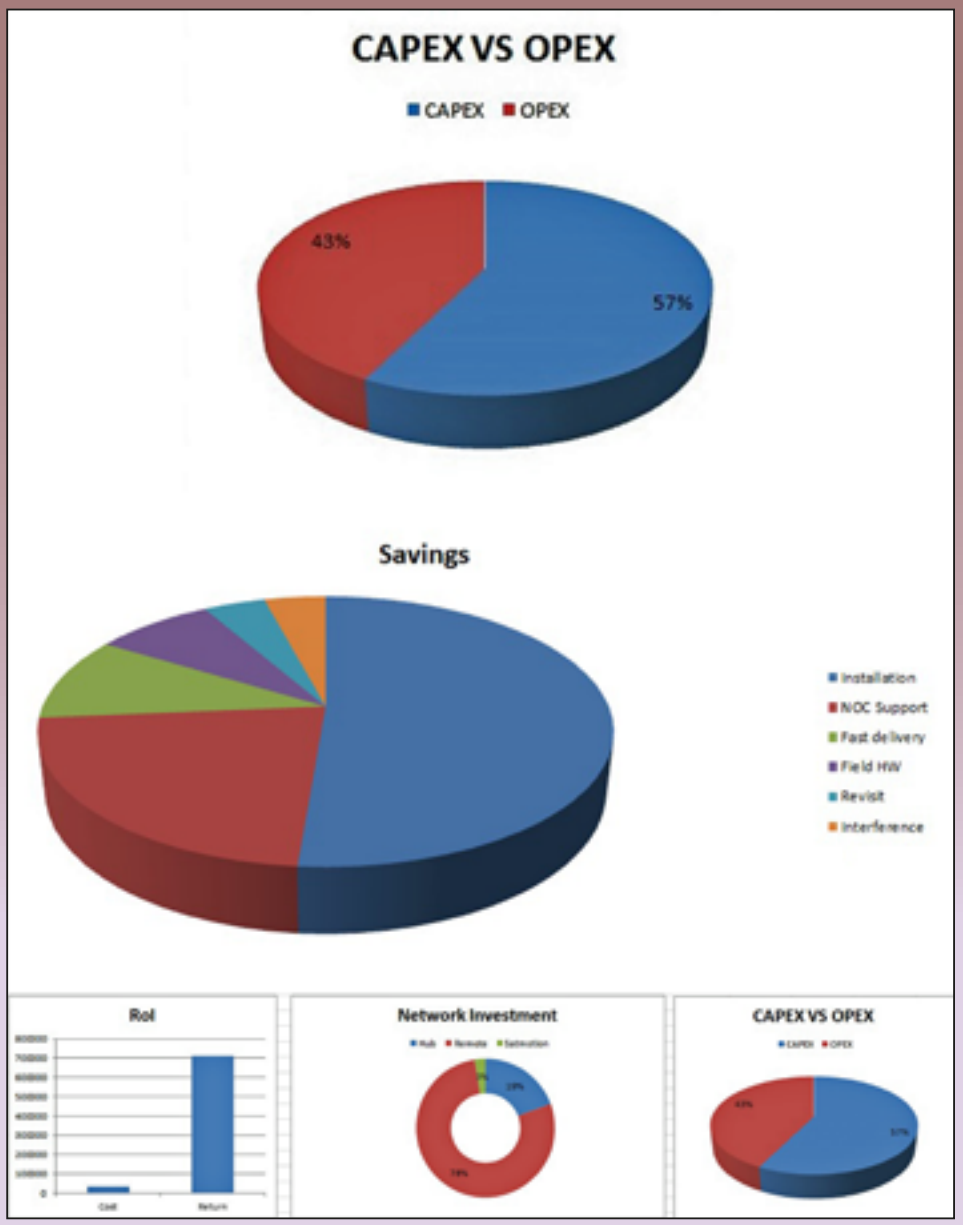
When things go wrong with a VSAT terminal, then that entire process is repeated with engineers traveling to the site, spending time on site diagnosing the problem and then resolving that problem before heading home. Again, this additional cost for the network operator.

Minimizing Costs While Maximizing Service

Certainly clear from all of the responses is that VSAT terminals need to be far more efficient in order to enable cost savings and this must be accomplished without any compromise on quality of service. This is where clever tools and technology come into play. Tools for improving installation can significantly reduce that cost. For example, if an installation can be accomplished faster, then the time on site and the associated labor cost is immediately reduced. If, at the same time, the installation is made accurately, then the chance of error has been reduced, something that otherwise could mean a repeat trip by the engineers — more money required. The easier and more automated these tools are, the fewer experts are required to operate them, and that has a massive impact on labor costs.

Before the introduction of tools, such as the Integrasys Satmotion Pocket that enables fast and accurate antenna pointing, installers were completely dependent on the NOC operations staff who are reached by voice calling to ensure correct pointing, power, and signal. That is particularly challenging when you consider the number of installs. One operator told us, "*...there are times when we may be managing between five and 100 installs in a day.*"

Better and more accurate installation also reduces maintenance costs. Technology that enables remote monitoring and operation from the NOC is also having a major impact on maintenance costs and make it easier than ever before for the NOC to have a clear picture of exactly what is happening throughout the network without having to send people into the field, unless there is a problem that cannot be resolved remotely. The more operators can control their networks remotely, the more cost-effective they are likely to be over their lifecycle. Some are even using technology to remotely control modems during installation. "*Even if the remote site has no VSAT or IP network, we can activate modems and uplink power control, we can remotely change the frequencies, and sometime change the data rate, via control from our NOC.*"



Understanding the ROI of VSAT Networks

Better technology and automation can have a massive impact on reducing those operational costs and resources. Advanced tools ensure accuracy and consistency across the network, which will lead to a better quality service for customers. To understand more ways in which ROI can be improved for these networks, download the full report from the WTA website. A webinar is also being hosted — ***Understanding and Improving the ROI of VSAT Networks*** (***worldteleport.site-ym.com/store/ViewProduct.aspx?id=9372792***) — during the Comsys VSAT Event (***www.comsys.co.uk/***) in September.

A New Technology Contender for TWTAs?

A Terrasat Perpsective

by Ron Merritt, Regional Vice President of Business Development for Euopre, Middle East and Africa, Terrasat Communications

Has the time come to consider GaN solid state Block Upconverters rather than TWTAs for higher power?

There has been a lot of press about Gallium Nitride (GaN) amplifiers and BUCs in recent years. Is this "new" technology really a contender to replace TWTAs in higher power applications?

Hub Ground Station Design

The higher power RF hub has been the domain of TWTAs (Traveling Wave Tube Amplifiers). Often, the TWTA is coupled with converters to upconvert the modem output from the 70 to 140 MHz Intermediate Frequency to the RF frequency at C-band, Ku-band, etc.

The history of this industry has been that SSPA manufacturers have continuously strived to increase output power in an effort to displace the market space occupied by tubes. Solid state power amplifiers deliver longer life and are less delicate than tubes. However, because they are lower gain devices, it requires combining multiple solid-state amplifier devices to achieve the output power of a single tube. Device cost, combining losses at higher power levels and removing heat from devices put economic limitations on increasing power with solid-state amplifiers.

GaN devices yield higher gain and higher power, reducing the quantity of devices required. GaN technology performance continues to improve, yielding higher power, gain, and more attractive packaging. However, the improvements do not come without challenges — more on those later.

First, consider the linear or effective usable power of a 200W GaN IBUC compared to a 400W TWTA. The terms used to rate TWTAs and SSPAs are quite different. What matters is how much linear or effective power is delivered at the output. Maximum linear power (P_{Linear}) is defined by the MIL-STD-188-164B stating that spectral regrowth is to be no higher than -30 dBc and third order intermodulation distortion (IMD3) to be no more than -25 dB relative to two carriers combined power.

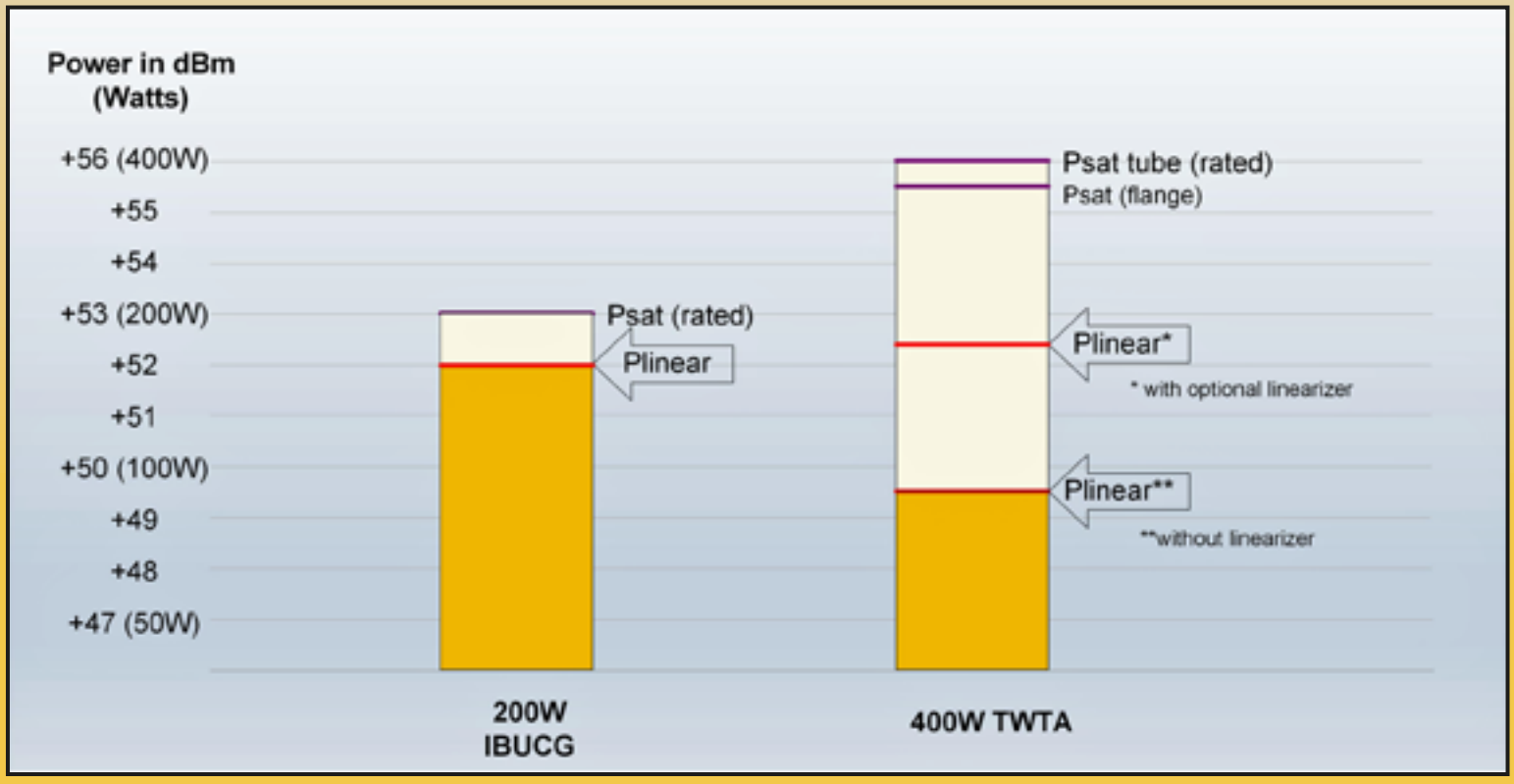
The chart below shows a comparison of linear output power illustrating that a 200W IBUCG delivers 2.5 dB more effective output power than a 400W TWTA. When the TWTA is equipped with an optional linearizer, the 200W IBUCG comes within 0.5 dB of producing the same amount of output power.

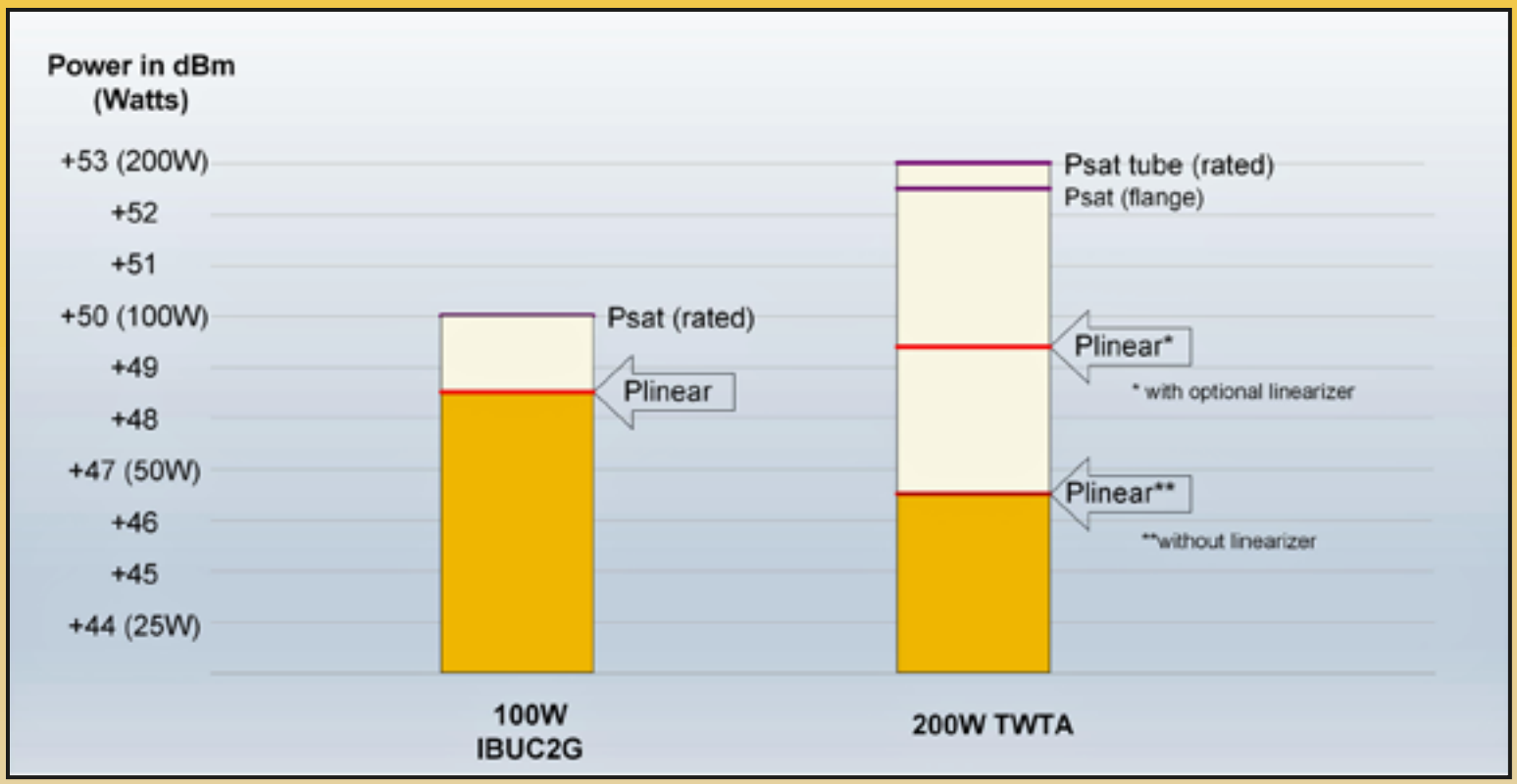
How can a 200W device deliver the same power as a 400W device? This comes down to different ways in which output power has been stated by tube and solid-state amplifier manufacturers. TWTAs are rated at the saturated output power of the tube. The HPA manufacturer will typically then state output power at the flange and provide an IMD3 specification. From that, one can calculate the P_{Linear} point meeting the MIL-STD definition.

On the other hand, SSPA output power is rated at the flange. For GaN amplifiers, that is stated as the saturated output power level (P_{Sat}). The manufacturer will then state the P_{Linear} output relative to P_{Sat} according to the MIL-STD on their data sheet.

This is the crucial point. P_{Sat} in a sense does not matter. It does not provide a useful value when comparing dissimilar amplifiers. In comparing TWTA to solid-state amplifiers, it is the linear power — the effective or usable power — that matters.

It is necessary to normalize to P_{Linear} to compare two amplifiers. In a well-implemented GaN BUC/SSPA, the amount of back-off required to achieve P_{Linear} is much less than that of a TWTA. That is what is seen in the example below. A 200W Ku-Band IBUCG only needs 1 dB of output power back-off to meet the P_{Linear} definition. A TWTA requires 6 to 7 dB of back-off. That can be improved to 3-4 dB with the linearizer option. However, a linearizer adds cost and complexity that also must be factored into the decision-making.





100W Ku-Band IBUC2G to 200W TWTA Comparison

Advantages in Mobility

Size and weight are often critical issues for mobile systems. A constraint with GaAs (Gallium Arsenide) solid state amplifiers has been the amount of space required to combine and cool multiple devices. With the higher power density, GaN technology enables the RF unit designer to pack more power into a smaller space. A GaN IBUC2G weighs half as much as an equivalent output power TWTA and occupies much less than half the space.

Like the higher power hub example, a 100W Ku-band IBUC2G will deliver more effective output power than a 200W TWTA without its linearizer option — in a much smaller and lighter package.

An additional feature of GaN amplifiers is that they are more efficient in power consumption. Again comparing to equivalent linear power TWTAs, there is now little difference in the amount of power each consumes.

Challenges

As mentioned previously, there are challenges. There always are tradeoffs in RF design. GaN amplifiers have different performance characteristics than GaAOne of the most noticeable differences is that the GaAs power transfer curve is linear. Each 1 dB of additional input transfers to 1 dB of power output.

With a GaN amplifier, in the usable range, a 1 dB increase in input results in something less than 1 dB in output power. It is possible to compensate with an AGC loop where the gain of the driver amplifier is adjusted to keep overall gain of the unit constant. This could come into play in Uplink Power Control systems for example.

Another characteristic of GaN amplifiers is that there is a limitation where further output power back-off yields no improvement in spectral regrowth and IMD3. That is, there is a "floor" where the intermodulation distortion performance does not get any better. This can be a factor in multicarrier operation where IMD3 is the key performance requirement. When planning a multicarrier hub, it would be prudent to consult with the manufacturer.

Driving the Change

Over the last 15 years the industry has largely made a transition from IF modems, converters, and HPAs to L-band modems with Block Upconverters. Cost, reduced complexity, and reliability drove the change. Today we are seeing a similar transition of upgrading from tubes to higher power SSPAs. The reasons are similar — simpler, more robust design at a comparable or reduced cost. In the future expect to see even higher power SSPAs covering more bands.

http://terrasatinc.com/

Ron Merritt is Terrasat Communication's Regional VP Business Development for Europe, Middle East and Africa. He has over 25 years of experience in the microwave and satellite industry involving projects for satellite ground stations, terrestrial links, and airborne systems.

Innovation: Differentiation Through Performances

A Phasor Focus

by David Helfgott, Chief Executive Officer, Phasor

With the commercial launch of Phasor's unique flat panel, Electronically Steered Antenna (ESA) rapidly approaching, the commercial, passenger mobile broadband services market is eager to learn more about how the antenna's benefits can be reaped — the time has come to address the factors that set this technology apart from other offerings.

Phasor has already received positive feedback from industry insiders who acknowledge the ESA's impressive performance and the unit's sleek design. With their ESA, Phasor has focused on empowering the commercial mobility market, satellite operators and service providers.

Today, airlines, high speed passenger rail companies, cruise operators and yacht owners are dependent upon reliable, ubiquitous mobility networks to support a range of activities from entertainment and network connectivity to mission critical applications on-board.

For business and leisure travelers alike, broadband access on board their selected mode of transport has become a crucial portion of their journey. For train commuters who want to check on their emails in advance of arriving at the office or use their mobile devices to remain in touch on social media or for viewing their favorite TV show, a basic requirement for all users is a reliable broadband connection. The expectations of passengers have grown to the point where they expect to be able to access everything that they receive at home or in the office, and on the move, from business presentations to video chats.

For companies that operate aircraft, vessels, trains and other land vehicles, true mobile broadband is rapidly becoming the essential tool that enables them to run a more efficient and profitable business.

For airlines, mobile broadband brings opportunities to streamline aircraft operations. In addition to the rapid growth in demand for high-speed passenger Wi-Fi connectivity, the "Internet of Things" (IoT) has headed skywards, offering the promise of telematics information to help drive aircraft operational efficiency.

On board cruise ships, mobile broadband enables multiple services, such as retail, banking and hospitality that would ordinarily place big demands on communications infrastructure, especially as these requirements expand. The ability to offer a high standard of connectivity to passengers on board is a differentiating factor and also helps to streamline cruise ship operations.

For train operators, access to broadband connectivity enables monitoring of the equipment on board and the provisioning of updates on the train's status along the route. Crew communications are also enhanced through the use of VoIP, messaging and alerts, plus essential information can be shared such as scheduling, track conditions, security and logistics updates.

Both service providers and users demand an antenna system that is flexible, powerful and one that can reliably meet a wide range of requirements for high-speed services today and in the future.

What, exactly, does Phasor's technology offer that will benefit these aforementioned market sectors?

Performance

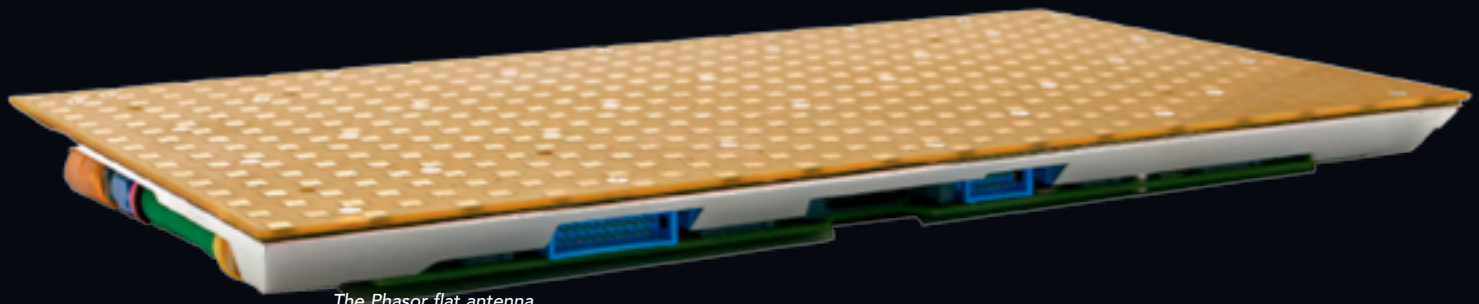
Phasor's unique and proprietary semiconductor-based system design allows for an extraordinarily high level of performance and flexibility. This fact has already been successfully showcased during a live demonstration that occurred at last years' Monaco Yacht Show — a single 70x70 cm Phasor array was able to close uplink speeds of up to 15 Mbps off-satellite, under real-life circumstances with a moving antenna array.

Scalability

Phasor's unique system design enables multiple "core modules" to be combined seamlessly without any prohibitive losses or complex and expensive coupling devices. This modularity allows for the creation of an ESA of almost any size, scaled to the desired requirement, from 40 centimeter to 2.4 meter arrays.

Design

In comparison with traditional domed, three-axis stabilized dish antennas, Phasor's solution offers a far more attractive, low profile and compact configuration that is easier to install aboard vessels, aircraft, passengers trains or vehicles of virtually any size. The Phasor ESA system is entirely solid-state and has no moving parts, resulting in a system that is smaller, flatter and lighter.



The Phasor flat antenna.

Unique Features

The Phasor ESA has broad functionality that far exceeds any traditional, mechanically steered VSAT system available on the market today. These outstanding features include instantaneous beam switching, extremely fast scan rates (>200 degrees/second) as well as a single or dual beam illumination per aperture that enables connectivity to two satellites from a single ESA at the same time.

The Phasor terminal can be either flat or conformal to the vehicle superstructure, (and still only 2-inches in height). This antenna can be a single/contiguous system or a distributed "logical" array made up of multiple independent ESAs acting as a single system in BOTH transmit and receive modes. The software-defined beam forming allows for dynamic control, tapering and adjacent satellite interference mitigation.

The Phasor antenna system has been designed to be "future proof", able to work interoperably with any satellite constellation in the same frequency band, and between various kinds of satellite constellations (Geosynchronous/High Throughput Satellites [GEO], and Low Earth Orbit [LEO] networks) giving unprecedented coverage and unrivaled flexibility to network operators and users alike.

As of this writing, there is nothing like Phasor on the market today….

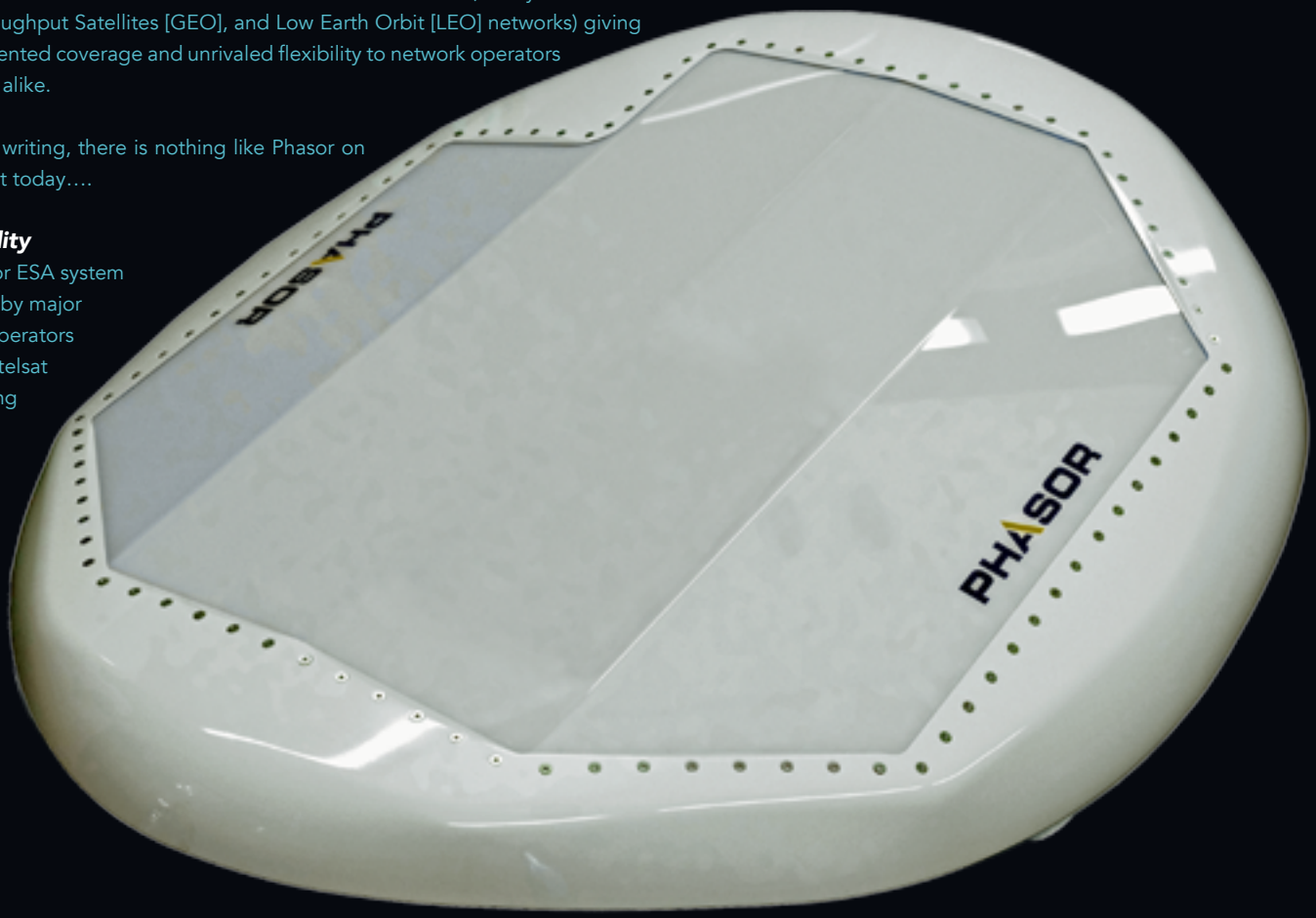
Availability

The Phasor ESA system is backed by major satellite operators such as Intelsat and leading network service operators such as OmniAccess, Gogo and Speedcast. Fully functional prototypes have been used for 'over the air' testing since September of 2016 and Phasor is currently on track to release the first commercially available products to the market in H1 2018, with a clearly defined product and feature roadmap.

For commercial airlines, rail companies, cruise operators, yacht owners and designers and their service providers, the Phasor ESA will make mobile broadband access faster, more cost-effective, more reliable and ubiquitous.

Phasor will be installed quickly and will require little maintenance. The antenna can be scaled to match user requirements and will work interoperably with diverse SATCOM networks. This is why Phasor's electronically steerable antenna will transform connectivity for the commercial, passenger mobile broadband services market.

To find out more about Phasor's groundbreaking technology, please take a look at the informational videos located at ***www.phasorsolutions.com***.



Innovation: Beam Hopping — The Next-Generation Satellite Technology

A SatixFy Spotlight

by Gil Shacham, SatixFy

How beam hopping enables the flexibility that is missing in the current generation of satellites and how this technology provides additional revenue opportunities for the next-generation of Ultra High Throughput Satellites (UHTS), that's the focus of this article.

High Throughput Satellites (HTS) have been a revolutionary satellite technology breakthrough that has occurred over recent years. HTS provided an excellent solution for data unicast/multicast oriented satellite networks. HTS increases the total capacity of the satellite by generating multiple small beams and re-using the available satellite spectrum multiple times. To overcome the interference between adjacent beams, the spectrum is divided to "colors," which are separated by frequency allocation and polarization.

A New Satellite Generation

Thirteen years have passed since the first introduction of HTS, and with that debut, the satellite industry has changed as well as usage models and use cases. HTS has enabled the industry to bring a significant reduction in the price of capacity as well as to provide larger amounts of capacity. HTS initiatives have had their fair share of challenges, technical and business. Among these challenges one can count:

- ***The growth of mobility applications*** — mostly inflight connectivity and maritime applications, where these applications require large capacity and beam changing, according to the trajectory of the user. HTS architectures struggle to provide high capacity to loaded beams while maintaining coverage to large areas in a cost-efficient manner.

- ***Low fill factors*** — an industry that was used to satellites with 70 percent fill factors, or higher, often sees much lower utilization in HTS architectures. Capacity is often not in the right place at the right time. Typically, HTS beams are created equal, while demand on the ground varies according to customer distribution. As a result, many of the beams experience over-capacity, while in others there are unmet capacity requirements and there is no way to institute load balancing. In other cases, demand changes throughout the day and the capacity is fixed. Revenues are lost in saturated beams.

- ***Increasing competition from terrestrial broadband*** — as terrestrial broadband — and especially cellular — continues to expand, the satellite industry faces intense competition. This drives satellite operators to lower capacity pricing as well as incorporating lower cost user terminals. To reduce the cost of the capacity, beam size must be reduced. This results in increasing spectrum re-use as well as increasing the effective power of the signal, which has the additional benefit of also reducing satellite terminal cost due to a decrease in the size of the antenna and RF, which are the cost bottlenecks.

- ***Increased satellite cost while CAPEX investments are stagnant or even declining*** — while HTS architectures provide more capacity than legacy wide-beam satellites, this comes at an increase of cost. This means that there will be fewer satellites launched and each satellite will be more expensive. At the same time, satellite operators are facing challenging times from their existing business, such as video end enterprise data. All of these conditions drive many satellite operators to reduce their CAPEX investments. A direct outcome is that satellite operators face more uncertainty and risk with decisions regarding HTS — payload design, number of beams, beam planning, coverage areas, and so forth.

These are exciting times, as the satellite industry is on the verge of introducing a newer generation of UHTS or Terabit satellites. In this new generation of satellites, designed to increase capacity, the coverage will be divided into many more smaller beams. In this manner, each beam will have a higher gain and will enable more capacity at even lower prices.

An additional outcome will be that smaller antennas and RF at the terminals or higher bits/Hz ratio will be enabled through the use of higher MODCODs. However, dividing the coverage to smaller beams increases the probability of having under-utilized beams.

To make Terabit satellites a reality, operators are adding flexibility to overcome the increased uncertainties they face, the most significant being flexibility as to where to allocate the capacity in time and location. This is where beam hopping plays a critical technology role.

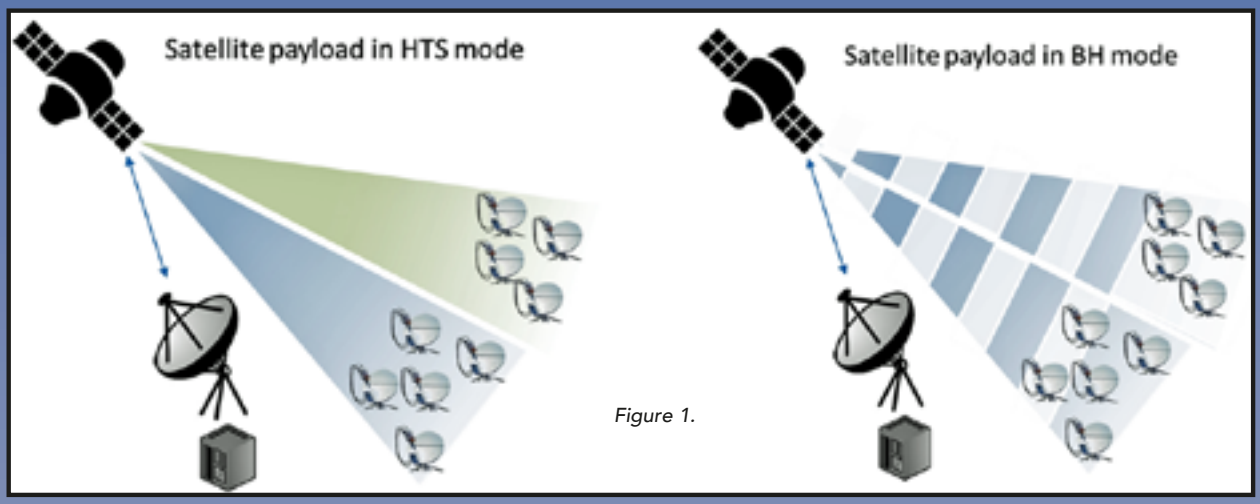


Figure 1.

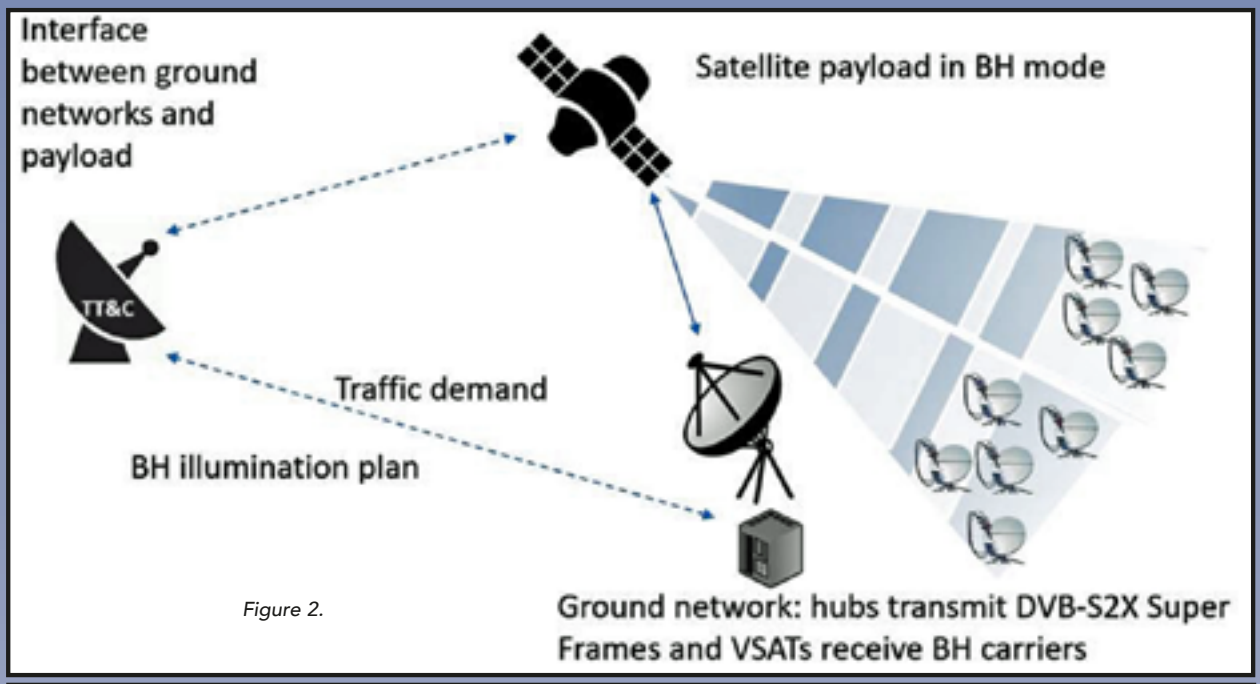


Figure 2.

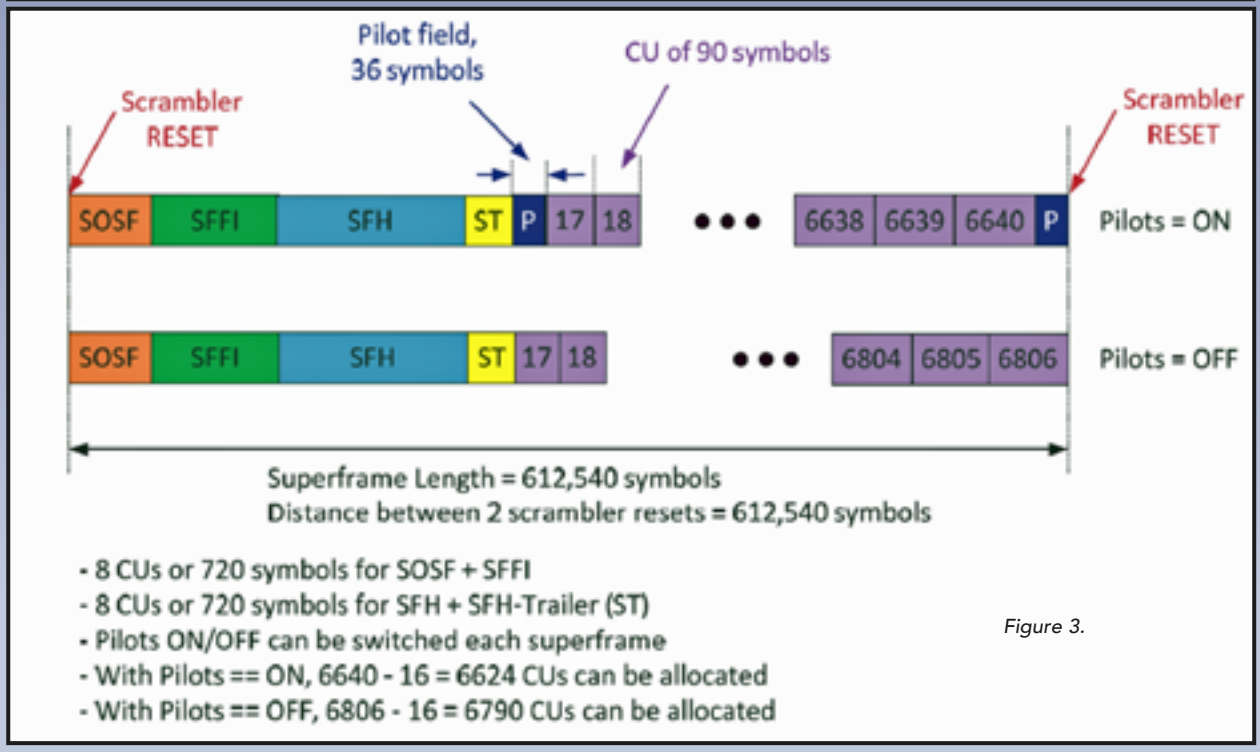


Figure 3.

What is Beam Hopping?

The ability to allocate capacity momentarily according to demand and therefore have a flexible capacity mapping is achieved by changing the traditional forward link transmission from continuous to time-based burst. The traditional color separation (frequency/polarization) is replaced by time division multiplexing over a single frequency carrier.

Customer data needs can now be measured constantly and capacity can be allocated to different beams, according to demand. The flexibility is achieved by changing the distribution of capacity in different beams on a time basis using a beam illumination plan that is communicated from the gateway to the satellite and can constantly change (*See Figure 2*).

The technology foundation for beam hopping has been incorporated into the new DVB-S2X standard, Annex E, which introduces the concept of Super Frames. The ability to receive a forward link carrier in a burst manner is assured by a higher layer of synchronization, which is based on a fixed length Super Frame. There are multiple types of Super Frames defined in the standard, with Super Frame type 4 being the most flexible (*See Figure 3*).

The Super Frame can hold multiple DVB S2/S2X Baseband frames and allows a guard for the satellite switching between beams. The use of SF goes hand-in-hand with an increase in the symbol rate per beam, up-to 500 Msps so that minimal delay is introduced by using a TDM

scheme (each Super Frame is ~1 msec long).

Satellite Operators and Service Providers Benefits

Revenue increase:

- ***Flexible capacity allocation that meets future demands*** — no need to design the satellite with uncertainty of data patterns. Capacity can be provided wherever and whenever required. The example below demonstrates the ability to change the capacity allocation over multiple time zones as peak hour changes across the U.S. and capacity needs to transfer from the east to the west coast. Revenues can increase by more than 50 percent just from this flexibility.

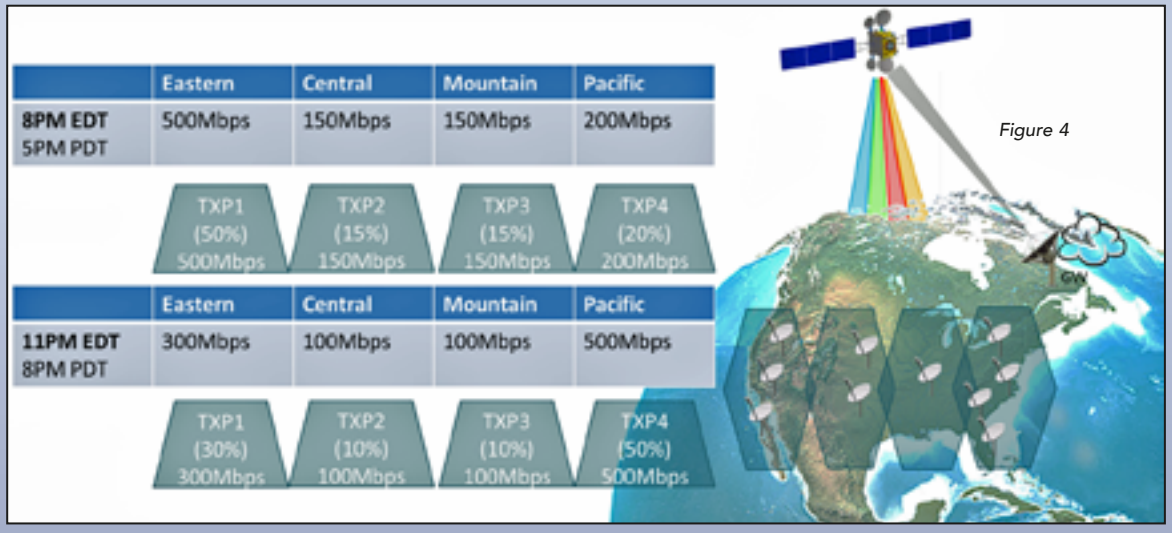


Figure 4

This is an illustration of peak hour shift in time. Residential Peak hour is 8PM. Peak hour spreads over 3 hours according to the relevant time zone in the U.S. Traffic needs to be allocated accordingly.

- ***Consumer/Cellular Backhaul in Beam Hopping*** (*See Figure 4.*)
- ***Interoperability between equipment vendors*** — multiple satellite systems from different vendors who follow the DVB-S2X standard can be operated on a single beam.
- ***Support wider geographical coverage and mobile traffic*** — beams can be allocated along critical aviation and maritime routes and be activated only when there is a need. The utilization factor can be easily doubled by introducing beam hopping concept for these applications.

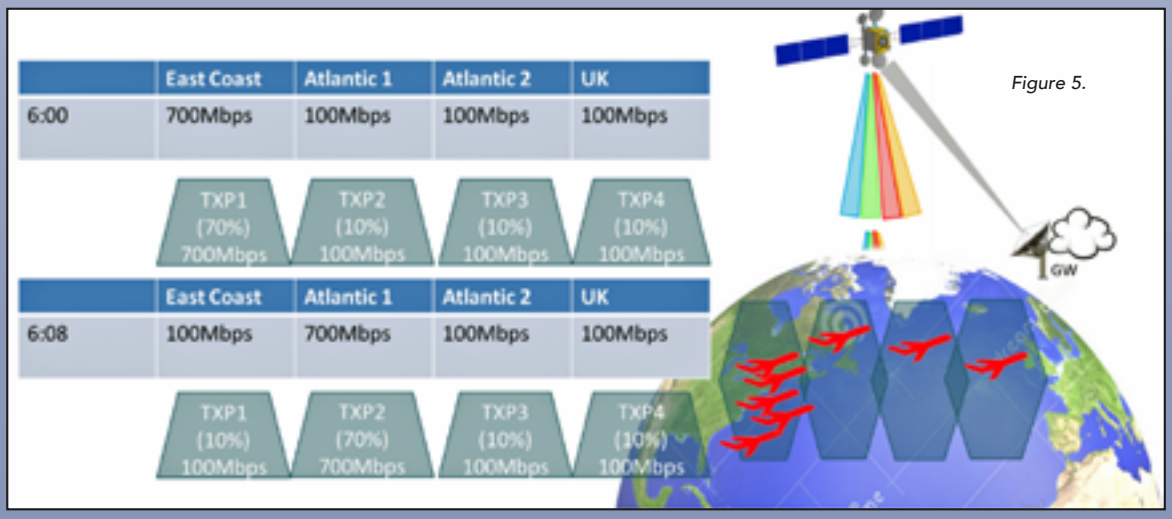


Figure 5.

This is an illustration of flight traffic allocation as the plane is moving through different regions during a cross Atlantic flight. There is a concentration of traffic due to typical flight itineraries from both sides of the ocean.

- ***Mobility network in Beam Hopping*** (*See Figure 5.*)
- ***Better performance with less interference (IBI)*** — separation between adjacent beams is now done on a time basis. No two adjacent beams will have transmission simultaneously, thus — no interference even when adjacent beams use the same frequency.
- ***Smaller antennas and RF CPE*** — a result of stronger beam signals on the ground
- ***Better bit/Hz*** — stronger signals enable the use of higher modulation schemes.
- ***High Spectrum utilization*** — the complete satellite spectrum can be reused, namely reuse factor=1. As there is no adjacent beam interference all the band can be used in any beam. This fact leads to more efficient use of the satellite power amplifiers, as well as offers advantages in statistical multiplexing.

Cost savings

Several research documents were published on the subject including a publication by the European Space Agency simulating the savings achieved by using beam hopping, which demonstrated:

- ***Lower satellite cost*** — due to reduction of number of TWTA per satellite and lower DC power consumption
- ***Lower ground segment cost*** — due to reduction of GW equipment

SatixFy's role

SatixFy is a provider of advanced satellite technology in the fields of modems, smart antennas and payloads, with a vision to make satellite communication affordable and widely spread. SatixFy's SX-3000 is the first industry available ASIC supporting DVB-S2X with Annex E Super Frame transmission and reception.

VSATs based on SX-3000 Software Defined Radio ASIC can receive 500 Msps beam hopping transmission (burst reception) and enable deploying terminals that will be future proof to the next generation of satellites. SatixFy also introduced a beam hopping testbed enabling satellite builders and operators study the effects of beam hopping networks prior to launching their satellites.

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Bulking Up the Business Case for GEO-HTS

An NSR Analysis

by Blaine Curcio, Prinicpal Analyst, NSR Japan

The phrase High Throughput Satellite (HTS) can, at times, understate the extent to which HTS technology is indeed a great leap forward for SATCOM.

Traditional FSS widebeam satellites have tended to see a capacity of around 20 to 50x 36 MHz transponder equivalents (TPEs), which equates to between ~1 and ~5 Gbps of capacity. High throughput satellites, on the other hand, oftentimes see capacity exceeding 30 to 40 Gbps, and in some instances, capacity of more than 100 Gbps.

Clearly, if all capacity is created equal, and if pricing were to remain stable, HTS would be an absolute boon to satellite operators everywhere — this is even more pronounced given the fact that the cost to manufacture and launch HTS is generally not that much more than traditional FSS, which is generally ~1-1.5x the cost.

However, the world we live in does not work as such, in the sense that not all capacity is created equal and prices are far from stable. Rather than being a boon for satellite operators, HTS has instead complicated the market, leading to overcapacity and falling prices.

This has complicated "*build it and they will come*" HTS business models, such as Avanti, which has found that offering cheap capacity post-launch on the open market is not a business model for success. This therefore begs the question of, how can satellite operators best monetize these significantly larger, but not that much more expensive assets?

First, the Challenges

One way of moving more capacity is to build out a distribution network that allows a company to sell into new, ideally larger/scalable markets. This might include, for instance, a satellite operator trying to build out a consumer broadband distribution network.

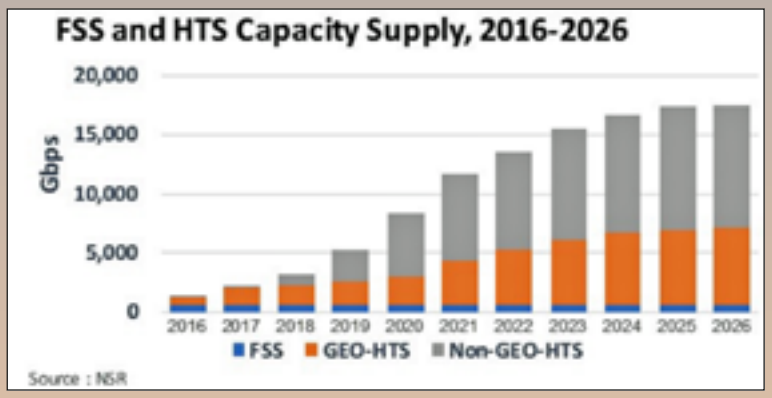
However, procuring a distribution network can be extortionately expensive, with an example being the 2009 purchase of WildBlue by ViaSat for $568 million. This purchase, aimed to help distribute capacity on the ViaSat-1 satellite that launched in 2011, ultimately cost significantly more than the satellite itself (~$400M).

Beyond the challenges of distribution network, building a scalable HTS platform will inevitably run into the challenge of demand/supply optimization. In short, a satellite with a few very large beams will generally have less capacity than a satellite with many small beams. However, a satellite with many small beams will tend to see some beams fill more quickly than others. When beams fill, customers on those beams will either need to see lower speed, lower availability, or both. This "beam saturation" has been a challenge for both Eutelsat in Europe and ViaSat and Hughes in North America.

How to Address These Challenges?

The most apparent way for a satellite operator to address the challenges of HTS is to bulk lease HTS capacity, ideally pre-launch. This presents some challenges as well, namely the decrease in bargaining power a satellite operator will see if a telco or service provider is responsible for delivering the capacity to the customer, with this likely leading to a large decrease in price paid for capacity.

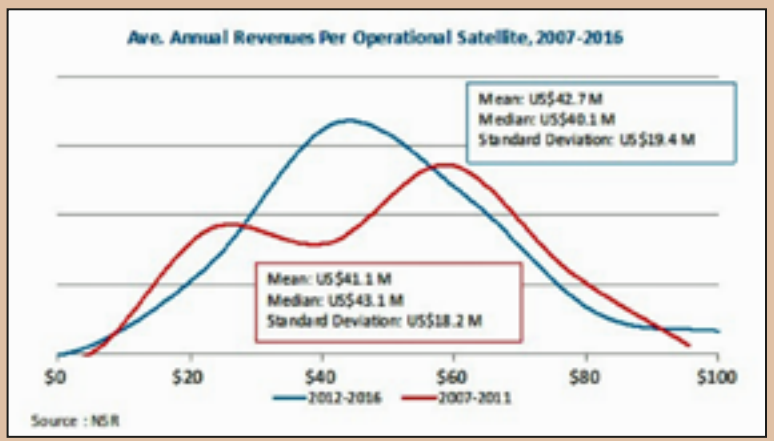
However, with the massively increased scale of HTS, even dramatically lower prices can and should lead to an increase in revenues. As discussed in detail in NSR's ***Global Satellite Capacity Supply & Demand, 14th Edition (****www.nsr.com/research-reports/satellite-communications-1/global-satellite-capacity-supply-and-demand-14th-edition/****)***, GEO-HTS supply will outnumber GEO-FSS supply by a factor of approx. 10:1 by 2026 (from around 1:1 today).



Selling the Whole Thing Wholesale

To take a real world example, late 2015 saw the pre-launch lease of the entirety of Telesat's Telstar-19 South America GEO-HTS coverage to Hughes Network Systems.

The 15-year contract obliges "***Telesat to deliver Ka-band capacity of 31 Gbps on Telstar 19 Vantage.***" To put into context the extent to which 31 Gbps is an extraordinarily large number for satellite operators, we can look at the data from NSR's ***Satellite Operator Financial Analysis, 7th Edition (****www.nsr.com/research-reports/financial-analysis/satellite-operator-financial-analysis-sofa-7th-edition/****)***, which finds that the average annual revenue per satellite across ~25 satellite operators was around $42M per year for the 2012-2016 period. Using this as a baseline, we can play with Telesat's 31 Gbps number to ascertain an approximate required price per Mbps.



If we make the generous assumption that the above-mentioned contract involves Hughes leasing all 31 Gbps every single month for the entire 15 year lifetime of the satellite, we arrive at a price of *$113 per Mbps* per month to reach $42M per year in annual revenues (see below):

31 Gbps x 1,000 = 31,000 Mbps X 12 months = 372,000 "Mbps months"

$42,000,000 / 372,000 = **$113**

This $113 per Mbps per Month price is an extraordinarily low figure. For context, historically anything in triple digits for Mbps pricing has been considered low, and even in today's low-price environment, ~$500 is considered cheap.

Therefore, even if Hughes is only paying for ~1/3 of the capacity at any given time, Telesat can still reach the industry average for annual revenues per satellite at a price of ~$350 per Mbps per month, e.g.

~10 Gbps x 1000 = 10,000 Mbps X 12 months = 120,000 "Mbps months"

$42,000,000 / 120,000 = **$350**

The above example is far from the only one of a satellite operator bulk leasing a large amount of an HTS payload pre-launch, and as the above arithmetic shows, there is room for what would be considered a large "wholesale discount" to a telco or other distributor. Other examples of this type of business model include SES bulk leasing much of the HTS capacity onboard SES-14/15 to IFC provider Gogo, Hughes do Brasil buying the entire Eutelsat 65 West A HTS payload over Brazil, and Gogo leasing a large amount of Intelsat EpicNG capacity for IFC. Last but not least would also include the ill-fated Facebook bulk lease of Amos-6 capacity that went up in flames in September 2016 in a pre-launch explosion, but the bigger picture takeaway is that HTS opens big and scalable markets.

Bottom Line

The implementation of HTS capacity has already disrupted the market for satellite capacity in more or less all regions. As NSR reported in its ***Satellite Capacity Pricing Index, 3rd Edition (****www.nsr.com/research-reports/financial-analysis/satellite-capacity-pricing-index-3rd-edition-q3-2017/****)***, prices have fallen dramatically over the course of the previous few years, and moving forward, this trend is expected to continue.

However, lower pricing does not necessarily equal lower revenues, with the total addressable market growing markedly. In a world increasingly dominated by HTS, the keys to success for satellite operators will lie in being able to sell capacity in bulk, while maintaining a degree of bargaining power and value-add. In the instance of operators like Avanti, which has pursued an "if you build it, they will come" strategy, the message is clear—satellite operators need to design GEO-HTS (or Non-GEO-HTS) payloads with anchor clients in mind, or ideally, with pre-committed anchor clients helping to design the system itself.

What was considered a "nice to have" in the satellite industry historically is increasingly becoming an absolute necessity for success.

www.nsr.com

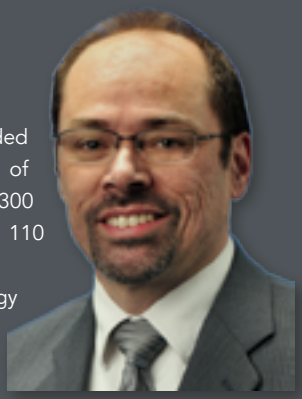
Mr. Curcio joined NSR in 2012, following a position as project manager in Shenzhen, China, and is the lead author of NSR's Global Satellite Capacity Supply & Demand (GSCSD) report, Satellite Operator Financial Analysis (SOFA) report, and Satellite Capacity Pricing Index (SCPI) report. As head of NSR's satellite finance practice, Mr Curcio's areas of coverage include development of HTS, how macro industry trends impact operator finances, and global satellite supply. He regularly leads consulting projects related to asset valuation, business model validation, and contract analysis.

Mr. Curcio has previously worked with SES in The Hague as a strategic marketing intern, where he helped develop a strategy to increase the company's share-of-wallet with key European customers. His prior consulting experience also includes a market-entry strategy project for SGS International, aiding the company's entry into the Mainland Chinese market. Blaine speaks English, Chinese, and Italian. He obtained a Bachelor of Science Degree in International Business from Illinois State University.

Innovation: Solar Array Success for SSL Implementation

A Space Systems Loral Focus

by Dr. Matteo Genna, Chief Technology Officer and Vice President, Product Strategy and Development, Space Systems Loral (SSL)



The Air Force Research Laboratory (AFRL), the Air Force Space and Missile Systems Center (SMC) and NASA recently tested a new type of solar array on the International Space Station (ISS).

This test validated the design for solar arrays that roll up for launch instead of folding like an accordion. The new design, which is being qualified for use by Space Systems Loral (SSL) on the company's SSL 1300 spacecraft platform, is a modular and scalable system that enables larger, more powerful spacecraft to be launched on today's launch vehicles.

SSL joined NASA and Air Force Research Laboratory in funding a company called Deployable Space Systems (DSS) in their development of this advanced power subsystem for spacecraft. In June, the Roll Out Solar Array (ROSA) was tested on the ISS, which paved the way for implementation on both commercial and government missions, which will require power ranges beyond the capabilities of conventional rigid solar arrays.

High Power for SEP

The array was delivered to the ISS on a cargo resupply mission and was positioned by a robotic arm built by MacDonald, Dettwiler and Associates Ltd. (MDA) in conjunction with the Canadian Space Agency.

ROSA uses rolled booms and flexible, light-weight mesh to support photovoltaic cells designed to power satellite payloads. ROSA is able to support a greater number of solar cells than a standard solar array, and can also provide the high levels of power required for spacecraft that employ large scale solar electric propulsion (SEP) systems. SSL is a leader in SEP and is the first adopter of this new array design. The company has provided extensive ground testing and development of ROSA's integration onto its evolutionary 1300 platform that has been proven on more than 110 commercial missions.

SSL is happy for DSS, whose innovative technology has now been successfully demonstrated in space. Over the course of more than five years of working together, SSL found DSS had the ability to translate creative ideas into flight hardware with high value and high reliability. The core technology used in DSS' design is the elastic roll-out, slit-tube booms, made up of multiple composite plies. Solar cells are mounted to a flexible fiber mesh, which is stretched between the booms. The booms and fiber mesh are rolled onto a mandrel for storage during transport and launch and are unrolled for deployment in space using the damped release of stowed energy in the booms.

The flight demonstration equipment tested in June was a small-scale version of the ROSA design; however, DSS has worked with SSL to develop a larger scaled version for use in SSL's commercial product line. The measurement data obtained during the on orbit testing validated the DSS analytical models, which will allow for scaled performance predictions. The successful ISS demo has helped to qualify the main mechanical components of ROSA, while SSL's ground testing efforts, which are near completion, will qualify the integrated ROSA blanket assembly at full scale.

Photo of the ROSA demonstration on the ISS. Image is courtesy of NASA.

ROSA technology is a key element in SSL's future product roadmap and the company expects that it will be valuable in the increasingly competitive spacecraft marketplace both for commercial and U.S. government missions. SSL has already proposed the ROSA array for several different spacecraft and expects to integrate it into a flight program very soon.

Design Benefits

The ROSA design offers a number of significant benefits over traditional rigid arrays. Top among these is its scalability to provide very high power, beyond what would be possible with traditional rigid technologies.

At power levels of 30-kW and above, ROSA is very mass and volume efficient. The simplicity of the design, which uses fewer mechanical components than rigid solar arrays, is expected to provide improved reliability, which is a key concern for satellite and spacecraft operators. In addition, the array's modular construction allows for multiple form factors and upgraded solar cell technologies with minimal changes to the basic qualified design. This extensive flexibility makes ROSA an attractive solar array solution for multiple spacecraft bus sizes and shapes as well as for applications requiring future growth options with minimal additional design work.

Power Capabilities

Power remains one of the biggest benefits provided by the ROSA design, which enables technology for very-high-power systems and surpasses the capabilities of rigid arrays. SSL has studied the development of a ROSA configuration that provides the power needed for NASA's Solar Electric Propulsion (SEP) missions — on the order of 50 kW or greater.

DSS has also demonstrated a prototype solar array for NASA called MegaROSA. This array is capable of delivering up to 500 kW and can be compactly stowed and then deployed using multiple ROSA winglets on a backbone structure. With this technology, NASA can plan future human exploration missions where high-powered solar array capabilities, along with high-powered electric thrusters, propel human habitats and cargo modules to planets such as Mars.

Future Mission Enabler

The AFRL successful flight takes ROSA from theory to real-world application, validating both the design and functionality of the system. When integrated with the SSL satellite platform, ROSA will be of great benefit to commercial and government space programs, providing the high power and high reliability that SSL is known for.

SSL commends DSS and the government agencies that have supported the program. The new solar array is an excellent example of commercial industry working together with the U.S. government on a new technology development that will benefit a plethora of missions. Implementing the new roll out solar array is one more step toward an ecosystem that will enable deep space exploration, habitats and missions that have not yet been imagined.

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Dr. Matteo Genna is the Chief Technology Officer and Vice President of Product Strategy and Development at SSL, where is he is responsible for advancing SSL's capabilities in a variety of markets. He directs the company's innovations in geostationary satellites, robotics, small satellites, and advanced systems for space infrastructure and exploration. SSL designs and builds innovative satellites and spacecraft systems and is a leader in commercial satellites for services such as direct-to-home television, video content distribution, broadband, mobile communications, and Earth observation.

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