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The launch of the One Web satellites. Photo is courtesy of Arianespace.

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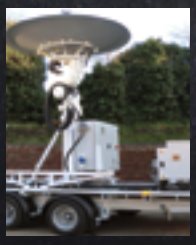

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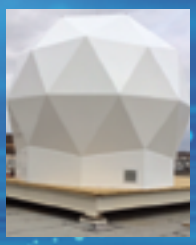

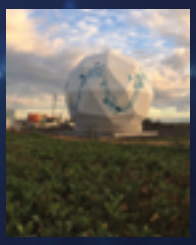

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Successful launch by Arianespace of the first six OneWeb satellites

Arianespace played a significant role in improving global connectivity with the Soyuz launch that deployed the initial six satellites in OneWeb's constellation, which will provide affordable high-speed internet access for users around the world.

The Arianespace Soyuz launch vehicle lifts the first six OneWeb satellites to orbit. Photo is courtesy of Arianespace.

The cluster of spacecraft — produced by the OneWeb Satellites joint venture of OneWeb and Airbus — was successfully deployed into a circular LEO on Arianespace's first Soyuz mission of 2019 (and the launch services company's second mission overall for this year).

Lifting off from the Spaceport precisely at the scheduled 6:37 p.m. launch time in French Guiana, the workhorse medium-lift vehicle delivered its payload during a flight lasting 1 hour and 22 minutes. Total payload lift performance was estimated at 1,945.2 kg.

After an initial powered phase of Soyuz' three lower stages, the flight — designated VS21 in Arianespace's numbering system —– included two burns of the Fregat upper stage to place its passengers at their targeted deployment point.

OneWeb is building the world's largest and highest throughput satellite system to connect everyone, everywhere — by land, air, sea with a vision to bridge the digital divide once and for all. The first six spacecraft will operate at an altitude of 1,200 km. in a constellation that will deliver extremely low latency for customers and provide communications access to the entire world with fiber-quality internet connectivity.

The initial constellation will be compromised of approximately 650 satellites and will scale to more than 900 spacecraft as it grows to meet demand around the world. OneWeb signed a contract with Arianespace in 2015 for a total of 21 Soyuz flights from three launch bases (the Spaceport in French Guiana; Baikonur Cosmodrome in Kazakhstan and Vostochny in Russia), to be performed through 2020.

The OneWeb constellation will support a wide range of markets, including aeronautics, maritime, backhaul services, community WiFi, emergency response services and more. The operator also is focused on connecting unconnected schools and working to bridge the digital divide for people everywhere.

This launch success marked Soyuz' 21st flight from the Spaceport since this vehicle's 2011 introduction at French Guiana, as well as the second Arianespace mission from this equatorial launch site in 2019 — following the heavy-lift Ariane 5 flight that orbited Saudi Geostationary Satellite 1/Hellas Sat 4 and GSAT-31 on February 5. With a busy launch schedule in 2019, Arianespace targets up to 12 missions from the Spaceport with Ariane 5, Soyuz and the light-lift Vega.

Arianespace CEO Stéphane Israël congratulated OneWeb in his post-launch comments from the Spaceport and underscored the importance of today's Soyuz success for both companies and said this initial mission makes this ambitious partnership —– built around the launch of more than 600 OneWeb satellite — a reality. He also announced that following this launch's success, Arianespace and OneWeb have reached an agreement that completes the current launch services order. This agreement is for OneWeb's

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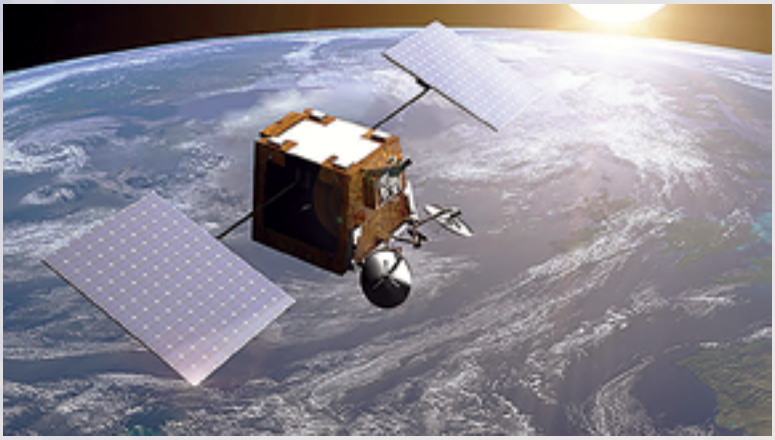

Artistic rendition of a OneWeb satellite. Image is courtesy of the company.

accelerate the development of the first truly global communications network by 2021. OneWeb's system will deliver high speed, low latency, seamless broadband access, everywhere on Earth. OneWeb's satellites, produced through its joint venture with Airbus doing business as "OneWeb Satellites", will ramp-up production this spring at its new, state-of-the-art manufacturing facility in Exploration Park, Florida. Following the company's successful launch of satellites on February 27th, OneWeb will embark on the largest satellite launch campaign in history. Starting in Q4, OneWeb will begin monthly launches of more than 30 satellites at a time, creating an initial constellation of 650 satellites to enable full global coverage. After this first phase, OneWeb will add more satellites to its constellation to meet growing demands.

use of Ariane 6's inaugural flight in its A62 version, as well as options for two future Ariane 6 missions.

Speaking at the Spaceport, OneWeb CEO Adrian Steckel noted the group effort of many participants, including Arianespace, that led to the launch and stated that the notion of doing good is deep in the foundations of the company — and OneWeb is looking forward to doing their part in connecting the world, together with the firm's partners.

Nicolas Chamussy, EVP—Space Systems at Airbus Defence and Space, acknowledged Arianespace's important role in this first step of establishing the OneWeb constellation and added the company thanks Arianespace for having delivered spot-on, providing world-class access to space.

In related news, OneWeb has secured their largest fundraising round to date with the successful raise of $1.25 billion in new capital — this brings the total funds raised to $3.4 billion and this round was led by SoftBank Group Corp., Grupo Salinas, Qualcomm Technologies Inc., and the Government of Rwanda.

The new funds, following the successful first launch of OneWeb's satellites, enable the company to

OneWeb's priority rights to a large block of globally harmonized spectrum and its Low Earth Orbit (LEO) constellation design will enable a unique combination of high speed, low latency, and truly global service. OneWeb's network will go beyond the limits of existing infrastructure, enabling connectivity for rural communities and schools as well as for business and industries that demand seamless global connectivity solutions such as Aviation, Maritime, Backhaul, and Land Mobility. OneWeb's customers will be able to develop and support a wide range of emerging applications that require real-time communication and collaboration.

OneWeb's network will provide services to billions and will support the emerging digital economy and advanced mobile application needs. To support the deployment of the system, OneWeb relies on high-tech satellite operation centers in both Virginia and in London, and has installed ground stations in Italy, Norway, and Canada, with more on the way. A global company, OneWeb now has offices in Virginia, London, Florida, California, and has recruited top talent around the world to execute the rollout of its system.

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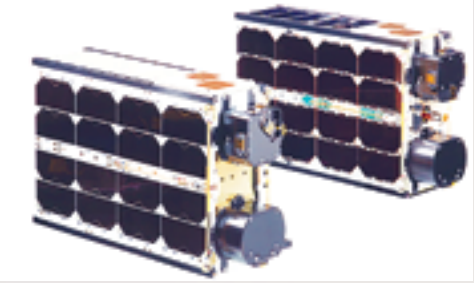
NanoAvionics smallsat orbital missions launch is upcoming

NanoAvionics has announced their upcoming launch of two orbital missions based on the firm's M6P nano-satellite (smallsat) bus.



The smallsat manufacturer and mission integrator uses innovative approaches to technology and business that makes a new generation of space applications possible. The launch of these smallsats will demonstrate how the company enables a faster, more responsive approach to space technology development.

Among the features of the M6P bus is a pre-integrated design that shortens development cycles. In addition, NanoAvionics' ridesharing program lets several customers conduct technology demonstration missions at a fraction of the time and cost of a dedicated space mission.

The satellite, BlueWalker 1, is the first of a series of satellites for AST & Science and is to be used for testing the company's patented technologies in space. The two companies are partnering to take advantage of NanoAvionics' buses, power systems and services for this and subsequent AST & Science missions during the coming months.

Such a rapid tempo of space missions is the direct result of NanoAvionics' design approach. The subsystems in each M6P bus are pre-integrated and pre-qualified. This allows the integration of customers' payloads to begin immediately, saving both time and money.

Vytenis J. Buzas, the CEO of NanoAvionics, explained that it only took one month to manufacture "BlueWalker 1" and integrate its payload, with the mission demonstrating how NanoAvionics' pre-integrated smallsat bus enables faster, more responsive approaches to advancing space technology readiness.

The second smallsat — M6P — is a ride-share mission that will host payloads from two Internet of Things (IoT) communications companies. SpaceWorks Orbital and Lacuna Space are each developing satellite-based communications systems for a new generation of low-power IoT devices.

SpaceWorks Orbital will complete a multi-year development effort with its patented IoT radio technology by demonstrating ground-to-space communication with the M6P spacecraft while on orbit, validating the company's low-cost IoT architecture for its Blink Astro business line.

In parallel, Lacuna Space will receive LoRaWAN signals from terrestrial IoT devices and relay the data through the company's cloud-based Lacuna Network to participants in Lacuna Space's beta program. In addition to supporting the ride-sharing missions, NanoAvionics will demonstrate some of its recently-developed nano-satellite technology on the "M6P" flight.

A dedicated satellite would be overkill for technology demonstrations such as these. By sharing an M6P bus's up to 5U payload volume, project teams can divert resources to other essential tasks. M6P bus standardized hardware and software interfaces several times accelerate satellite integration timeframe as well as help to define interface for payload.

Access to M6P FlatSat, which is granted to each customer, allows to develop and test payload software and simulate all operational aspects of their mission. Also, the Rideshare service relieves the burden of launch integration and logistics, frequency allocation and satellite operation while it's in orbit for NanoAvionics customers.

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InfoBeam

Phasor's ESA systems to be manufactured by Surface Technology International

Phasor has engaged manufacturer Surface Technology International (STI) to initiate the production of the company's ESA systems.

STI is a specialist Contract Electronics Manufacturer, serving world-class customers in high-reliability industries by providing a complete set of electronics design and manufacturing solutions in both printed circuit board assembly (PCBA) and full box-build manufacturing.

Headquartered in Hampshire, UK, and part of the AC Industrials group, STI has decades of experience in the manufacture of complex aerospace, military and SATCOM systems. This will ensure that Phasor can successfully ramp up production as required with a partner that is located within easy reach of Phasor's London Technology Center.

In contracting a trusted manufacturing partner, Phasor can continue to focus on its core competencies in advanced ESA technology development, product design, and market development.

Phasor's low profile (2-inches high), low weight, solid-state electronically-steerable antenna has no moving parts, making it more reliable and resilient than mechanically steered antennas.

The modular, dual-beam architecture of the Phasor ESA provides resilience and interoperability between geosynchronous high-throughput satellites (GEO HTS), and non-geosynchronous satellites (Low Earth Orbit [LEO] and Medium Earth Orbit [MEO]) satellites.

Simon Best, STI Managing Director, said the products will be manufactured in the STI Poynton facility, an industry-leading center manufacturing high-quality electronic systems and the company looks forward to seeing Phasor grow in this rapidly expanding market.

David Helfgott, the CEO at Phasor, added that STI brings vast experience to the table and consistently reaches the highest technical standards within demanding timeframes to offer a manufacturing solution with world-class technical competence.

He added that this is essential as the company moves into commercial production.

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Rohde & Schwarz satellite amplifiers empower SES 8K satellite broadcast

By Christian Baier, Product Manager, Satellite Amplifier Systems at Rohde & Schwarz.

We live in interesting times. Just a few years ago, High Definition TV provided viewers with a quality of experience that provide a 'WOW' factor and was guaranteed to maintain their loyalty to the channel. Today, HD is accessible over a diversity of smart devices and has become the norm.

In an effort to attract viewers, broadcasters constantly strive to achieve a better quality of experience. By the time the next Olympic Games arrive in Tokyo, host broadcaster, NHK, has declared its intention to produce coverage in 8K.

This ambition is creating ripples on a global scale. In Europe, satellite operator, SES, has for the first time broadcast an 8K television signal via its satellite system. The broadcast happened last May during the SES Industry Days in Luxembourg. In this demo broadcast, the uplink signal transmission was enabled using R&S PKU100 Ku-band satellite uplink amplifier from Rohde & Schwarz.

This new satellite amplifier is proving capable of creating significant new opportunities for satellite operators. In this article, Rohde & Schwarz's Christian Baier explains how these amplifiers differ from traditional tube-based designs and what advantages this brings to the user.

SES 8K satellite transmission showcase

So, to start this story, let's first understand a bit more about SES's Luxembourg 8K satellite transmission showcase.

Using the DVB-S2X standard, SES transmitted an 8K TV signal on a single 36 MHz transponder via its Astra 3B satellite. The demo video had a staggering resolution of 7680 x 4320 pixels (8K), which is four times higher than for 4K. The signal was encoded in HEVC and transmitted at a rate of 80 Mbit/s. The 8K content was broadcast with a frame rate of 60 frames per second and 10 bit color depth. A native IP-formatted signal was used in addition to learn about the requirements to be met for a fully IP-based broadcast infrastructure.

The Rohde & Schwarz R&S PKU100 satellite amplifier was used in the demo broadcast to send the HEVC encoded signal to the satellite. It features adaptive linearization for improved signal quality, enabling network operators to transmit significantly more data using the same signal bandwidth – ideal for 8K transmission. Thomas Wrede, Vice President, New

Technology & Standards at SES Video, comments: "Even though 8K resolution is not yet commercially relevant, we have shown that our satellite network is able to deliver 8K content. We are proud to provide an insight into the future of television. Rohde & Schwarz has made a valuable contribution to this achievement."

Satellite uplink amplifiers

With our rich heritage in broadcast, we are continually seeking for new opportunities where we can leverage on our experience in designing and manufacturing high power transmission equipment for demanding 24/7 applications and new satellite-based markets to establish. One critical area of satellite technology is the amplifiers which are used within ground-based equipment to uplink signals to satellites.

At Rohde & Schwarz, we have a proven track record stretching over more than six decades in the field of high power RF amplifier design. Our products were initially designed for terrestrial transmission applications but the portfolio has been successfully widened to include a diversity of applications including communications, scientific, EMC and design and product validation.

The reason for our entry into the satellite uplink amplifier market today is the opportunity we have to apply significant advances in solid-state transistor technology, which could impact the entire market. Traditionally, high-power ku-band satellite uplink amplifiers are tube-based devices. The tube-based product is proven technology which is relatively compact and lightweight and offers good operating efficiency. However, there are some long-standing issues with tube-based amplifiers which can make their operation problematic. After first powering up the tube takes a period of time to warm up, thereby delaying system operation, plus when the tubes are subject to failure then the entire system stops operating. An alternative is solid-state amplifiers, however they have only been available in low-power categories so far and just recently, high power solid state amps have become available but are still relatively large and heavy.

At Rohde & Schwarz, our goal is to substitute traditional tube technology with the latest advances in solid state transistors. Working at high frequency, the big challenge is to design a clever heat sink concept to keep the transistors cool which increases their lifetime and performance and to come up with a compact topology for the RF components with as little as possible attenuation caused by the insertion losses of power splitters, combiners, connectors and cables. Also, we sought to develop a product that is easy to integrate within existing satellite systems, is compact, lightweight and efficient in its use of power. After a great deal of in-house R&D, we have succeeded in every respect.

Using the latest transistor technology, we have developed a new family of solid-state amplifiers which combine the best of both worlds and offer users new and radically different functionality. Importantly, if transistors fail during operation, the amplifier continues to operate with reduced output power. With no high voltages used within the product it is easy to maintain and it offers a significantly longer operating lifetime than its tube-based counterpart. Moreover, it is possible to equip the R&S amplifiers with redundant power supplies, both for AC and DC operation, so that a power supply failure does not stop the operation of the amplifier.

We have developed two power classes for our uplink amplifiers: 400W and a 750W models will be available as outdoor and indoor units and for the two frequency bands 12,75 GHz to 13,25 GHz and 13,75 GHz to 14,5 GHz. The amplifier can be used in large scale fixed satellite installations serving customer applications such as broadcasters, telecom & internet service providers, financial institutions, government and non-government organizations. At the same time, the smaller amplifier can also be used for mobile, vehicle-mounted satellite applications.

What is so important about signal linearization?

One of the most important features of the PKU100 is adaptive linearizer, which provides outstanding signal quality and makes the PKU almost 100% linear within 100MHz signal bandwidth. Signal linearization has been a feature found in several tube-based amplifiers but until now it has not been possible within solid-state amplifiers.

The R&S PKU100 comes with optional adaptive linearization. Within satellite uplink amplifiers signal linearization is critical since it produces a significantly cleaner signal from the amplifier. The linearization has two effects: first it improves the inband signal quality which means better MER (Modulation Error Rate) respectively better EVM (Error Vector Magnitude) or NPR (Noise Power Ratio), which makes the signal easier to receive. Secondly, linearization yields much better out of band performance, i.e. significantly better shoulder attenuation which translates into lower adjacent channel power and therefore less influence on neighboring channels on the satellite.

Conclusion: a new approach for today's drive towards UHD and beyond

A key aspect is the selection of the modulation scheme for transmission. Today, the de-facto standard is DVB-S2, and the trend towards ever higher data rates, required for the transmission of 4K or 8K video for example, compels the use of higher order modulation formats in the future which are already defined in the DVB-S2X standard.

With its built-in signal linearization, the new R&S satellite amplifiers provide much better amplifier performance and offer potential for higher order modulation formats such as 64 APSK or even 256 APSK. It enables the user to extract the most from the available resource in a gallium nitride transistor.

As a consequence, satellite operators will need a significantly less powerful amplifier to transport more data across the same satellite. At a time when energy saving and increased efficiency are key drivers in the satellite communications market this is important news. Our amplifiers are easy to transport and come in a compact enclosure: an issue which will drive a change in technology replacing tube-based amplifiers with an innovative design of solid state solution.

In many respects the R&S PKU100 family represents a quantum shift in satellite uplink amplifier technology – the world's first solid-state amplifier with automatic adaptive signal linearization offers the best of all worlds.

In the current economic environment where organizations are constantly striving to do more with less resources, the introduction of the R&S PKU100 will be a high-water mark in the international satellite market. The product will be showcased on the Rohde & Schwarz booth (# SL6405) at NAB – come along and see what all the fuss is about!

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InfoBeam

Axelspace and ODYSSEUS Space take on the world

These two companies will be combining their talents to deliver Earth Observation (EO) images directly to Taiwan of the entire Earth from the new AxelGlobe constellation.

Axelspace Corporation, a Japanese company specializing in small satellite platforms development, and ODYSSEUS SPACE, a Taiwanese company developing space technologies for small satellites will provide Earth Observation data in Taiwan from the new AxelGlobe constellation.

AxelGlobe is the Earth observation infrastructure for a new era. It will have the ability to image the whole civilized world with a resolution of 2.5 m—enough to distinguish large cars—every day.

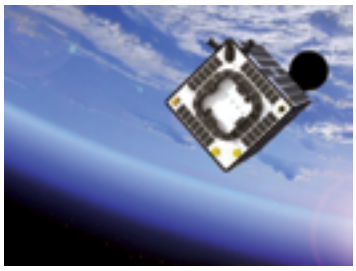
Axelspace has begun the development of AxelGlobe, an Earth observation service based on a multiple-satellite single plane constellation. With it, they will be able to obtain imagery of more than half of the planet's dry land once every single day, with consistent imagery at 2.5m resolution. As a first step to construct the constellation, the company launched the first satellite named GRUS on December 27 last year.

The first light from the satellite was successfully shared and the commercial service is to begin in May 2019. After that, Axelspace expects to launch three more GRUS satellites in 2020 and to complete the entire constellation by 2022.

Jordan Vannitsen, Chief Executive Officer and co-founder of ODYSSEUS Space said this is a great opportunity for Taiwan to gain large access to such fast revisit time high-quality imagery. There is a real hunger for consistent Earth Imagery data with high revisit time, and Taiwan is the perfect place to reach to startups who want to develop innovative applications for Smart Cities, Green Energy or Disaster Management. There is a huge burgeoning and enthusiastic entrepreneur community with great novel ideas here, and with this agreement, they want to help them to change how Earth Imagery is part of everybody's life. With a partner like Axelspace, who has a reputation of high quality and high performance platforms, they are very confident that this will be reflected on the quality of the data and of the service.

Developing an ecosystem in Taiwan where ODYSSEUS could have access to visual data processing expertise will be key for their own future space resources prospection activities.

Yasunori Yamazaki, Chief Business Development Officer for Axelspace added that the ODYSSEUS SPACE Team has been a great help to



understand the Taiwanese market and reach to key actors in the local space industry, but also to the startup ecosystem. Taiwanese government has been receptive so far and they want to keep working in that direction with ODYSSEUS. Because of its size and high-tech environment, Taiwan will become the perfect laboratory to try new ideas and business models.

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InfoBeam

Marlink's hub and uplink station installed for Mahd Satellite

Marlink's partnership with Mahd Satellite has been further cemented with the installation of a new Terralink Hub and RF uplink station at the company's headquarters in Muscat, in the Sultanate of Oman.

The flexibility of this fully-managed network operator service from Marlink enables Mahd Satellite to offer a comprehensive range of VSAT communications capabilities for its customers while controlling the infrastructure to function within the country's regulatory framework.

Marlink's managed Terralink Hub service supplies a complete end-to-end VSAT connectivity solution which features 24/7 Level 2 monitoring and control plus full marketing and engineering support, with value-added IP services including internet backbone access, routing, firewalling and a customer portal.

For Mahd Satellite, the breadth and adaptability of the Terralink Hub's managed service translates into a highly efficient and cost-effective means of meeting network capacity requirements and providing internet access for end-users to access diverse applications from business-critical email and video streaming to web browsing and support of internet apps. The service is specially adapted to sectors including defence, oil and gas, security, telecoms and IT, construction and utilities.

Kevin Thorley, Head of Sales Middle East, Marlink, said the installation of the firm's versatile Terralink Hub on Mahd Satellite's premises in Oman signifies a promising development in the continuing alliance between the two companies.

Not only is this an affirmation of the satisfaction which these connectivity services have already delivered, complying to a set of extremely specific parameters, but also accentuates the company's commitment to facilitating business development for partners in the Middle East.

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InfoBeam

The Vega launch of Italy's PRISMA satellite another success for Arianespace

Vega begins its ascent from the Spaceport in French Guiana, carrying Italy's PRISMA Earth observation satellite on the third Arianespace mission of 2019. Photo is courtesy of Arianespace.

Arianespace's third mission of 2019 — which marked the Vega rocket's 14th consecutive success — orbited the Italian PRISMA Earth Observation (EO) satellite tonight, bringing the total number of spacecraft lofted by the launch services company to 600 — this was the 308th flight overall of an Arianespace launcher.

Vega deployed the payload into Sun-Synchronous Orbit (SSO) during a 54 minute mission performed from the Spaceport in French Guiana. The PRISMA satellite had an estimated liftoff mass of 879 kg., with the Vega launcher delivering a total payload lift performance of 953.5 kg. — which included integration and deployment system hardware.

PRISMA (PRecursore IperSpettrale della Missione Applicativa) was produced for the Italian ASI space agency by OHB Italia as prime contractor, with Leonardo responsible for the EO system.

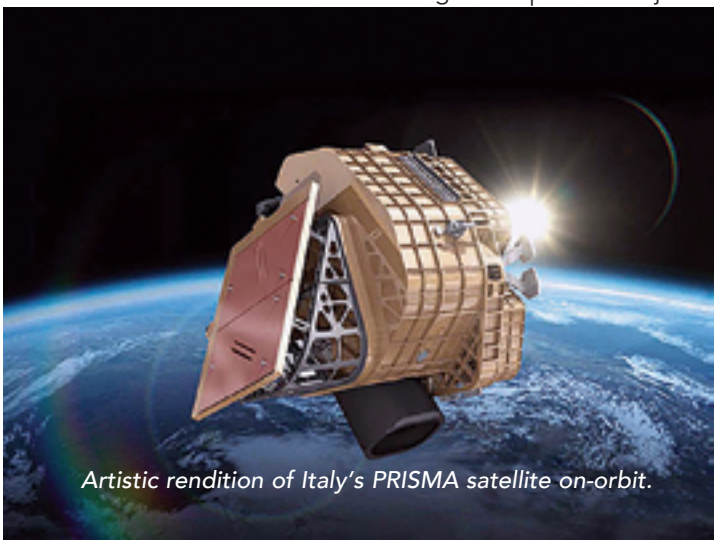
Operating from LEO, the satellite is designed to provide major applications for protection of the planet and for Italy's national environmental safety.

PRISMA is equipped with a state-of-the-art electro-optical instrument with a medium-resolution camera and an innovative hyperspectral sensor.

Once operational, PRISMA will provide data for environmental monitoring, resources management, the identification and classification of crops, the fight against pollution and other uses.

Designated Flight VV14 in Arianespace's launcher system numbering system, this mission underscored the company's role in deploying EO satellites, as PRISMA was the 70th spacecraft orbited by the company for this type of application.

It was highly appropriate that PRISMA was orbited by Vega for Italy, as this lightweight launch vehicle is delivered for launch to Arianespace by Italian production prime contractor AVIO.



Artistic rendition of Italy's PRISMA satellite on-orbit.

Flight VV14 followed Arianespace's two previous year-opening successes in 2019: the first, performed on February 5, using a heavy-lift Ariane 5 to place the Saudi Geostationary Satellite 1/Hellas Sat 4 and GSAT-31 communications relay platforms into geostationary transfer orbit; while the second employed a medium-lift Soyuz vehicle on February 27 to deploy the first six satellites into a circular LEO for the OneWeb communications constellation.

Luce Fabreguettes, Arianespace's EVP — Missions, Operations & Purchasing, said there was no better way for Vega to start the year 2019 than with this 14th success in a row. The PRISMA satellite is fully in accordance with Arianespace's motto: Space at the service of a better life on Earth.

Following the launch, Arianespace CEO Stéphane Israël said that with this successful launch of the PRISMA Earth Observation satellite, Arianespace has orbited its 600th satellite. The company is proud to continue performing the firm's primary vocation of ensuring independent access to space for Europe, with a focus this evening on Italy.

Israël added that the mission, carried out for the Italian space agency, ASI, and the Italian industry consortium led by OHB Italia SpA and Leonardo SpA, illustrates the reliability of the Vega launcher, which has performed its 14th successful launch in a row.

Arianespace now has 9 Vegas and Vega Cs in its launch order backlog.

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InfoBeam

Kymeta and Airbus deliver hybrid connectivity to Peru

Kymeta has demonstrated their hybrid, one-source connectivity platform during a recent pilot program throughout Peru with the assistance of their partners Intelsat, Cubic Telecom, and Cradlepoint — the firm also worked with Airbus to create SmartBus, an innovative project, in partnership with the World Bank and with the support of the Ministry of Transport and Communications of Peru (MTC), which aims to gather data on road safety and other statistics to improve Peru's transportation while connecting people in difficult geographical areas of Peru.

Buses owned by TEPSA, a pioneering inter-provincial bus line, were outfitted with Kymeta satellite terminals that leveraged satellite capacity from Intelsat, cellular coverage from Cubic Telecom, and a software-defined wireless WAN solution from Cradlepoint. This enabled information to be gathered and transmitted in real-time across a 742 km. route through urban and rural areas of Peru. Kymeta demonstrated a similar solution featuring this unique hybrid network approach at Mobile World Congress in Barcelona, February 25-28, 2019.

Using Kymeta's hybrid satellite-cellular solution, the SmartBus is enabling uninterrupted connectivity in the country's most rugged and isolated terrain, while gathering and transmitting essential data with unprecedented precision. This will accelerate research into new technologies to provide connectivity to remote areas, along with satellite images provided by the Peruvian Space Agency (CONIDA).

The project will collect information about the state-of-the-road network between Lima and several cities at the edge of the jungle, and enable communications in rural areas, which are easily isolated in the event of a natural disaster.

The SmartBus pilot lays the foundation for a variety of industry applications for Kymeta's ubiquitous mobile connectivity platform, including commercial agriculture, fleet management, public transportation, and critical access for first responders.

Each use case requires uninterrupted connectivity and reliable access, data collection, and communication. Kymeta highlighted the hybrid network solution at Mobile World Congress using their new satellite and cellular connected vehicle, featuring a fully embedded Kymeta terminal.

Kymeta also announced the release of its whitepaper, A Hybrid Network Solution for Reliable, Wide-Coverage First Responder Communications. Accidents, disasters, and emergencies often cause physical damage to cell sites or network congestion, inhibiting first responders from access when it's needed most. The whitepaper highlights two field trials and features the solution for resilient and protected networks, and rapidly deployed infrastructure that can make a difference in life or death.

Alberto Rodríguez, Director of the World Bank for Bolivia, Chile, Ecuador and Peru, said this project is making a tangible contribution to development by connecting people in an extremely difficult geographical region of Peru.

Emmanuel Sauzay, SmartBus Project Manager within Airbus Defense and Space, noted that Kymeta has strong partnerships that, collectively, have provided Airbus with a one-source connectivity solution: cellular and satellite access, a platform for integration, plus solution management.

www.kymetacorp.com

www.airbus.com

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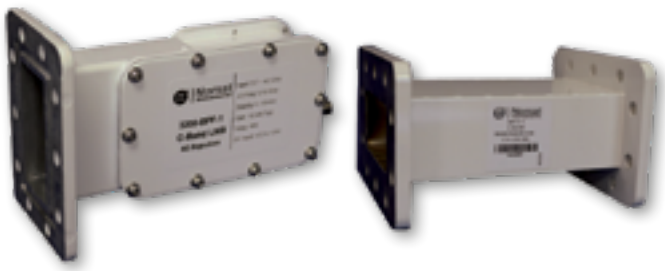
InfoBeam

Norsat International's product family solves 5G interferene issues

With all the news about 5G there are some issues that need to be addressed, and Norsat International Inc. ("Norsat" or "the Company") announced the launch of a family of products and solutions to address interference issues for the introduction of 5G within the C-band spectrum.



Norsat's 5G interference product family includes:

- *3200-BPF — This family of C-band phase-locked loop (PLL) LNBs can mitigate 5G signals up to -20 dBm with no performance degradation. This high-performance LNB can be used in conjunction with our BPF-C filters for greater rejection.*
- *BPF-C Band Pass Filter — Comes in a variety of frequency ranges with variable rejection offerings.*
- *Custom LNB and Filters — As every installation is unique depending on the antenna position relative to the 5G source, Norsat can also provide custom variants of these products to meet special requirements.*
- *Solutions — Norsat offers consulting services to provide complete solutions for existing networks experiencing 5G issues.*

This new series of products is ideally suited for existing installations or new installations needing to mitigate interference with the onset of 5G.

Dr. Amiee Chan, President and CEO of Norsat said that they are excited to bring these new products and solutions to market to address the increasing issue of 5G interference on C-band ground terminals.

Norsat is a pioneer in the satellite industry and has been working through interference issues on satellite terminals for years. They are pleased to be part of the coordination effort to ensure a smooth transition of 5G into the C-band spectrum.

These products are available now — first shipments are scheduled for Q2 2019.

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InfoBeam

Archinaut ground-based manufacturing and assembly completed successfully by Made in Space

As part of a NASA Tipping Point contract, Made In Space (MIS) has reached a significant milestone for their Archinaut program by successfully demonstrating its additive manufacturing and robotic assembly capabilities in a space-like environment.

During the Fall of 2018, the Archinaut system underwent thermal vacuum (TVAC) testing at teammate Northrop Grumman's Space Park facility in Redondo Beach, California.

TVAC testing simulates the thermal and pressure environment of a satellite in LEO to validate the technology readiness for the space environment. The testing is part of the Archinaut Technology Development Project (ATDP), funded by NASA's Space Technology Mission Directorate (STMD).

Made In Space successfully demonstrated Archinaut's additive manufacturing (3D printing) and robotic assembly capability in a simulated space environment, a key milestone that paves the way to operate in space.

During TVAC testing, MIS successfully demonstrated manufacturing and robotic assembly of a variety of structures. While inside the vacuum, operations were monitored and inspected by an internally developed camera system to validate proper printing and assembly operations.

MIS demonstrated autonomous reversible connection and joining techniques of 3D printed parts and other pre-fabricated components such as nodes and trusses via a robotic arm system and end effector designed for in-space assembly operations.

Furthermore, the robotics system is also capable of carrying out repair operations and can be integrated into smallsats for payload retrievals and installations.

With the completion of this ground-based testing, core Archinaut technologies are now prepared to operate in space. This milestone represents the defining capabilities of the Archinaut platform and raises its technology readiness level.

One example application of Archinaut is the PowerKit system, which can deploy a 2 kW power system on a 150 kg., ESPA-class satellite, nearly 5x the average state-of-the-art power system.

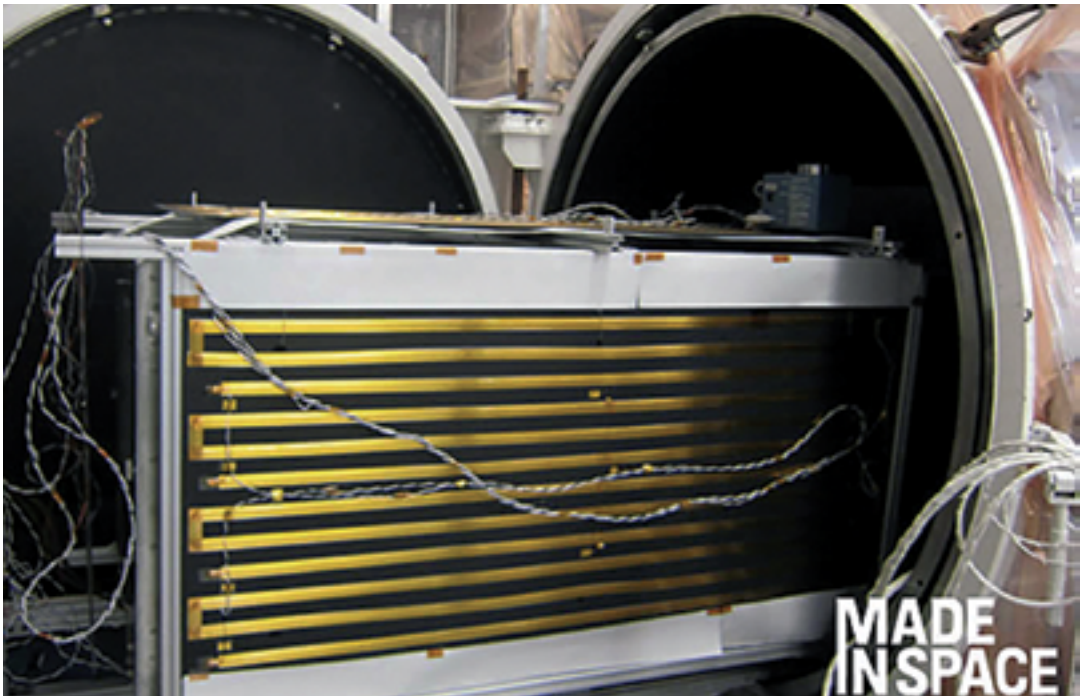
This is made possible by using the onboard Extended Structure Additive Manufacturing Machine (ESAMM), where expansive solar array systems are deployed from the satellite bus.

These solar arrays, paired with Archinaut's power system, will provide large satellite power to an ESPA class satellite. Other deployment opportunities include large scale antenna used for remote sensing, telecommunications, and scientific exploration.

Archinaut's core additive manufacturing ESAMM technology was the first piece of hardware to successfully manufacture in a space-like environment mid-2017.

Shortly after, ESAMM set a Guinness Book World Record by fabricating the "world's longest 3D printed non-assembled piece." The beam, measuring at 123.69 feet (37.7 meters), represents a building block showcasing the large scale structures Archinaut will manufacture and robotically assemble in space.

The MIS-led team includes Northrop Grumman, which provides systems



Archinaut manufacturing and assembly unit enters the Thermal Vacuum Chamber (TVAC) at teammate Northrop Grumman's facility in Redondo Beach, California. TVAC simulates the thermal and pressure environment of LEO.
Photo is courtesy of Made In Space.

integration, and Oceaneering Space Systems, who developed the hardware robotic arm.

MIS sees the union of 3D printing and robotic assembly as paramount to optimizing large structures for the space environment that are otherwise too large to be launched in a rocket fairing from Earth. Archinaut's multi-purpose technology will also enable repair, upgrade, and sustainment missions which will ultimately play a key role in space commercialization.

madeinspace.us

www.nasa.gov/directorates/spacetech/solicitations/tipping_points

www.northropgrumman.com

InfoBeam

Rocket Lab sends DARPA's R3D2 smallsat to orbit from New Zealand launch site

An important mission was successful as a Rocket Lab Electron launch vehicle successfully lifted the R3D2 satellite for DARPA from Launch Complex 1 on New Zealand's Mahia Peninsula at 23:27, March 28th UTC (12:27, 29 March NZDT).

The mission launched a prototype reflect array antenna to orbit for the Defense Advanced Research Projects Agency (DARPA).

The launch marks Rocket Lab's 25th satellite deployed to orbit, continuing the company's mission success heritage. And this is just the beginning with a busy year of launches booked for lift-off every four weeks.

Lift-off R3D2 mission from LC-1, Image credit Kieran Fanning and Sam Toms

Rocket Lab's consideration for the atmosphere is revealed as throughout the mission Rocket Lab's unique Kick Stage, an additional stage designed for precise orbital deployment and equipped with the ability to deorbit itself upon mission completion to leave no orbital debris behind.

The announcement from Rocket Lab is as follows:

"Congratulations to our dedicated team for delivering another important and innovative asset to space — on time and on target. The unique requirements of this mission made Electron the perfect launch vehicle to lift R3D2 as a dedicated payload to a highly precise orbit," said Rocket Lab founder and CEO Peter Beck. "Thank you to our mission partners. We look forward to continuing to provide frequent, reliable and rapidly-acquired launch services for innovative small satellites."

Rocket Lab was selected for the launch because of the company's proven mission heritage and its ability support rapid acquisition of small satellite launch capabilities.

Due to Rocket Lab's streamlined acquisition practices, DARPA's R3D2 mission was launched just over 18 months from conception — a significant reduction in traditional government launch acquisition timeframes.

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Rocket Lab's Launch Complex 1 in Mahia, New Zealand

With proven flight heritage from four orbital missions, Rocket Lab is the only fully commercial small satellite launch service provider in operation. The experienced Rocket Lab team has delivered 25 satellites to orbit, including innovative new space technologies that provide vital capabilities such as weather monitoring, Earth Observation (EO) and Internet of Things (IoT) connectivity.

The R3D2 mission was Rocket Lab's first of 2019, as the company heads into a busy year of launches booked for lift-off every four weeks.

To support the smallsat industry's highest launch cadence, Rocket Lab is currently producing one Electron launch vehicle every 30 days across its Huntington Beach, California, and Auckland, New Zealand, production facilities.

DARPA's R3D2 (Radio Frequency Risk Reduction Deployment Demonstration) spacecraft intends to space-qualify a prototype reflect array antenna to improve radio communications in small spacecraft.

The 150 kg. spacecraft carried an antenna, made of a tissue-thin Kapton membrane, designed to pack tightly inside the small satellite for stowage during launch, before deploying to its full size of 2.25 meters in diameter in LEO.

The design is intended to provide significant capability, typical of large spacecraft, in a much smaller package.

The mission could lay the groundwork for a space-based internet by helping to validate emerging concepts for a resilient sensor and data transport layer in low Earth orbit — a capability that does not exist today.

The R3D2 mission was launched on an Electron launch vehicle, comprised of two fully carbon-composite stages, powered by a total of ten 3D printed and electric pump-fed Rutherford engines, designed and built in house by Rocket Lab at the company's headquarters in Huntington Beach, California.

The R3D2 payload was deployed to a circular orbit by Rocket Lab's unique Kick Stage, an additional stage designed for precise orbital deployment and equipped with the ability to deorbit itself upon mission completion to leave no orbital debris behind.

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InfoBeam

Australian Space Agency announces new Mission Control Center + Shuttle Commander joins Myriota

Aerial photo of Lot Fourteen.

A Mission Control Center will be built alongside the new Australian Space Agency in Adelaide, Australia, to provide a focal point for orbiting spacecraft.

The Australian Government has just announced $A12 million for the space industry in the South Australian capital, consisting of $6 million for the Mission Control Center and $6 million toward establishing a Space Discovery Centre for STEM education, also in Adelaide.

The funding will form part of the Adelaide City Deal, which was announced in December and aims to drive population, economic growth and renewal within the CBD.

The Mission Control Center will be built at Lot Fourteen, a former hospital site in a prominent city location that is envisioned by the South Australian government to become a "globally-recognized creation and innovation neighborhood."

Australian Industry, Science and Technology Minister *Karen Andrews* said the Mission Control Center would complement the work of the national space agency, which will also be based at Lot Fourteen together with the Office of South Australia's Chief Entrepreneur, ***Jim Whalley***, and a variety of space and defence related startups.

"*The Mission Control Centre will be a focal point for space missions in Australia, providing facilities to control small satellite missions, enabling real-time control and testing and the accelerated development of Australian satellite technology*," Minister Andrews said. "*It will be available for use by space startups and small-to-medium enterprise space businesses, as well as research and educational institutions from across Australia. These investments will help the Australian Space Agency foster the growth of a globally competitive space industry, worth about US$345 billion.*"

The Australian Space Agency was officially launched in July of 2018 and received $41 million over four years from 2018 to 2019 in the federal budget to "*grow the Australian space industry*," including $26 million to help launch the agency which will "*coordinate domestic* space activities for Australia."

Australian firm Myriota has also revealed that former Space Shuttle commander ***Pamela Melroy*** has joined the company's board.

This announcement comes just three weeks after Myriota announced the first of a string of commercial products that will use the firm's low-cost, Earth-to-satellite transmission technology.

Melroy, a former NASA astronaut and ex-DARPA Deputy Director of the Tactical Technology Office, joins Myriota's board as a non-executive director.

Existing members of Myriota's board include Chairman ***Peter***

Former NASA astronaut Pamela Melroy.

Mabson, who is also President of Canadian company **ExactEarth Ltd**; an early international investor into Myriota, which is based in Adelaide, South Australia.

"*As one of only two women to ever command a space shuttle, Pam is used to breaking new ground in space*," CEO and co-founder of Myriota *exploration* Dr. ***Alex Grant*** said.

Melroy brings expertise in the global space industry, having spent more than 30 years at the forefront of space exploration, including as a shuttle pilot and commander, as well as thousands of hours logged working on multiple space shuttle missions. She began her career as a pilot in the United States Air Force, before joining NASA and becoming the second woman to command a NASA space shuttle mission.

Following a distinguished career at NASA, Melroy held a number of senior roles in private industry and public administration including at the FAA's Office of Commercial Space Transportation, and DARPA (Defense Advanced Research Projects Agency). She is currently Director of Space Technology and Policy for Adelaide-based professional services firm Nova Systems, a position she has held since 2017.

Melroy said she was excited to be joining Myriota as it ramps up its efforts to apply space technologies to solve global problems.

"The industrialization of space is improving the world's ability to monitor and communicate globally, and is having real world benefits on industries including agriculture and logistics," she said.

"Myriota is a serious player in the diverse and growing global space ecosystem, and I'm excited to be joining its board at a time when the maturity of space as a commercial industry is growing."

Myriota has been scaling up since it was spun out of the University of South Australia in 2015 and last year raised $15 million through a Series A funding round, with Boeing HorizonX Ventures among the contributors.

The South Australian company launched its next generation of technology on Spaceflight's SmallSat Express mission aboard Falcon 9 late last year and this month announced a partnership with fellow Australian business

Myriota is based at Lot Fourteen, an innovation precinct in the CBD of Adelaide that will also host the Australian Space Agency from July, and is part of a growing ecosystem of more than 80 companies working in the space industry in South Australia.

Managing Director of Boeing **HorizonX Ventures** *Brian D Schettler* said Melroy's world-leading space experience made her "*the perfect person to help Myriota navigate the next phase of its global expansion.*"

"*Myriota is a company poised to make a big impact on the global IoT industry, and the appointment of Pam Melroy to its board adds a new dimension*," he said.

Story by Andrew Spence, The Lead (theleadsouthaustralia.com.au)

www.australianspaceagency.com.au

myriota.com/

InfoBeam

Important endorsements received by Reaction Engines for the company's SABRE™ rocket engine

The development program of the world's first air-breathing rocket engine has taken an additional significant step forward, which will lead to major testing milestones being undertaken within the next 18 months.

Reaction Engines has received further endorsement of their SABRE™ engine design via its collaboration with ESA and the UK Space Agency (UKSA). The two agencies recently reviewed the preliminary design of the demonstrator engine core of the Synergetic Air-Breathing Rocket Engine (SABRE), which Reaction Engines will use to undertake ground-based testing at its under-construction test facility at Westcott, Buckinghamshire, UK.

Reaction Engines launched a significant new element of its development program in October of 2016 to design, build and demonstrate a SABRE engine core. The test item consists of an engine core, which is a major module of the complete SABRE engine, but without the pre-cooler and rocket nozzle in place. This core design and development activity is a major undertaking and upon completion of the tests, major elements of the world's first air-breathing engine capable of accelerating from zero to Mach 5 will have been demonstrated.

The SABRE engine core tests are part of a range of development activities currently underway at Reaction Engines. The company will shortly begin its HTX 'hot' heat exchanger testing in a unique test facility the firm has constructed in Colorado, United States.

The HTX test program is a manufacturing and performance ground-level demonstration of the SABRE engine 'Pre-Cooler' heat exchanger in a high temperature environment, similar to that expected to be seen by the SABRE engine during its air-breathing flight regime — up to 1000°C air inlet temperature.

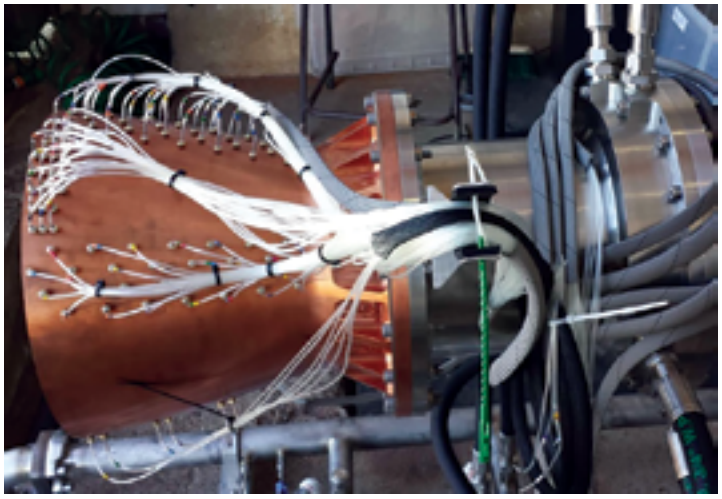
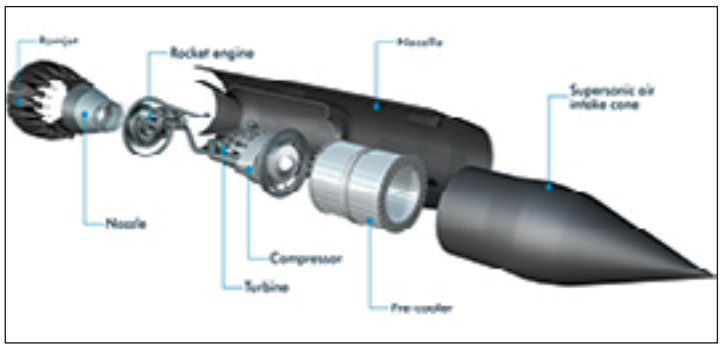


Photo of the Sabre engine is courtesy of Reaction Engines.



A test firing of the Sabre rocket engine. Photo is courtesy of Reaction Engines.

Over the last four years, Reaction Engines has raised more than £100 million from public and private sources and had secured investments from BAE Systems, Rolls-Royce and Boeing's venture capital arm, ESA, via the UK Space Agency, has invested €10 million in SABRE development, together with £50 million from UKSA. ESA also performs a technical oversight role on behalf of UKSA.

ESA's involvement started in 2010 with an independent review of SABRE's viability, opening the way to UK government investment. Then in 2012, ESA collaborated with Reaction Engines testing of a key element of SABRE—– the pre-cooler that cools the hot airstream entering the engine at hypersonic speed, the performance of which was fully validated under ambient air temperatures.

The complete air-breathing core demonstrator will be fully representative of the SABRE thermodynamic core cycle, fueled by liquid hydrogen, and will contain heat-exchangers, combustion and turbomachinery modules.

Testing of the core demonstrator will be undertaken at a dedicated test facility currently being built at Westcott Venture Park in Buckinghamshire, a historic site for British rocketry where engines for the Blue Streak and Black Arrow rockets were tested.

Shaun Driscoll, Programs Director, Reaction Engines, said the company has had a hugely supportive relationship with ESA and is delighted with this further endorsement of the SABRE engine design. This step opens the door to some exciting testing milestones which the company will be undertaking in the next 18 months and moves the firm closer to the demonstration of the first SABRE engine, a unique class of scalable aerospace engines, which will revolutionize the way travel is accomplished around the globe as well as get into orbit.

Westcott Venture Park in Buckinghamshire, a historic site for British rocketry where engines for the Blue Streak and Black Arrow rockets were tested.

The Sabre team. Photo is courtesy of Reaction Engines.

Richard Varvill, CTO, Reaction Engines, added that one of the great advantages of the SABRE propulsion concept is that it is totally modular from both design and operational perspectives. Therefore, it is possible to subject each of the key components of the engine to rigorous ground testing, which fully mimic the operational conditions the engine will face up to Mach 5 flight at 25 km. altitude.

Mark Ford, the head of ESA's Propulsion Engineering section, noted that the positive conclusion of the Preliminary Design Review marks a major milestone in SABRE development and confirms the test version of this revolutionary new class of engine is ready for implementation.

Chris Castelli, Director of Programs at the UK Space Agency, reported that this is the home of the jet engine — the UK has a rich aerospace heritage and world-renowned skills and expertise. This is an exciting landmark for Reaction Engines in the development of their SABRE engine, which could revolutionize both access to space and international travel by powering aircraft to five times the speed of sound.

www.reactionengines.co.uk

InfoBeam

SATCOM to be used by Australian firm to monitor wind farms and Myriota update

The final trials of listening devices that monitor the health of wind turbines and use satellite communication to transmit data will take place in the coming months ahead of a commercial launch mid year.

Adelaide, Australia,-based startup Ping was awarded an $A170,000 Australian Government Accelerating Commercialization grant last week to help trial, upscale, connect and launch its device on domestic and international markets after six years in research and development.

The Ping Monitor is a world-first application of aero-acoustic analysis to help continually detect wind turbine blade damage and has the potential to replace or reduce drones and maintenance crews that routinely inspect wind turbines, sometimes long after a problem has occurred.

An initial, portable, Ping Monitor was launched in September of 2018 but a new solar-powered version that is fixed magnetically to the turbine pole about two-meters above ground or sits off the ground alongside the turbine will be launched mid year.

The 2.0 version will also benefit from a collaboration between Ping and South Australian IoT satellite communications company Myriota, enabling the acoustic monitor to transmit data into the cloud from almost anywhere on Earth regardless of cellular network connectivity.

A Ping Monitor version 2.0 and associated solar panel will use magnets to affix to turbine towers. There are about 400,000 active wind turbines in the world with blades up to 80 meters long that spin up to 300km/h.

Ping Monitor at the Starfish Hill wind farm in Australia. Photo is courtesy of the company.

Ping CEO Matthew Stead said pilot trials of the updated monitor are being conducted in Australia, the United States and follow extensive version one trials last year that tested analytics and fault detection algorithms.

He said the South Australian company had already generated interest among a number of local investors. "What we are doing is dramatically different, it's continuous sound wave monitoring so it's definitely exciting times — it's going to be a big year. We're calling this an Intelligent Listening Platform and what we mean by that is our device can be applied to a whole range of scenarios such as surveillance, listening for aircraft or drones you don't want to be there and monitoring for the presence of predators such as wild dogs on farms.

The key piece of technology in the patented device is the algorithm that can rate the health of the turbine based on its acoustic signature on a scale of one to five and monitor changes over time.

Stead said there were 3,800 blade failures globally, per year, that cause as much as $5 billion in damage. He said sources of damage included lightning strikes, hail, sand, rain, wind and accelerated wear in coastal environments. "We've seen some sites where they've got damage that they didn't know about for a year or another site hadn't been inspected for three years — you don't really want the damage getting worse over time," Stead said.

Fellow South Australian startup Myriota has been scaling up since the company was spun out of the University of South Australia in 2015 and last year raised $15 million through a Series A funding round, with Boeing HorizonX Ventures among the contributors.

The company launched its fourth, next generation smallsat on Spaceflight's SmallSat Express mission aboard a SpaceX Falcon 9 in December of last year.

Myriota last month announced a collaboration with another Australian company to connect mass-market water-level sensors to its low-cost, Earth-to-satellite transmission technology, enabling farmers to receive water level data direct to their mobile phones.

Ping has been part of the first cohort of the Venture Catalyst Space program run by the University of South Australia at its Innovation and Collaboration Center. Stead said he hoped to move the company to Lot Fourteen, a former hospital site in the center of Adelaide that is being transformed into an entrepreneur and defence hub, alongside existing tenants Myriota and the new Australian Space Agency.

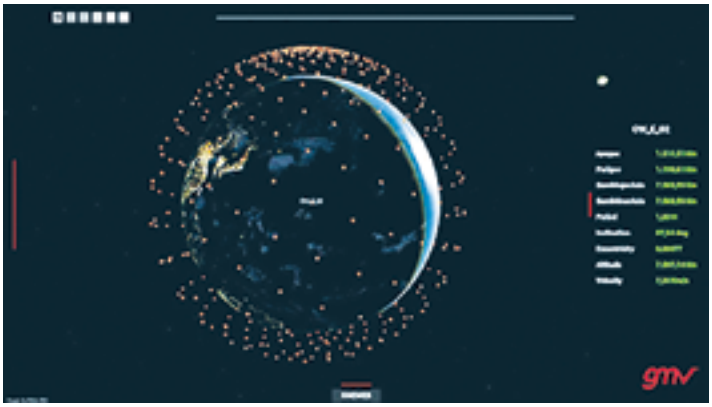
South Australia has been a major player in the nation's space industry and is home to major Tier 1 defense companies and several emerging space start-ups, including Fleet Space Technologies and Southern Launch, which is establishing a launch facility in the state's northern area.

pingmonitor.co

Story by Jim Plouffe, Publishing Editor ***The Lead*** *infosite. theleadsouthaustralia.com.au*

InfoBeam

GMV's tech employed for OneWeb constellation



GMV has helped to achieve all of the OneWeb constellation goals, having won the contract in 2016 for developing the command and control (C2) center for the entire constellation.

On February 27, at 21.37 UTC, the first six satellites of OneWeb's constellation were successfully launched on a Soyuz rocket from the Kourou spaceport.

These six satellites form part of a constellation to be initially comprised of 648 LEO satellites, possibly building up to as many as 900 satellites as needed to meet clients' growing needs.

After weighing diverse C2 platforms, OneWeb opted for GMV's product line, technologies that are capable of meeting OneWeb's specific and complex needs while adhering to a tight development schedule.

GMV's C2 system has been installed in the constellation's UK and U.S. operation centers and will be providing access to the command process and telemetry, automation of contacts between the satellites and ground antenna as well as keeping track of the overall state of the constellation.

GMV's command and control center includes different solutions from its in-house real-time product line, such as hifly® for satellite monitoring and control; flyplan, for automation of contacts, and fleetDashboard.

There were all developed in collaboration with OneWeb's operations team, which will provide global knowledge on the state of the constellation.

OneWeb's constellation will provide connectivity for billions of users around the whole world, taking communications networks to areas that would otherwise be unconnected.

The system can provide global 3G, LTE, 5G and WiFi access at affordable prices to users right around the world.

This launch marks the transition from successful proof-of-concept to the commercialization of OneWeb "for everyone, everywhere", all in the interests of bridging the digital divide.

OneWeb has now initiated the deployment of the biggest satellite constellation ever produced; from the close of this year, the company will regularly launch about 30 satellites each month.

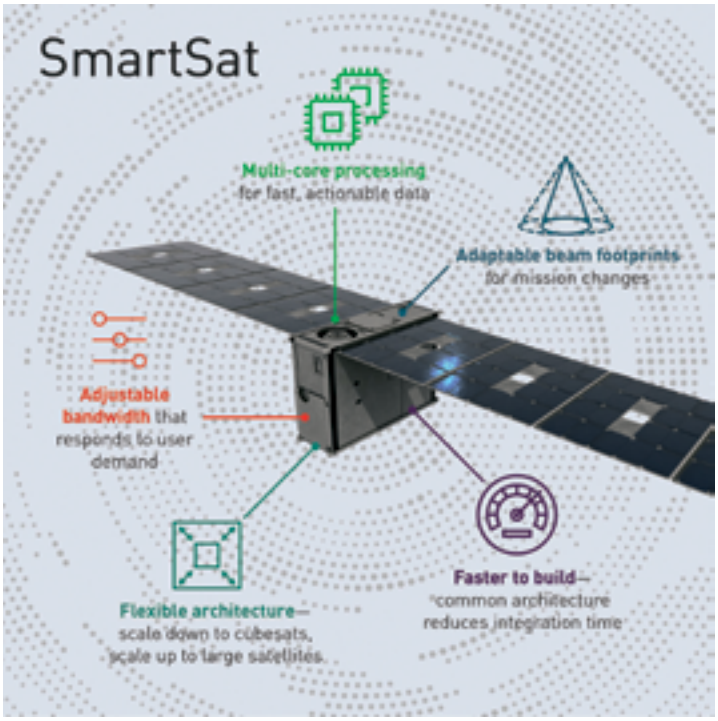
OneWeb has also committed to connecting up to six schools in formerly unconnected regions of the world: Alaska, Nepal, Honduras, Ecuador, Rwanda and Kyrgyzstan.

www.gmv.com/en/

www.oneweb.world

InfoBeam

Satellites will be able to alter their mission on orbit with new Lockheed Martin technology



Lockheed Martin (NYSE: LMT) has announced a new generation of space technology that will launch this year that will allow satellites to change their missions in orbit.

Satellites that launched one, 10 or even 15 years ago largely have the same capability they had when they lifted off. That's changing with new architecture that will allow users to add capability and assign new missions with a software push, just like adding an app on a smartphone.

This new tech, called SmartSat, is a software-defined satellite architecture that will boost capability for payloads on several pioneering nanosats ready for launch this year.

This year, Lockheed Martin is integrating SmartSat technology on 10 programs and counting, including the Linus and Pony Express smallsats, which will be the first to launch. These are rapid-prototype, testbed satellites using internal research and development funding, ready for 2019 launches on the first LM 50 smallsat buses:

- *The Linus project delivers two 12U cubesats performing a technology demonstration mission, validating SmartSat capabilities as well as 3D-printed spacecraft components.*
- *Pony Express builds multiple 6U satellites destined for a low Earth orbit and will space qualify state-of-the-art networking technologies. Pony Express 1 is a pathfinder for a software-defined payload that will test cloud computing infrastructure and was developed in nine months. Follow-on Pony Express missions will prove out RF-enabled swarming formations and space-to-space networking.*

Cyber security is at the core of this new technology. SmartSat-enabled satellites can reset themselves faster, diagnose issues with greater precision and back each other up when needed, significantly enhancing resiliency. Satellites can also better detect and defend against cyber threats autonomously, and on-board cyber defenses can be updated regularly to address new threats.

SmartSat uses a hypervisor to securely containerize virtual machines. This is a technology that enables a single computer to virtually operate multiple servers to maximize memory, on-board processing and network bandwidth. It takes advantage of multi-core processing, something new to space. That lets satellites process more data in orbit so they can beam down just the most critical and relevant information — saving bandwidth costs and reducing the burden on ground station analysts, and ultimately opening the door for tomorrow's data centers in space.

SmartSat uses a high-power, radiation-hardened computer developed by the National Science Foundation's Center for Space, High-performance, and Resilient Computing, or SHREC. Lockheed Martin helps fund SHREC research, and in turn gains access to world-class technologies and student researchers.

Rick Ambrose, EVP of Lockheed Martin Space, said this new type of satellite acts more like a smartphone. Add a SmartSat app to a satellite on-orbit and the mission is changed. The company is the first to deploy this groundbreaking technology on multiple missions. SmartSat will give customers unparalleled resiliency and flexibility for changing mission needs and technology and unlocks even greater processing power in space. SmartSat is a major step forward in our journey to completely transform the way we design, build and deliver satellites.

Ambrose added that the LM 50 bus is the perfect platform for testing this new, groundbreaking technology. Lockheed Martin is self-funding these missions to demonstrate a number of new capabilities that can plug into any satellite in the firm's fleet, from the LM 50 smallsat to the flagship LM 2100. The same technology plugs into ground stations, improving space-ground integration, as well as one day be able to connect directly with planes, ships and ground vehicles, connecting front-line users to the power of space like never before.

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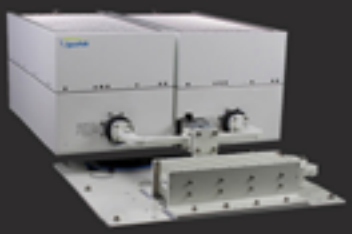

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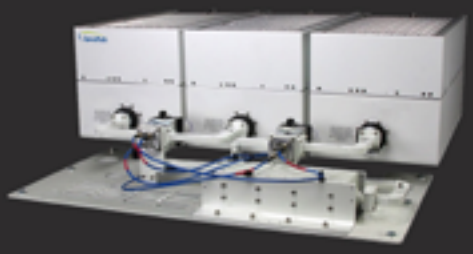

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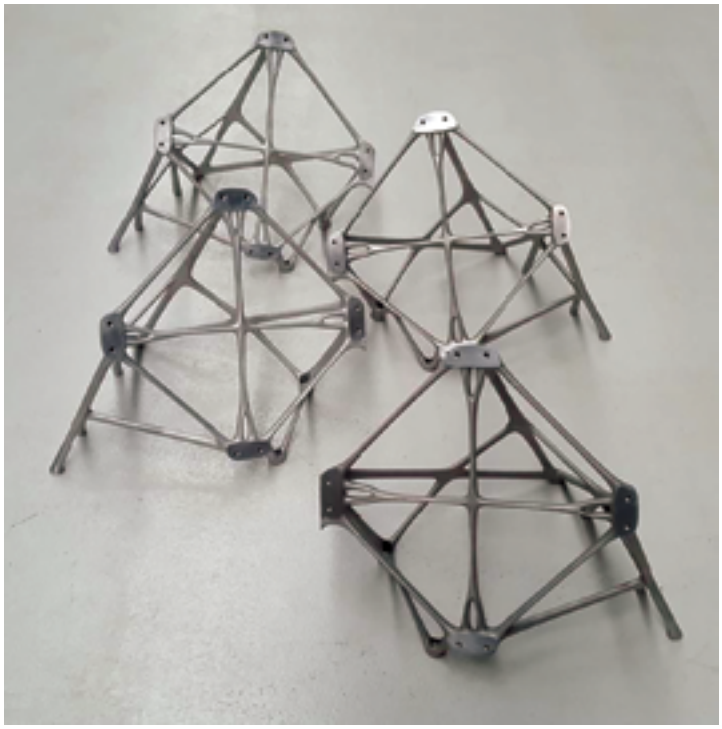
InfoBeam

Taking 3D Printing into Series Production is Thales Alenia Space

Thales Alenia Space first used additive manufacturing a few years ago with the 3D-printed aluminum antenna brackets for the TurkmenAlem/ MonacoSAT satellite, launched in 2015, and the polymer tube supports for the Iridium® NEXT constellation.

The Koreasat 5A and 7 telecommunication satellites, orbited in 2017, featured the largest 3D-printed spacecraft parts ever manufactured in Europe at the time.

Today, Thales Alenia Space is taking 3D printing into series production to make components for telecom satellites built on the company's new all-electric Spacebus Neo platform.



Spacebus Neo will feature four reaction wheel brackets made of aluminum and 16 antenna deployment and pointing mechanism (ADPM) brackets: four in aluminum and 12 in titanium.

The innovative 3D-printed reaction wheel bracket is designed to meet market demand for lower costs, now reduced by about 10 percent, and shorter lead times, with production schedules cut by one to two months. The new part is also 30 percent lighter and offers improved performance.

The metal powder-bed fusion technique used for these parts allows series production with a high degree of customization, making it possible to tailor designs to the exact requirements of each new mission.

The four reaction wheel brackets for each satellite, for example, are 3D printed as two sets of symmetrical parts, while the orientation angles and interfaces of the ADPM brackets can be adjusted to their specific function and position on each satellite.

Thales Alenia Space has also incorporated connector and cable fittings directly into the overall design, which is printed as a single-piece part, thereby avoiding additional assembly requirements.

To produce these large (466 x 367 x 403 mm) reaction wheel brackets, the biggest powder-bed 3D printer in Europe has been installed and signed off — an Xline 2000R metal 3D printer from Concept Laser, which has a build chamber of 800 x 400 x 500 mm.

The first four parts have already been integrated on Eutelsat's Konnect satellite, which was successfully mated earlier this month. Other Spacebus Neo platforms will also feature organically designed 3D-printed parts in the near future.

Philippe Sicard, engineer at Eutelsat, said the company is now fully involved in the development and use of 3D-printed satellite parts at all stages of the process, from design to final delivery. These parts are recognizable by their highly specific design. To ensure the most stringent quality standards, the overall process and individual components are robustly traceable and Eutelsat has established a comprehensive testing and inspection process.

www.thalesgroup.com

www.concept-laser.de

InfoBeam

Kleos Space and ImageSat International team up for enhanced geospatial intelligence analytics

Artistic rendition of a Kleos Space EO satellite. Image is courtesy of the company.

Kleos Space S.A. (ASX: KSS, Frankfurt: KS1) has signed a collaborative, non-binding Memorandum of Understanding (MoU) with Israeli-based end-to-end geospatial intelligence company ImageSat International N.V. (iSi) to explore opportunities to use Kleos' maritime RF activity-based satellite data to enhance geospatial intelligence analytics.

Under the MoU, the companies will develop a value-add proposition for current and future iSi maritime customers using Kleos' geolocation data.

The MoU also covers the development of a methodology to reduce collection to dissemination latency.

iSi has more than 20 years' experience in end-to-end space, intelligence and analytical solutions for defense and intelligence customers. Israel-based, the company's areas of expertise include integrated ISR solutions, Very High-Resolution satellite services, GEOINT and data analysis. Its innovative ground-segment is designed to manage high-revisit satellite constellations.

Kleos is on track to launch its initial Scouting Mission satellites on a Rocket Lab Electron rocket from New Zealand by the end of the second quarter of 2019.

The multi-satellite Scouting Mission system will form the cornerstone of a constellation that delivers a global picture of hidden maritime activity, enhancing the intelligence capability of government and commercial entities when AIS (Automatic Identification System) is defeated, imagery unclear and targets out of patrol range.

Andy Bowyer, CEO of Kleos Space said the launch of the company's Scouting Mission satellites will enable the firm to commence generating revenue by delivering this commercially available data-as-a-service through collaboration with strategic global partners within the defence and intelligence sectors.

kleos.space

www.imagesatintl.com

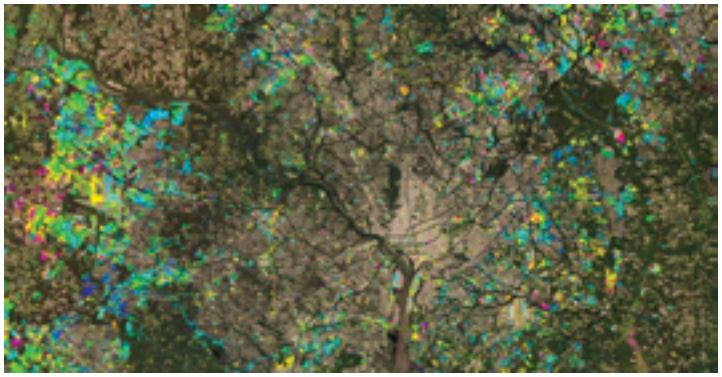
InfoBeam

Maxar's NaturalView® to be integrated into the ArcGIS Living Atlas of the World

Maxar Technologies (NYSE:MAXR) (TSX:MAXR) has agreed to integrate their NaturalVue® 2.0 image mosaic and National Urban Change Indicator (NUCI) commercial products into ArcGIS Living Atlas of the World.

The operations of DigitalGlobe, SSL and Radiant Solutions were unified under the Maxar brand in February; MDA continues to operate as an independent business unit within the Maxar organization.

ArcGIS Living Atlas of the World is the world's foremost collection of maps developed by Esri partners and the Esri user community and is available in ArcGIS Online, Esri's flagship cloud-based geospatial platform. These enhancements will accelerate the speed at which analysts distill actionable intelligence from sources of geospatial data to solve a variety of problems and missions globally.



NaturalVue® 2.0 is Maxar's next-generation global image mosaic, encompassing over 60,000 Landsat 8 images. As the highest quality global, commercially available, and virtually cloud-free 15-meter mosaic with current imagery, NaturalVue® 2.0 provides a seamless basemap that reflects the Earth's true colors.

NaturalVue® 2.0 updates and improves upon previous versions with enhanced positional accuracy, color fidelity and spatial resolution. Maxar's image mosaic portfolio also includes Vivid and Metro mosaics, which are the highest resolution global mosaics available commercially.

NaturalVue® 2.0, Vivid and Metro enable a broad range of geospatial and web-based mapping applications, including military and defense logistics, GIS backdrops, flight simulation, cartographic mapping, 3D visualization and GPS tracking.

NUCI is Maxar's commercial urban change detection product, which highlights areas of new construction activity by isolating changes that persist over time, derived from over 13,000 Landsat images.

NUCI enables analysts to rapidly identify areas of urban expansion across the landscape of the continental United States by filtering out noise from seasonal, agricultural and other natural cycles that hamper traditional image-to-image change detection methods. The dataset includes an archive covering nearly 30-years of change.

NaturalVue® 2.0 and NUCI will soon be available to all Esri users with access to ArcGIS Online through ArcGIS Living Atlas of the World.

www.maxar.com

livingatlas.arcgis.com

InfoBeam

SatixFy and ST Engineering combine forces for IFC terminal

JetTalk, a joint venture between SatixFy UK Limited and ST Engineering, is bringing their state-of-the-art In-Flight Connectivity (IFC) satellite Aero terminal, based on SatixFy's Electronically Steered Multi-beam Antenna Array (ESMA) technology, to the Aircraft Interiors Expo, April 2-4, held at the Hamburg Messe, Germany.

JetTalk's Aero all-in-one terminal is fully electronic. With no moving parts, it allows fast and simple installation, maintains the highest reliability and is low maintenance.

Able to simultaneously communicate with multiple GEO/MEO/LEO satellites, the terminal provides aircraft passengers with continuous seamless broadband IFC. The terminal supports acquisition and tracking capabilities for multiple beams at multiple polarizations and integrates SatixFy's next generation modem baseband ASIC for a comprehensive terminal solution supporting any external modem.

SatixFy's Aero terminal.

Charly Ben Chetrit, the JetTalk Chairman, said that with high demand for onboard real-time video streaming over the internet and high bandwidth consuming social media applications, 300 to 450 passengers in larger jets will soon require a grade of service of up to 1 Gbps during flights. Moreover, most local and regional lines run by single-aisle aircraft are eagerly awaiting an IFC solution that has a quick and simple installation and calibration to compete in the market and offer added value services to their passengers.

JetTalk Aero terminal consists of software defined antenna, as such it supports multiple satellite operators with its future proof SDR (Software Defined Radio) modem and offers straightforward integration with available networks or broadcast operators

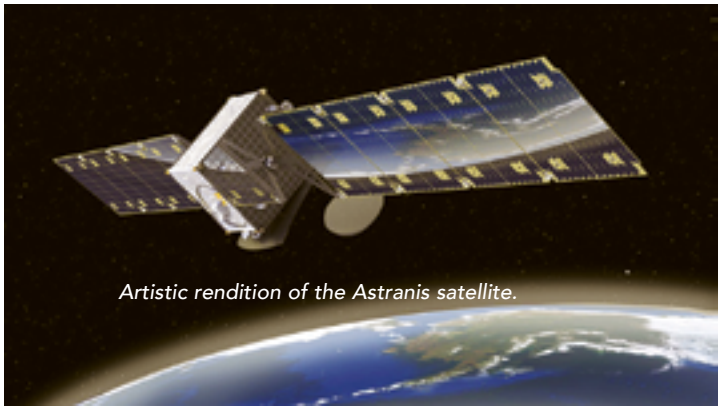
Each tile is ESMA based, containing SatixFy's family of dedicated System on a Chip (SoC) devices. The Beamformer ("Prime") is an industry-new true-time delay chip for pointing and tracking multiple beams from an array of radiating elements. Each element is connected to the RFIC chip ("Beat") which serves as up and down converter LNA and PA per element. Together, the Prime and Beat create the basis for the ESMA tile.

The Aero terminal offers embedded LEO/MEO support, is software configurable and enables customers the flexibility to migrate to new constellations when available, and with inherent make-before-break capability.

InfoBeam

Wind River brings control and comms to Astranis smallsat

Wind River® has announced that Astranis Space Technologies Corp. is using the company's VxWorks® real-time operating system for its next generation satellite that will deliver cost-effective, high-speed internet to underserved markets.



Artistic rendition of the Astranis satellite.

More than half of the world doesn't have access to the internet — and satellites are expected to play a major role in solving that problem. Astranis is building satellites that are capable of delivering broadband internet services to individuals around the globe. It targets areas where, due to the high cost of building the infrastructure, broadband internet isn't widely available or is completely unavailable.

Astranis will use VxWorks to run the main flight computer that controls the avionics in guiding the satellite and keeping it in communication with Earth. Astranis recently announced that its first satellite will be going over Alaska, in partnership with Alaska-based internet provider Pacific Dataport, Inc.

Wind River's comprehensive software portfolio for the edge supports a diverse range of customer journeys in aerospace and defense, from design to development to deployment, with technologies that span across real-time operating systems, open-source-based platforms, system simulation and virtualization.

In addition to its VxWorks for safety- and security-critical environments, the company offers Wind River Linux and other commercial-grade open source technologies for general purpose functions.

The recently launched Wind River Helix Virtualization Platform is for consolidating multiple federated systems with both safety-critical and general purpose applications onto a single compute platform.

For system simulation enabling unmodified target software to run on a virtual platform the same way it does on physical hardware, the company offers Wind River Simics®.

www.windriver.com/inspace/

www.astranis.com/

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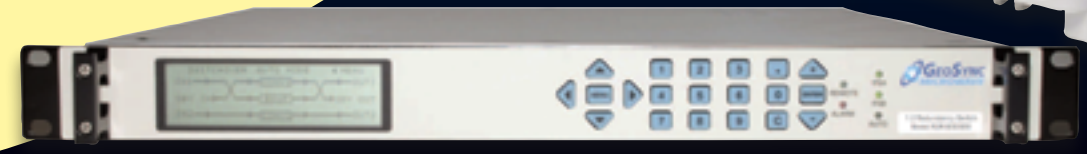

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The Forrester Report: 2018 Is Long Over

Will 2019 be the year of C-band?

By Chris Forrester, Senior Columnist

The 'big four' satellite operators have all unveiled their 2018 results, with Telesat of Ottawa completing the quartet's numbers on March 1.

Telesat showed a three percent fall in overall revenue to C$903 million (about $662 million). However, their EBITDA margin improved y-o-y from 82 percent in 2017 to the slightly better 82.2 percent last year.

The Big Four

- ***Intelsat**: Still losing money*
- ***SES**: Solid year for Networks*
- ***Eutelsat**: Challenges ahead*
- ***Telesat**: New company for LEOs*

Consensus

- *Q2 is make or break for the **C-Band Alliance***

Telesat, the world's fourth-largest operator, is moving some assets around in preparation for its planned multi-billion dollar constellation of LEO spacecraft. That planned LEO investment — estimated to be around $3 billion — sees Telesat preparing to hive off a new division, one that will be separate from the core company.

Telesat operates under a number of borrowing covenants — not in themselves unusual — and the new business will be free of those borrowing restrictions. Telesat is weighing two potential bidders to build its fleet of LEO craft: **Airbus** and **Thales Alenia+Maxar Space Systems**. These firms should be able to present their recommendations by the end of this year.

Intelsat's numbers for 2018 were also under pressure. On February 20, the company reported total revenue of $542.8 million and a net loss of $111.3 million for the three months ended December 31, 2018. For the year ended December 31, 2018, Intelsat reported total revenue of $2.161 billion and a net loss of $599.6 million.

Those cold numbers reflect much of what the market was expecting. *Stephen Spengler*, the company's CEO, said that the operator's 2019 priorities were to focus on its high-throughput fleet of '***EPIC***' satellites and to continue working diligently to clear — with SES — 200 MHz of "complex" spectrum over the USA for repurposing and sale for 5G. Revenues on Intelsat's new EPIC fleet were worth $1.4 billion, up 16 percent on a year ago.

Intelsat also told the market that its EBITDA margin would also slip from 76 percent last year (and 77 percent in 2017) to about 74 percent this year, as higher OPEX kicks in. Also something of a concern is about $150 million in annual revenues which come up for renewal this year and will likely see reductions in lease rates for customers.

On the investment front, Spengler confirmed that two '***rescue tugs***' are now in the final stages of manufacture. ***MEV-1*** will launch this summer and go to 29.5 degrees West and attach itself to the I-901satellite, which is low on fuel. The second rescue tug will launch next year.

Equity analysts at investment bank **Exane/BNPP** agreed that the results were disappointing. "*Q4/18 revenues of $543 million declined by four percent y-o-y driven by lower renewals and lower pricing in Government, Media and Networks. This was broadly in line with consensus expectations. Pricing pressure in Government and Networks for wide beam capacity is presented as the main driver of the revenue pressure. Lower volume consumption in the U.S. and Latin America is given as the main driver of the decline in Media. Intelsat's contracted backlog (adjusted for ASC 606 accounting changes) fell from $7.3 billion at the end of September 2018 to $7.1 billion at the end of December.*" (and $7.8 billion a year ago).

In terms of a 2019 outlook, Intelsat is guiding for revenues and EBITDA that are respectively three and five percent below current consensus forecasts. This reflects a guided decline of -3 percent to -6 percent in Media, -3 percent to -6 percent in Networks and -1 to +2 percent revenue growth in Government. Increased direct costs and lower revenues explain the comparatively disappointing EBITDA outlook.

Exane's analyst ***Sami Kassab*** (analyst at Exane/BNPP) stated that Intelsat's numbers bring home the intense pricing pressure that the industry is suffering from, especially for wide beam capacity. While the read across is negative for European satellite operators, each player has its own specificities that drive differences in operating trends.

Intelsat has historically been more exposed to trunking and cable distribution, structurally more challenged segments. Volume reductions in video capacity consumption is partly reflective of its U.S. cable distribution focus.

Eutelsat volume consumption is growing as per management statement and our own independent tracking.

SES Networks has been a growth driver throughout 2018 as it has gained share thanks to lower priced higher capacity services."

C-Band restructuring: "Encouraging Feedback"

The second quarter of this year should see the **Federal Communications Commission** (**FCC**) make its ruling on whether the **C-Band Alliance** (***CBA***) of Intelsat and SES (with Eutelsat and Telesat) can restructure — and sell — 180 MHz of spectrum over the U.S. for 5G take-up.

Much of the February 20 analyst call with senior staffers from Intelsat was focused on the prospects for a positive C-band outcome. It emerged that the CBA has sent around 400 letters to parties potentially interested in buying its spectrum. Intelsat's management claims there has been good market interest in the spectrum. The CBA is having ongoing discussions with several of these parties to better understand their needs (band plans, geographic coverage, etc).

Spengler told analysts that the C-band restructuring was #5 on his list of priorities. "*Clearing C-Band spectrum is a complex endeavour. This complexity is what gives us confidence in the strength of our proposal. The CBA proposal is the only one before the FCC that includes an interference mitigation plan. This key element of our proposal is supported by detailed cross-sector technical analysis, demonstrating the feasibility of 5G satellite services coexistence.*

"*Our proposal is the only one that commits to launching satellites to replace capacity lost to clearing, ensuring all incumbent services can continue uninterrupted. Lastly, our proposal is the only one, featuring a commitment to clear spectrum within 18 to 36 months following an order, essential if the U.S. is to win the race for 5G.*

"*We're seeing market interests, and we're seeing very clear market requirements from big and small players and we're ready as I said earlier, we're ready to proceed once the FCC makes a decision and issues an order.*

"*We've been engaged with equipment manufacturers for months now with the CBA. And so, we've had a lot of work going on with Nokia and Ericsson specifically they've been engaging in testing with us and verifying our technical approach to manage the guard band and the interference that could potentially be present. And*

so, that work has been very active and ongoing."
There was also encouraging optimism that, should the FCC give approval for the scheme and issues an order to 'make it so,' then only a U.S. court injunction against the FCC could stop the process.

In Sami Kassab's view, "*Intelsat indicated that its C-band grooming plans were based on a combination of modulation and compression techniques. In other words, the current plans are not based on state-of-the-art modulation and compression techniques. In our view, this suggests that more spectrum could be freed in the medium to long term as broadcasters embrace DVBS2 and HEVC. Overall, we take this call as supportive of our positive view on the C-band monetization opportunity.*"

SES: Helped by 'Networks'

SES was suffering similar challenges at its key 'Video' division which, from Day One (when it was better known as '***Astra***'), was the company's extraordinarily lucrative 'cash cow'.

However, after three years of top line declines in some of their key divisions, CEO ***Steve Collar*** reported a return to group organic revenue growth of 1.9 percent. Importantly, SES said that it believed it is making "*considerable progress*" with its C-band initiative for the realignment of some 200 MHz of satellite spectrum over the U.S. and expects a decision in Q2. Helping confidence were comments made on February 26 by FCC Commissioner ***O'Rielly*** saying that it was "*near certain*" that the C-band would be re-allocated.

Collar told analysts that SES was very much ready to start moving as soon as the FCC ruled (presumably in favor of the C-Band Alliance's scheme). Analysts report that C-band proceeds are likely to be used to deliver and to accelerate the growth in SES Networks, and management does not expect to free up more spectrum than the 180 and 20 MHz currently communicated.

Revenues for 2018 were one percent ahead of expectations (at €2.010 billion) with its all-important Video division turning in revenues of €1.306 billion, while the growing Networks division was a highly useful four percent ahead (at €696 million).

SES says it has been a "breakout year" for SES Networks which delivered double-digit underlying growth and growth in all three market segments.

Collar said, "*2018 was a good year for SES. We have delivered top-line growth, exceeding the top end of our revenue outlook on the back of an exceptionally strong year for SES Networks. We are transforming our business internally and externally, retooling the organization in response to the strong demand for end-to-end services, managing operational costs while expanding competencies and capabilities to drive growth. The strong focus on cash flow and cost control that started in 2018 will continue and accelerate in 2019.*

"*SES Video, representing two-thirds of our group revenue, also delivered on its 2018 revenue outlook and scored important wins despite challenging market conditions," added Collar. "We signed new customers and platforms while securing important renewals in our core neighborhoods, including with Viacom, M7, QVC and Channel 4 in Europe as well as Comcast in North America.*

"Given our 30+ year experience as one of the first providers of DTH services, I am delighted that we signed multi-year agreements to launch and expand new DTH platforms in the Caribbean with Kiwisat and in Eastern Europe with Telekom Srbija. In MX1, our video services business, new deals were secured with Agence France-Press, Discovery and Cell-C, while our HD+ service in Germany expanded with the addition of an Ultra High Definition channel from RTL. We continue to carry more HD and UHD channels across our network than any other satellite service provider."

According to analysts from Exane/BNPP, the 2019 outlook is three percent below consensus in terms of midpoint revenues. Management has trimmed its Video outlook but reaffirmed its double-digit guidance for Networks. "*We note that Management is guiding for broadly flat top-line growth for 2019 and a return to growth 2020.*"

Eutelsat's Mixed Bag

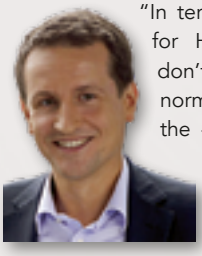
Eutelsat's half-year results (February 15) generated a mixed bag of comments. Equity analysts such as *Patrick Wellington* from **Morgan Stanley** said the 'downside' risk were still much in evidence, and argued that there were "***No significant signs of Video demand growth have been observed by the industry players, and overcapacity — primarily in Data applications —- continues to weigh on pricing.***"

The core financials showed that overall first half revenues were down 4.4 percent (€658 million versus €688 million last year) and drilling down into the various divisions showed that Video was down two percent (and is now just 66 percent of Eutelsat's capacity), Fixed Data fell 11.9 percent, with Fixed Broadband down 5.8 percent. The only positive departments were Government Services, up 1.7 percent and Mobile Connectivity up 6.7 percent.

But Wellington was also prepared to be positive and said, "*The growth in video could accelerate as customers upgrade to HD channels and UHD takes off.*" He also incorporated a valuation for Eutelsat's approximate five percent share of the U.S. C-band market — and assuming the C-Band Alliance's scheme bears fruit — that five percent could be worth €298 million (€1.30 per share) if the '*market-based approach*' for the sale of capacity hits $0.30 per MHz pop.

Wellington referenced management's own estimates and guidance, saying that Eutelsat expects organic revenue growth to be stable for the year after -2 percent fall in H1. It specifies that the recently signed deal in Ethiopia is worth an extra €2 to €3 million pa, Afghanistan is worth c€2 million incremental pa and that there has been higher pricing on the recent BeIN contract at 8W.

"*The run down on Hotbird capacity discounts post the Hotbird purge means that Hotbird pricing should begin to firm up. Eutelsat observes that its Sky Italia deal still has some time to run and that there will be no effect from renegotiation (up or down) until fiscal 2021*," said Wellington.



"In terms of revenue performance for HOTBIRD as a whole, we don't really communicate on that normally. But I could say that for the — during the first half, our revenues on the HOTBIRD were well-oriented and exactly in line with our expectation and very, very, very solid. We have adopted a new rate card based on a per-megabits basis instead of a per-mega or per-transponder approach. And the impact of all that has been positive," said company CEO ***Rodolphe Belmer***.

He also stated that — at least for now — the j-v with **ViaSat** over the ownership of the Ka-SAT satellite "*remains in force*" and he said he saw no reason why Viasat would sour on the arrangement, at least until the ***Viasat-3*** satellite over Europe is ready for service.

Belmer added that while Viasat would not be part of Eutelsat's broadband ***Preferred Partnership Program***, a separate Eutelsat-Viasat agreement preserves Viasat's interests. Belmer said having Viasat as a customer for Ka-SAT is in both companies' interests.

"*We believe we are the [broadband] kingmakers in Europe, the only company with a substantial program to launch capacity to sustain growth: First Ka-Sat, then HTS capacity of Konnect Africa — part of which is reserved for Europe — and then, in three years, Konnect VHTS for Europe*," Belmer said.

Eutelsat is now using the ***Al Yah 3*** satellite to debut what will be its full ***Konnect Africa*** service. As is the case with Viasat in Europe, Belmer said he saw no reason to worry that the new broadband deployment partnership in Africa between Yahsat and **Hughes Network Systems** as a competitive threat.

"*Our business potential will not be affected by the competitive landscape in Africa. The demand in that market is very large. We have the best satellite with Konnect Africa, the cheapest and the most abundant [bandwidth], so if a competition materializes, we will lead the pack,*" Belmer said.

Eutelsat's channel count is at 7,067 (up 3.8 percent y-o-y). "***HD penetration continued to increase, standing at 1,500 channels, up 17.6 percent, with a penetration rate of 21.2 percent compared to 18.7 percent a year earlier***," said Deputy CEO ***Michel Azibert***. Overall fill rate is 68.3 percent (67 percent last year). Backlog was relatively stable at €4.6bn (€4.7bn).

Giles Thorne, equity analyst at **Jefferies**, summed up Eutelsat's position as, "*Like Sisyphus with his rock, Eutelsat's equity again rose (going) into the results and has then been hit on the print as one of the standard two things happened: Video teases those in the secular decline camp (not something really very evident today) or something "execution-like" in nature bobs up (today, logistical issues in Fixed Broadband in Africa).*"

Thorne echoes Eutelsat's management comments that all guidance for the rest of this year (to June 30) is reiterated. Thorne explained, "*In the past 6 quarters, Video has outperformed 3 times and underperformed three times — it never quite does what either camp of the secular debate want it to do. In that context, we note another ambiguous performance at Hotbird: on the negative side, a big drop in channels (-20 from -4 / -14 in 1Q19 / 2Q18) driven by an anticipated simulcast switch-off (and surely more will follow); on the positive side, four percent y-o-y Mb/s volume growth as the HD migration Eutelsat has been pushing for 2-3 years ramps (HD penetration of 35 percent still lags MPEG-4 penetration of 60 percent). Management again expressed the conviction view that Hotbird revenue is stable and performing to their expectations with the volume growth offsetting the HD price promotions to deliver "broadly stable Hotbird revenue. Critically, those customers coming out of the FY16/17 promotions are now on the "rate card" front-book prices.*"

The various analysts, having examined the numbers, took some relief in the mid-term prospects. For example, Sami Kassab at Exane/BNPP, said, "*Management has confirmed all elements of its FY19 and longer-term outlook and continues to guide for 'broadly stable revenues' in line with consensus forecasts. It also pointed to the positive effect of regulation on its tax rate but did not quantify the impact at this stage. We find it hard to call the direction of the stock as headline numbers are slightly below but management has reaffirmed with some credibility (i.e., contract gains) its outlook.*"

Laurie Davison, at **Deutsche Bank** was blunt and said, "*Another miss on Video. While contracts were announced with the Ethiopian Broadcasting Corporation and Afghanistan Broadcasting System, these are in low pricing regions and the implication is still that the core W. European and LatAM revenues are under pressure. The disclosure of HOTBIRD channels down 2.5 percent y-o-y (1002 to 978) further reinforces these concerns.*"

Davison also pointed out that Eutelsat had already trimmed their guidance for this current year. "*At 1Q, it moved its revenue target from 'slight growth' to 'broadly stable for this year'. It is also applying this target of 'broadly flat' to Operating revenues, rather than total sales (to exclude Other revenues).*"

Perhaps worrying for the market is Davison's comments that this "miss" on top-line numbers does not augur well for SES (on February 27) and Intelsat (numbers due on February 20).

Additional Eutelsat news

- *"The Ethiopian contract is coming — it's a multiyear contract for, let's say, basically, I would say 2.5 transponders. It comes with a ramp-up. It will generate something like between €2m and €3m or maybe slightly more for the full year for next year, and this year, it comes with a ramp-up."*
- *"Regarding Afghanistan, it's about 2 transponders for a platform with a ramp-up, starting free to air. And the range of magnitude of the contract on a full year basis for next year is in the range of €2 million."*
- *On UHD channels: "Some payTV operators, for instance, nc+ in Poland, is that we've been successful with the launch of their football channel, in 4K. There is a good momentum. And, yes, we're getting closer to 20 — the figure of 20 UHD channels, which — speaking about tuning channels, we have currently 27 feeds but a little less than 20 channels." — **Michael Azibert***

- *On potential Bad Debt, and mature overdue receivables standing at €169m: "The total receivables has decreased as compared to a year ago. Second, I would also highlight that if you look at the performance in term of cash flows, because I think it's the interesting question, that you have the change in working capital on this half year has been more favorable than the one a year ago. So the performance in terms of cash collection is satisfactory and even better than a year ago. As far as the receivable above 3 months, so you are right, they are increasing from the €150m approximately a year ago to €170m this year. But it's a gross amount." — **Sandrine Teran, CFO.***

- *Eutelsat major shareholders reduces stake*

  BPI France (Banque Publique d'Investissement), a French state-backed investment bank, has significantly reduced its stake-holding in Eutelsat. BPI has sold about 15.5m shares in the French satellite operator, and equal to 6.67 percent of the company. BPI will retain about 19.8 percent of its Eutelsat holdings.

  "This partial disposal reflects our strategy of active portfolio management and will allow to finance other growth companies," BPI CEO Nicolas Dufourcq said. The move also means that BPI will lose one seat of its three on the Eutelsat board of directors.

Senior Columnist Chris Forrester is a well-known broadcasting 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 1998 he 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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Redefining Disaggregation

Hives can form resilient satellite constellations in space

By The Aerospace Corporation

Historically, satellites have come in all shapes and sizes.

The first satellite, ***Sputnik 1***, was a mere 23 inches in diameter when launched by the Soviet Union on October 4, 1957. In contrast, when the **International Space Station** was launched in 1998, it was the size of a football field.

Today, the most common uses of satellites are for GPS navigation, communications, photography, scientific surveying, and imaging. Generally, most of the satellites currently orbiting in space serve a specific function, although some are capable of performing more than one task.

Satellites are clearly one of our most important space assets due to the important services they perform to make our lives easier as well as for the value they contribute to national defense.

However, because satellites are so important to modern life, there is concern that if a part of a satellite — or the entire satellite itself — were compromised due to a malfunction or an attack by enemies, this could adversely affect the mission, possibly rendering it useless.

Disaggregation and Resilience

In the company's pursuit to create resilient space, a team of technical experts at **The Aerospace Corporation** is experimenting with an innovative concept called ***Hive***.

Hive is a swarm of smallsat units that can form structures in space and reconfigure themselves for various tasks as well as also be disaggregated when necessary.

Similar to how Legos are assembled, the building block of Hive is a smart, mass-producible, smallsat unit that could interlock with other units and transmit power, data and heat. Each unit would also be able to rotate on a "face" (one of the smallsat sides) while attached to other units, as well as be able to climb over other units or detach, if necessary. They could also rendezvous, dock and reconfigure themselves on demand or autonomously.

"*This forward-looking technology could enable all kinds of missions with its adaptability, upgradeability, and large physical size*," said team lead Dr. ***Henry Helvajian***. The team's ultimate goal is to make units that are standardized, interchangeable, and with high reliability. As Helvajian said, a Hive unit "*rolls, hops, and can be swapped*."

Advantages And Applications

One huge advantage of Hive compared to a traditional satellite is that Hive could change its configuration to perform various missions.

For example, Hive could be used as a large, reconfigurable optical telescope,. By simply moving around key units, Hive could perform a different function.

This adaptability is especially valuable for long-term missions where needs, environmental conditions and technology may change over time.

Hive units could assemble into different configurations in space. (Illustration: Joseph Hidalgo)

Variants of Hive units Illustration by Joseph Hidalgo.

Another advantage of Hive is that, upon failure of a unit, upgrades would also be easier because malfunctioning or older Hive cells could be individually replaced. In the event of space threat, such as approaching debris, the Hive units could disperse and then reassemble themselves or change their pose after the threat had passed.

As Hive units are modular and each one is capable of being equipped with a specific function or capability, they can be made to aggregate in space. Consequently, it becomes possible to build very large structures that originally may have been too substantial to fit on a single launch vehicle.

Visualizing Hive's flexibility, Helvajian said, "*Hive units could first fly to Mars, where in space, they serve certain functions, but then once on the ground, they can turn into a support structure—for example, a building.*"

No doubt, the concept of Hive sparks the imagination and all kinds of interesting possibilities come to mind. The Hive team is also definitely thinking outside the box, as well as outside the cube.

Instead of typical CubeSats — cube-shaped smallsats mostly used for space research — they have considered making a circular shaped Hive unit that is comprised of nested rings.

"*In trying to figure out the best form factor to allow us to efficiently package and assemble the Hive units, we drew inspiration from a variety of sources, including the slinky toy, origami, molecular chemistry, and even IKEA*," Helvajian noted.

Although the idea of Hive is still a work in progress, Helvajian emphasizes that Hive is built on a solid engineering backbone saying, "*I didn't want this to be an exercise in 'viewchart engineering.' What stands behind this are 30+ subject matter experts, and the feasibility study stands on reasonable engineering foundations.*" He has assembled a broad team of technical specialists from a multitude of scientific areas including distributed software, timing and networks, mechanisms, and thermal and attitude control to investigate the viability of Hive.

This team is considering new approaches to deployable structures, looking at mechanical and thermal interfaces that enable dynamic configurability as well as systematically addressing the multitude of engineering challenges that inevitably arise with ground-breaking ideas such as Hive.

These creative engineers continue to investigate and consider different options, they are excited to consider what could ultimately be possible.

"*Hive is just a forerunner to the changes anticipated as space architecture evolves*," Helvajian said.

Although the concept of Hive is ambitious and visionary, as with all innovation, vision and imagination are required to make the fantastic an actual reality.

After all, not so long ago, travel to the moon was considered just a dream...

*This article and included imagery is courtesy of The Aerospace Corporation — **aerospace.org/***

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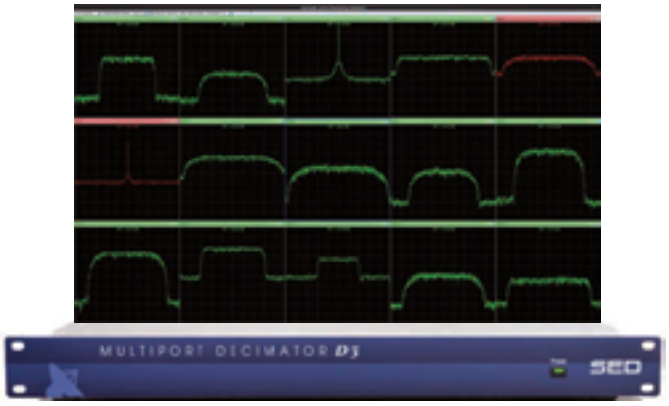

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Unlocking Dynamic Space Opportunities Across Asia-Pacific

By Dr. Bob Gough, Head of Business Development, Australia and Asia-Pacific, Goonhilly Earth Station Ltd.

Goonhilly Earth Station is pursuing ambitious plans aimed at putting the teleport and 'space gateway' at the vanguard of the new extra-planetary economy. Despite its eponymous UK location, Dr. Bob Gough explains how organizations throughout Australasia and Asia-Pacific will benefit from the company's growing international network.

By its very nature, the space and satellite industries are global. Goonhilly may be based in the far south-west corner of the UK, however, the company's ambitious roadmap of expansion is set to benefit a wide range of commercial and non- commercial organizations across the APAC region.

Goonhilly's new strategic partnership with the Australian Space Agency, struck in February of 2019 even before the ASA celebrated their first birthday, is a real milestone and a herald of things to come. In fact, the company's presence and partnerships in Australia are at the heart of our strategy to support the APAC and, indeed, the world.

Supporting Australia's New Space Economy

Goonhilly's shared goal with the ASA is to collaborate and create new opportunities in the space economy in Australia, the UK and beyond. Together, the aim is to help progress the Australian space sector and make the benefits of space more accessible for businesses, governments and institutions.

In the UK, mutually beneficial collaborations have been forged with other businesses and universities to develop next-generation space communications. The plan is to take this proven approach in Australia. This new agreement will provide greater opportunities for technology transfer between the UK and Australia as well as the creation of more skills and new opportunities in the Australian space sector.

Another opportunity is the proposed SmartSat CRC (Cooperative Research Center) space research initiative. The company joined this fast-growing consortium, comprised of space agencies, academic institutions, industry partners and other collaborators, at the end of last year.

Goonhilly's strategic partnership signing with the Australian Space Agency. Photo is courtesy of the company.

Goonhilly is committed to helping develop Australian-based deep space communication assets. The firm opened an Australian office in 2018 and investment is being committed to further infrastructure and facilities as part of Goonhilly's wider plan to support deep space projects across the globe.

The plan is to enhance connectivity, navigation and monitoring capability a cross Australia and to maximize the country's resources by solving major satellite system and advanced communications challenges.

An aerial view of the Goonhilly Earth station in the UK. Photo is courtesy of the company.

Goonhilly is also involved in Space Situational Awareness (SSA) and debris monitoring, Earth Observation (EO) Services as well as Research & Development. The ASA's focus on Remote Asset Management complements our own efforts.

To operate globally, it is technologically essential to build Goonhilly's presence on the other side of the world from the UK. In order to support space missions to the Moon or Mars, there must be at least three ground stations 120 degrees apart and, as the Earth rotates, there is always at least one ground station pointing in the correct direction.

However, the advantages of these burgeoning partnerships are commercial as well as operational. The company will be able to collaborate with a broad spectrum of players in Australia's expanding space economy and together create the correct environment for more space exploration and development that benefits Australia, the UK and beyond.

For any customer or project requiring worldwide reach, whether at the project's outset or later in its lifecycle, infrastructure must be available across the globe to support that need. When spacecraft are launched and move in orbit, they must be monitored and controlled across their complete path as they traverse across the entire planet. Goonhilly's core goal is to be able to provide that ubiquitous support.

A Diverse Region

The Asia-Pacific region is probably the most diverse on the planet and embraces large urban metropolitan areas that are among the world's most technologically advanced in the world, such as Singapore, Jakarta, Bangkok and Seoul.

Elsewhere, however, there are APAC regions that have limited terrestrial infrastructure and there are numerous isolated communities and countless islands such as Indonesia, Solomon Islands and elsewhere across the whole South Pacific that require connectivity.

Goonhilly and the firm's partners can support each of these markets, co-operating and providing services and facilities that they might lack or seek to complement.

Delivering Business Continuity

These days, most view internet connectivity as a right, not a luxury. Good, reliable internet connectivity is a prerequisite for domestic and international development and, indeed, the wellbeing of society.

Billions of dollars are being invested in multiple satellite mega-fleets whose raison d'etre is to connect people, wherever they may be located. Goonhilly wishes to play a major role in bringing broadband and WiFi to areas that are otherwise starved of reliable, 24/7 year-round connectivity that is needed to advance economies and support communities' needs.

Business continuity and disaster recovery are also high on the agendas of organizations across the region. Scenes of earthquakes and the resultant tsunamis, and the effects of crippled infrastructure following such disasters, remain fresh in the memories of people across the Pacific Rim and the Ring of Fire. Goonhilly expects to play an ever-greater role in helping businesses and governments mitigate these catastrophes.

We've already struck a chord with telcos and enterprises right across the region who seek to have reliable, robust and diverse backup for their terrestrial networks — including those who rely on VSAT driven communications.

Worldwide LEO Support

The burgeoning Low Earth Orbit (LEO) sector is an area where Goonhilly expects to play an important, enabling role. There is huge potential for LEO satellites to bring ubiquitous broadband and other life enhancing services to billions of people around the planet. However, today the real-world performance of LEO constellations, and how they interact with other constellations in the same spatial plane, as well as with spacecraft in other orbits, remains untested and unproven.

Telcos in tropical and sub-tropical countries are starting to use High Throughput Satellites (HTS) to service the country's growing internet needs. Virtually all HTS satellites now use Ka-band, either for GEO satellites or the rapidly emerging LEO constellations. The well-documented risk with Ka-band at 20/30 GHz is rain attenuation, particularly at high rainfall rates as occur in the tropical storms which dominate the climate in these regions.

Goonhilly will be able to provide "site diversity" Earth stations in drier climates such that, when the telco's primary Earth station cannot support the link, all of the traffic automatically switches to the company's Earth station via high-speed fiber.

This sounds straightforward... and it is for GEO satellites. However, there's a totally different story for the new LEO constellations because the network architecture is extremely complex.

LEO satellites orbit Earth each 90 minutes or so and, as each one disappears over the horizon, the Earth station terminals must have already acquired the next LEO in the constellation. Traffic in the LEO constellation typically is automatically switched between satellites via intersatellite links. Consequently, the Goonhilly site has to operate in an identical manner in order to be ready for the "switch" when the telco's main Earth station drops out with zero notice.

It is extremely important to provide all the reliable testing and communications tools these ambitious LEO providers need as they launch their satellites and roll out their technologies — and even test their business models. As the promise of the LEO dream starts to come to fruition, Goonhilly is committed to supporting LEO projects each step of the way.

The diverse APAC and Australasia region is characterized by a patchwork of regulatory frameworks and licensing regimes. Multi-party interconnection negotiations are enough to make one's head spin.

LEO satellites will affect the already complicated technical switching requirements, and what all the ancillary consequences will be, is yet to be seen.

Frequency coordination between mobile 5G and satellite communications is different in every country. We believe we are well positioned to be an enabler, leveraging technical expertise and a worldwide network of partners to help stakeholders across the ecosystem to navigate the inextricably interlinked labyrinth of technologies and regulations.

In order to help proactively support and mitigate risk in what looks to be an increasingly populated near-earth orbit, with a patchwork of frequencies and technologies, Goonhilly is busy building various in-house capabilities, expertise and infrastructure, including the active development of new antenna technologies, within the organization. The company is striving to be the low-risk partner of choice for customers.

While a top commercial priority is to establish Goonhilly's Asia-Pacific deep space network ground station, this is just the tip of the iceberg. In parallel, the company is starting to develop other communications-centric facilities and services that will benefit the region and beyond.

Datacenter Opportunities

Many Asia-Pacific countries require remote data centers for a variety of applications — Goonhilly offers a unique operational proposition as the company's UK site sits at the confluence of virtually all of the world's fiber links as they spread across UK and on to Europe.

Latency is lower than with the major London datacenters; furthermore, the SEA-ME-WE3 fiber from Perth, Australia, winds its way through Asia and the Middle East to land in the East Wing of the Goonhilly site — mere meters from the company's secure datacenter, which is due to open shortly. The datacenter sits at the epicenter of internet connectivity between the U.S. and Europe and will attract customers based in the APAC region who wish to have a global presence.

Disruptors Welcome

Goonhilly's success has been built upon collaboration and cooperation with space agencies, industry, educational institutions, telcos, local and central governments. The firm's mission in APAC is to adopt this same, winning business formula.

At one end of the spectrum, Goonhilly will support established organizations where the company can help them, taking into account the dramatic changes that are now taking place across the global satellite communications ecosystem. The company is also eager to work with start-ups to help them to grow successfully to everyone's mutual benefit.

Dr. Megan Clark, Head of the Australian Space Agency, recently said, "We can run between the legs of giants." This vivid image is totally appropriate for the rapidly changing worldwide space sector. Goonhilly's Enterprise Zone status, and the numerous opportunities such affords, certainly will play a significant role.

Space is a global industry and the company has never looked at the world through a UK-or European-only lens. Right from the start, the company's ambition has been to play a driving role in the new space economy. To accomplish this goal, we aim to partner and win contracts with relevant organizations, irrespective of their location.

Simply stated, the firm is building infrastructure and establishing facilities wherever the requirements and opportunities reside — and the dynamic markets in Asia Pacific are extremely important to Goonhilly.

www.goonhilly.org/

Dr. Bob Gough (BSc, PhD, CEng, MIET, MAIA) is the Head of Business Development, Australia and Asia-Pacific, for Goonhilly Earth Station Ltd. With more than 35 years in the space and satellite communications industry, Bob joined Goonhilly in July 2018. His experience includes working on major international projects in cooperation with space agencies, including ESA. He was a member of the project team at ESTEC and has worked on key projects and systems for Inmarsat, Intelsat, Eutelsat, Skynet and BSB, among others.

Bob has in-depth experience in systems and spacecraft design, having worked on TT&C stations, traffic stations operating in all satcoms bands, in-orbit testing stations, propagation measurement stations and radiometers. He has delivered large earth station projects carrying traffic for whole countries, small businesses, offshore oil rigs, fixed and transportable military Earth stations, VSAT terminals, mobile terminals and TV uplinks. Bob is also a Senior Contributor for Satnews Publishers and the company's daily and monthly publications.

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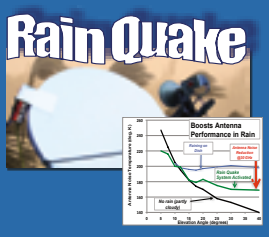

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The Propagation Impacts

... on Ka-band ground terminals

By Krystal Dredge, Director of Marketing, AvL Technologies

Ka-band is the microwave range from 26.5 to 40 GHz and the frequency's properties include millimeter wavelengths, good power manageability and narrow beams that are easily pointed to avoid interference with other satellites.

However, Ka-band's shorter wavelengths (significantly shorter than Ku-band) are susceptible to signal attenuation due to atmospheric conditions (often referred to as rain fade), though such can be mitigated somewhat with uplink power control.

Signal attenuation is due to the absorption of RF energy by adverse weather conditions, including rain and wet snow (dry snow has minimal effect on attenuation). With atmospheric liquid water, absorption peaks around 10 GHz due to the orientation of the molecules.

Atmospheric water vapor absorption peaks at 22 GHz, making Ka-band highly susceptible to any type of atmospheric moisture. Additionally, the leading edge of a storm can cause electromagnetic interference. In general, the higher the frequency, the deeper the fades can be.

With GEO satellites in particular, the effects of Earth's troposphere on propagation often are a limiting factor when using ground terminals. This becomes more of a challenge with the ongoing drive to move to smaller sized terminals, which often do not have sufficient receiver gain or transmit power to overcome the effects of path losses to and from the satellite. For Ka-band applications, the impact of these effects can make the difference between a viable communications link and a system outage.

When considering propagation effects that impair the communications channel of a ground terminal, the phenomenon considered typically includes: rain attenuation, cloud attenuation, tropospheric scintillation, gaseous absorption, melting layer attenuation and depolarization.

Rain Attenuation

Attenuation due to rain is typically the most significant and most common contributor to propagation loss.

When evaluating loss effects of rain at Ka-band, attenuation is a function of several aspects of the rain's physical form factor, including rain frequency, rain intensity, temperature and the physical size of the rain drop.

Rates and duration of rain fades are largely correlated to the type of rain experienced in the signal path.

Cloud Attenuation

The impact of clouds at Ka-band is dependent on whether the water in the clouds is in liquid or solid form.

When clouds are liquid, increased signal attenuation is experienced, as is amplitude scintillation. When the water is frozen, the small size of the ice particles is less significant when compared to the wavelength. This means that for ice clouds, attenuation is effectively a function of the cloud temperature in combination with any other liquid water along the signal path.

Tropospheric Scintillations

Tropospheric scintillations are changes in amplitude due to inconsistencies in the refractive properties in the lower part of the troposphere.

Dry scintillation occurs when there is no fading in the signal path, whereas wet scintillation occurs

AvL Technologies tracking antennas manufacutured for O3b. Photo is courtesy of the company.

when fading is experienced. The magnitude of scintillation increases with frequency. It also increases as elevation angle decreases as low look angles enable signals to bounce. Scintillation also increases as the aperture size decreases, which is of particular concern with the emerging demand for smaller terminal size in conjunction with Ka-band applications.

Gaseous Absorption

When compared to other effects in the communications channel, the gaseous absorption is a relative constant consideration and the impact of water content varies slowly over time. What is observed is that gaseous absorption increases with relative humidity as well as temperature.

Melting Layer Attenuation

This phenomenon occurs around the 0 degrees Celcius melting point, whereby snow and ice particles transition into rain.

The melting layer is a relatively, physically, small component of the propagation channel, with a typical width on the order of 0.5 km. The attenuation experienced due to this somewhat localized occurrence is typically higher than experienced for the rain in-close proximity.

Depolarization

When orthogonal polarization is used to increase communications bandwidth by frequency re-use, atmospheric depolarization may occur when rain or snow exists in the propagation path. Depolarization due to rain is a function of polarization angle, elevation angle, frequency and overall rain attenuation.

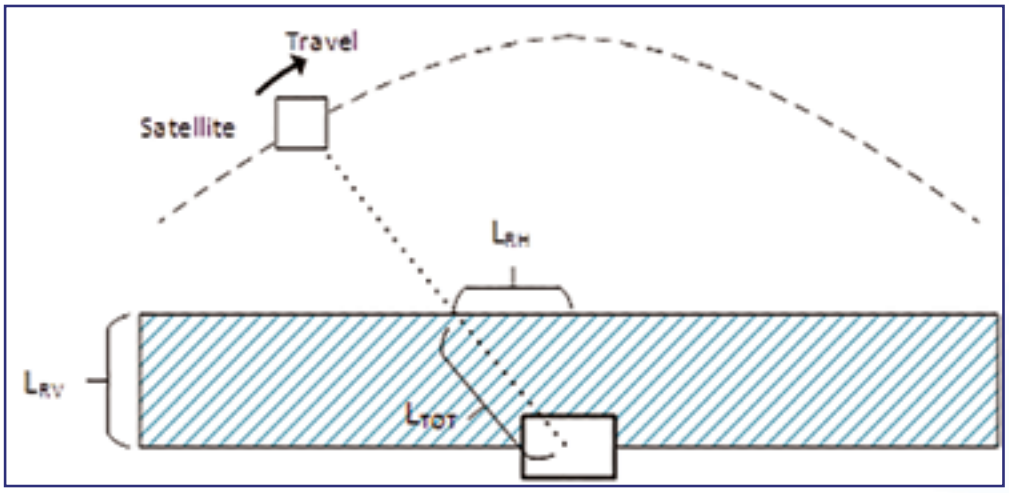
At Ka-band, rain depolarization only becomes significant when rain fades are at levels in excess of approximately 10dB. Depolarization due to snow is not tied to fading levels of frozen participation.

Impacts on LEO and MEO Communications

With GEO satellites (36,000 km), atmospheric attenuation is often mitigated with power management — Ka-band terminals easily manage increased power to enable a signal to "burn through" atmospheric conditions.

As GEO satellites are geostationary on-orbit and don't noticeably move unless the satellite is in a decaying orbit, antenna pointing and signal management is relatively simple. With LEO and MEO satellites, tracking adds a significant layer of complexity.

Satellites flying in MEO orbit (5,000 to 10,000 km.) are considerably closer to Earth than those in GEO orbit; however, these satellites are moving quickly and must be tracked as an orbit can range from roughly 2 hours to 24 hours and visibility can range from minutes to a few hours. MEO communications benefit from less free space path loss as compared to GEO, but the impact in the channel impairments does not change as rapidly as with LEO communications.



The LEO satellite travels rapidly across the sky. When a rain layer exists, the geometry changes substantially over the complete pass of the satellite. Image is courtesy of AvL Technologies.

LEO constellations (100 to 1,500 km.) typically have tens or hundreds, potentially thousands, of satellites in orbit — and all are moving at high velocities. Satellites in LEO orbit are typically small — weighing less than 500 kg. — and are not equipped with the abundant power sources found with GEO and MEO satellites. Because of this, power is nearly always managed from the Earth terminal and this creates an additional complexity with the requirements for tracking and communicating with a multitude of successive moving satellites for short periods of time.

The fundamental differences between GEO and LEO applications have to do with range — for LEO communications, the range is decreased significantly, but the satellite is in rapid motion as it travels over its pass.

An impairment effect can be modeled as a layer in the atmosphere, making it easy to visualize how the signal path changes as the LEO satellite travels through its field of view with respect to the ground station.

When the satellite travels, if there is rain, the length of propagation can substantially change. When the satellite first comes into view, the length through the rain layer would be the most severe, minimizing overhead, and then become severe again as the satellite moves out of view.

Mitigation of Weather Effects

While weather can certainly have a negative impact at remote terminal locations, the impact at gateway locations can have profound consequences at all of the remote sites. For this reason, satellite operators have developed very effective mitigation techniques that include:

- ***Planning*** *— most operators have developed and installed redundancy gateways, including gateways that can be located outside the spot beams*
- ***Adaptive power control*** *— perhaps the most effective weather mitigation tool that allows for automatic signal strength control*
- ***Adaptive modulation*** *— one of the most common tools that uses advanced signal processing algorithms*

Today, Ka-band ground terminals are installed throughout the world. As the original Advanced Communications Technology Satellite (*ACTS*) was launched in 1993 to confirm the feasibility of Ka-band for satellite communications, this powerful spectrum has proven to be the most effective platform for high throughput communications, in spite of the original concerns over rain fade.

While atmospheric issues have never been completely overcome, it is widely accepted that the mitigation tools developed over the past 25 years have allowed satellite operators and users to take advantage of this uniquely powerful spectrum.

www.avltechnologies.com

Krystal Dredge is the director of marketing for AvL Technologies. Krystal has 15+ years of product marketing experience in satellite and wireless communication, and worked at Honeywell and EMS Defense & Space Systems prior to joining AvL in 2012. She holds a BSJ degree in Journalism from the University of Kansas and an MBA from Wichita State University.

A Conversation With...

with Niklas Boman, Director, Marketing and Sales, Spacecraft, RUAG Space

Niklas Boman has extensive management experience in the aerospace industry. Those positions included sales and marketing, production as well as R&D activities. During the last few years, Mr. Boman held several senior positions in the space, aviation and military (development and production) environments. He also has several years of PnL success.

In the U.S. RUAG Space is mostly known for its payload fairings. However, for OneWeb the company delivered a wide range of products for that firm.

Niklas Boman (NB)

Indeed. For the OneWeb constellation program, RUAG Space is a key partner. The company delivered a superlight satellite dispenser, which is able to deploy 32 satellites safely into space. Our multi-layer thermal insulation protects OneWeb satellites from cold and heat in space. The OneWeb satellite panels are manufactured by us as well as high-tech containers and ground support equipment that OneWeb uses to transport the assembled satellites to the worldwide rocket launch centers.

RUAG space also provides launch support at the launch base to integrate the satellites onto the dispenser.

Mr. Boman, you mentioned Titusville. Why did you build up a new factory in the U.S. for OneWeb?

NB

For OneWeb, we have set-up a brand-new facility in Titusville, Florida, because we want to be very close to our customer OneWeb.

To have a facility close to the customer enables us to deliver on-time and to deliver high quantities of product. Over the years, RUAG Space has invested a significant amount of money in both

The satellite constellation will consist of hundreds of small satellites. How did you achieve such a large-scale production?

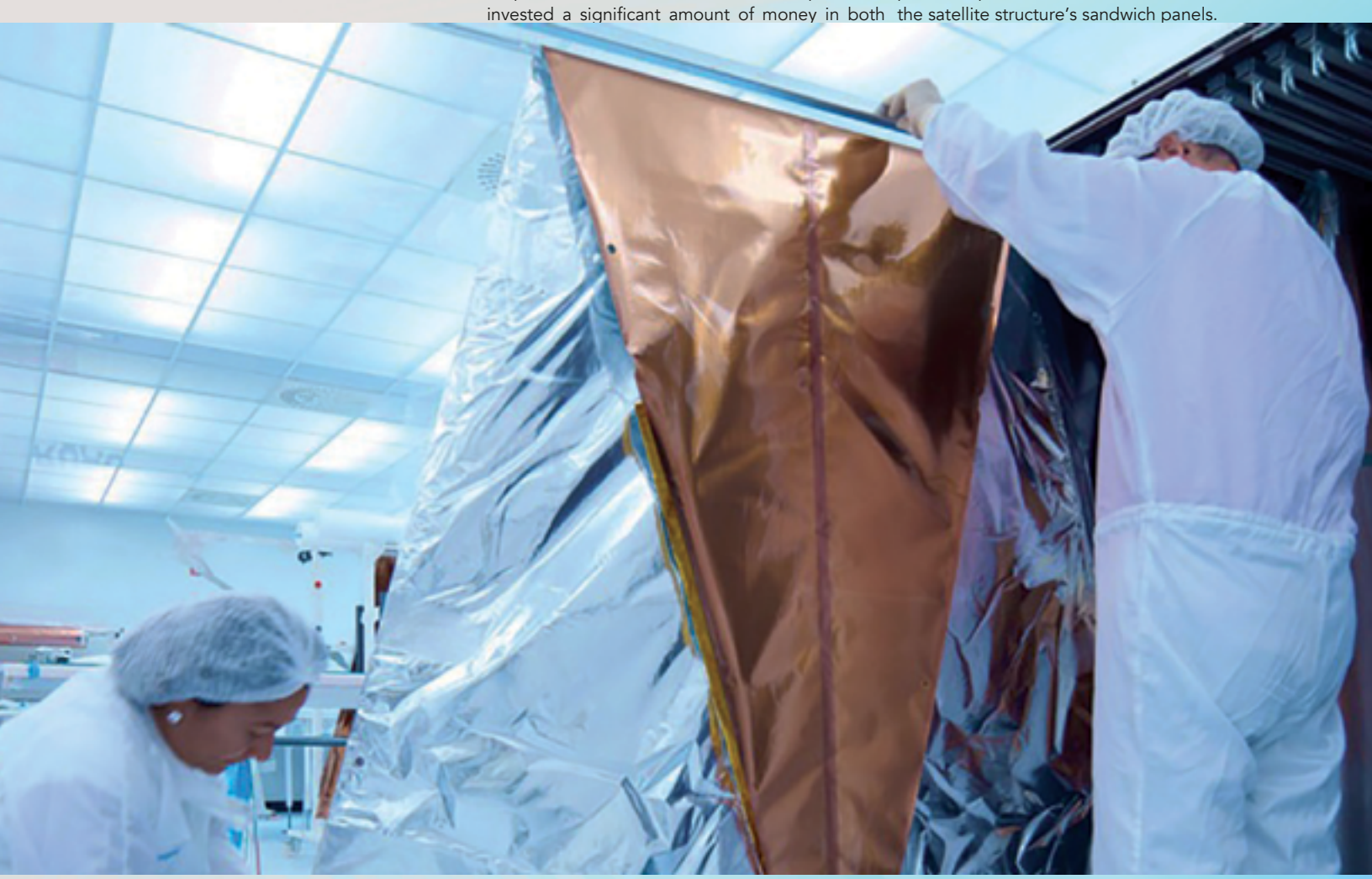
NB

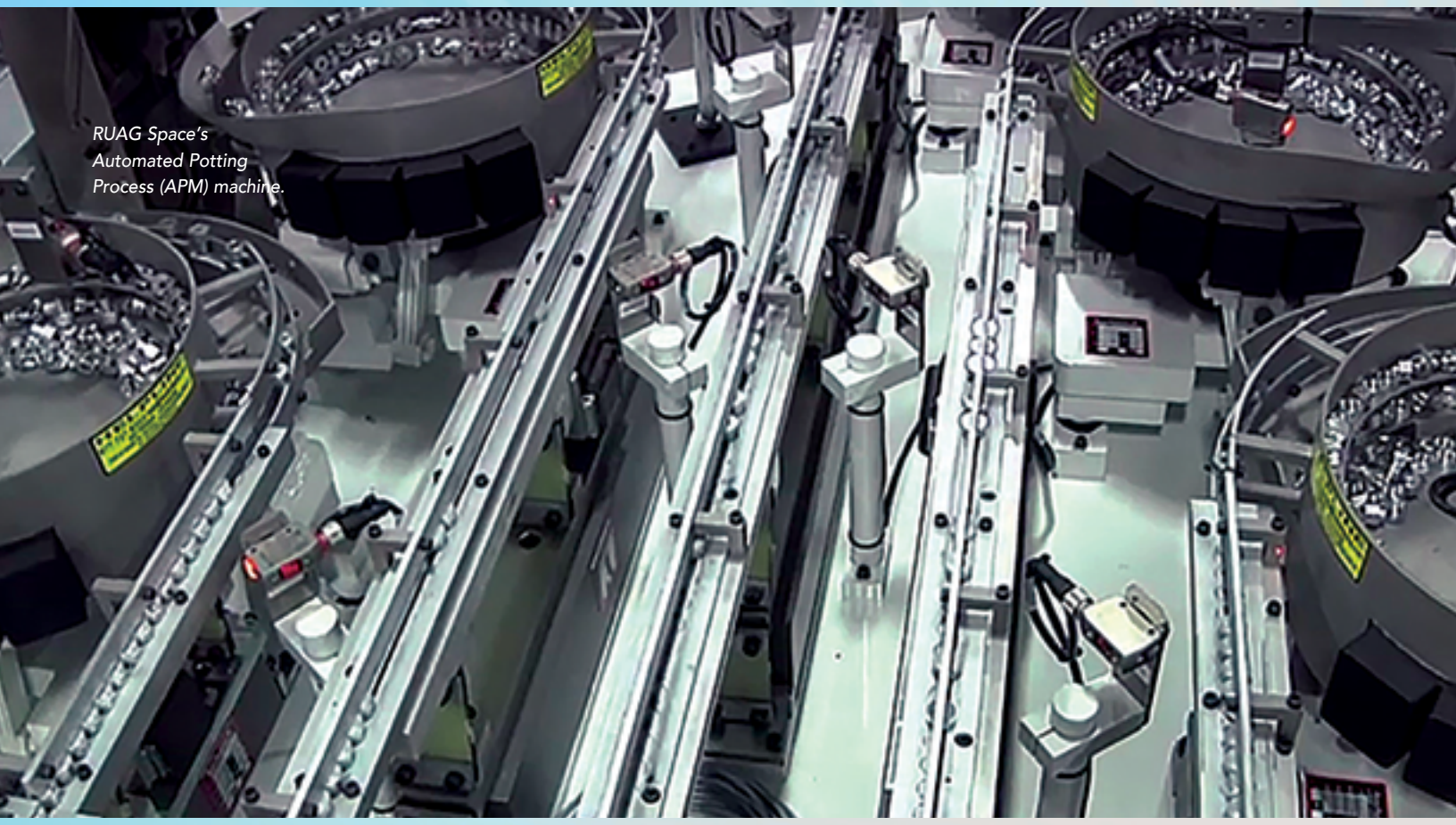
We have a highly automated production using efficient processes.

The OneWeb satellite panels, for example, are manufactured using the Automated Potting Process (APM). This potting machine is putting hundreds of inserts into a panel with a robot and is totally automatic. In the past this was done manually.

APM is a key technology for the OneWeb project. Using our APM technology, we can dramatically reduce the production time from 30 minutes per insert to a quick 90 seconds — or even lower.

The APM process, which was developed by RUAG Space, is a revolutionary production method patented by the company that uses a computer numerical control (CNC) machine to rapidly position special inserts filled with adhesive into the satellite structure's sandwich panels.





RUAG Space's Automated Potting Process (APM) machine.

How did the company produce the thermal insulation for so many satellites?

NB

We have more than 25 years of experience in producing high-quality thermal insulation for satellites.

We delivered more than 50 thermal insulation systems for space projects.

However, to produce multilayer insulation for 900 satellites, well, that is clearly a big amount for the space industry.

To rapidly produce such high volumes, we used state-of-the-art laser technology. We also used our experience in serial production for terrestrial thermal insulation, such as high temperature insulation for MRI scanners.

www.ruag.com/en/products-services/space/spacecraft

Since the start of the Galileo program RUAG Space has produced every thermal insulation for the whole Galileo satellite constellation. The Galileo satellites are 'wrapped up' almost entirely in a special thermal insulation blanket to ensure that the sensitive onboard electronics are not damaged by the extreme temperature fluctuations encountered by the satellites in space.

Artistic rendition of a Galileo satellite.

The New "Space Race" Is Well Underway

Firefly's acceleration of the smallsat industry

By Thomas E. Markusic, Founder and CEO, Firefly

2019 is the year of the smallsat... of course, 2018 was also the year of the smallsat... as was 2017 and 2016. Smallsat schedules always shift to the right — historically, there are several reasons for these occurrences.

Many companies pursuing smallsat applications are developing constellation strategies that consist of tens to thousands of satellites. The development of technology demonstrators and of full constellations requires substantial capital, often difficult to raise.

The year 2018 witnessed substantial movement on the financing front for constellation projects. Beyond the larger planned constellations such as **OneWeb** and **Starlink** that had previously announced funding, smaller constellations have also announced successful deployment of demonstration satellites and capital raises.

Cloud Constellation Corporation capped off 2018 funding announcements with a $100 million capital raise for space-based data centers, confirming there is venture capital interest for existing space-based applications as well as for unique applications that have not yet been implemented.

In all, closings of many hundreds of millions of dollars were announced for several new smallsat constellations in 2018 alone.

In additional to financing, years of mission planning culminated in the successful December 2018 **Spaceflight *SSO-A*** mission; a pivotal milestone for the Smallsat industry.

With more than 35 companies participating, including firms such as **Astro Digital**, **Astrocast**, **Audacy**, **Blacksky**, **Capella**, **Fleet Space**, **Hawkeye 360**, **ICEYE**, **Novawurks**, **Planet** and **Swarm**, many companies were able to prove critical technologies, add to existing networks and, in some cases, trigger that always crucial, additional financing.

A primary concern involved in funding such disruptive endeavors expresses to new entrants in the smallsat industry is that these companies must — aside from proving their technology — must also show a viable path to space. A completely developed and manufactured smallsat sitting on a shelf collects dust and does not generate revenue.

As most smallsat constellations in development are in the under 300 kg. category, they are typically relegated to secondary payloads on large launch vehicles. Schedule and orbit are determined by the primary cargo and slips in the primary cargo schedule can have devastating effects.

A company that raises money to launch a technology demonstrator where additional funding will be released after the technology is proven would be exposed to substantial risk should the primary payload fall six months to a year behind schedule, as often happens with large satellite development efforts.

Companies with smallsat business cases must demonstrate access to economical and affordable launch services.

As of last year, a Northrop Grumman survey indicated there are more than 100 companies developing small launch vehicles to service the smallsat market.

Most of those companies are not expected to succeed, as the technical and financial hurdles smallsat launchers must overcome provide an extremely high barrier to entry.

Despite those barriers, the expectation is that several of the well-financed smallsat launcher companies will succeed and provide launch services to the burgeoning smallsat industry.

Rocket Lab successfully executed three launches in 2018. **Virgin Orbit** has indicated they are preparing for their first launch in early 2019 and several other companies, including **Firefly Aerospace**, have announced an intention for an initial launch in 2019. Once the small launchers demonstrate consistent cadence at an economical price, additional smallsat business cases will begin to close and an even more rapid expansion of viable smallsat businesses will occur.

The Firefly Aerospace vehicle family is a primary path for this acceleration of the smallsat industry.

The company's ***Firefly Alpha*** launch vehicle will accommodate 1,000 kg. of payload to a 200 km. Low Earth Orbit (*LEO*) and 630 kg. of payload to a 500 km. Sun Synchronous Orbit (*SSO*). The SSO orbit is widely regarded as a critical destination for smallsat Earth Observation (*EO*) platforms and is currently underserved by dedicated launches.

Pictured: Left, FIrefly's Alpha launch vehicle — Right, Firefly's Beta launch vehicle. Images are courtesy of the company.

Artistic rendition of the Alpha separation. Image is courtesy of Firefly.

Firefly's Alpha is the largest U.S. smallsat launch vehicle that is expected to be in service by the close of 2019 — no competing vehicles of a similar payload capacity are expected to be in service until at least 2021.

Surveys of potential customers have indicated the one metric ton capacity of the Alpha is in the "*Goldilocks*" range of dedicated smallsat launchers. The Alpha is large enough to deploy multiple 125 kg. class satellites so that planes of smallsat constellations can be easily deployed while being small enough that aggregators can manifest entire vehicles consisting of a combination smallsats that could include microsatellites and CubeSats.

Firefly launch vehicle family will be expanded by adding the Beta vehicle by mid-2021. Beta is a four metric ton launch vehicle representing the only domestically available "*Constellation Class*" smallsat launcher and will directly compete with the with the **Indian Space Research Organisation**'s ***PSLV*** in both price and payload capacity.

Beta will be heavily derived from flight heritage Alpha technology, using substantially the same engines, structures and avionics. This will allow for rapid development of the Beta vehicle once the Alpha successfully launches and confirms performance and environment envelopes.

Artistic rendition of the Beta separation. Image is courtesy of Firefly.

Beta will also allow for missions beyond LEO. Firefly was recently selected by **NASA** as one of nine companies competing to deliver science payloads to the surface of the moon. NASA expects to spend more than $2.6 billion dollars over the next decade on commercial lunar payload science missions.

By providing an integrated offering that includes a launch vehicle and lunar lander, Firefly will allow companies developing lunar payloads schedule assurance and reliable access to launch slots, which may rapidly accelerate the nascent lunar science industry.

Firefly has demonstrated schedule credibility by consistently hitting major development milestones.

Commencing stage qualification testing was one of Firefly's primary goals for 2018 and was successfully achieved, demonstrating flight-configuration propulsion, structures and tankage,, pressurization and propellant management systems, and avionics.

The stage operated autonomously, controlled by Firefly-developed flight software.

These tests also demonstrated full activation of Firefly's large-scale vertical test stand, "***TS2***", at Firefly's Briggs, Texas test facility. In 2019, Firefly will continue qualification testing of both the first and second stages of Alpha and will begin flight acceptance testing in May, supporting a goal of a December 2019 first launch from *Vandenberg Air Force Base Space Launch Complex 2-West*.

There truly is a new "*Space Race*" underway. While consolidation is expected, and some entrants in both the smallsat manufacturer and launcher verticals may not make it to the finish line, there is substantial room in the market for multiple winners in both verticals and exciting prospects ahead in 2019 and beyond.

firefly.com

Thomas E. Markusic is the founder and chief executive officer of Firefly. Prior to co–founding the comp[any, Tom served in a variety of technical and leadership roles in new-space companies: Vice President of Propulsion at Virgin Galactic, Senior Systems Engineer at Blue Origin, Director of the Texas Test Site and Principal Propulsion Engineer at SpaceX.

Prior to his new–space work, Tom was a civil servant at NASA and the USAF, where he worked as research scientist and propulsion engineer. He holds a Ph.D. in Mechanical and Aerospace Engineering from Princeton University.

Adapt... and Survive

Sustained success through active and reciprocal partnerships

By NickFarrell, Director, Rock Seven

If the last few years of spooked and volatile trading conditions have taught us anything, it's simply that for corporations and customers alike, standing still does no one any favors.

The principle of '*adapt and survive*' is more imperative than it has ever been, even for institutions with a seemingly bulletproof infrastructure and an impressive product portfolio.

One clearly-signposted route to sustained success is the pursuit of active and reciprocal partnerships which have the effect of simultaneously broadening companies' consumer bases and driving cross-platform innovation. The intertwined destinies of **Rock Seven** and **Blue Sky Network** (**BSN**) indicate the dividends this approach can provide.

Founded in the UK in 2005, the Iridium-based satellite tracking and communication systems specialist Rock Seven has rapidly risen to a position of prominence within the industry, buoyed by a unilaterally positive reputation for the company's far-sighted products and services. The firm's market penetration has been further enhanced since the firm was acquired by the M2M and IoT provider, **Wireless Innovation**, in 2018.

Blue Sky Network (BSN), meanwhile, founded in 2001 and based in San Diego, prides itself on their position at the leading edge of global satellite technology. As with Rock Seven, the company's frontline status has been earned through pioneering work in the field of two-way communications solutions and satellite tracking systems — there was a certain inevitability that the two companies would, almost literally, find themselves within each other's orbit.

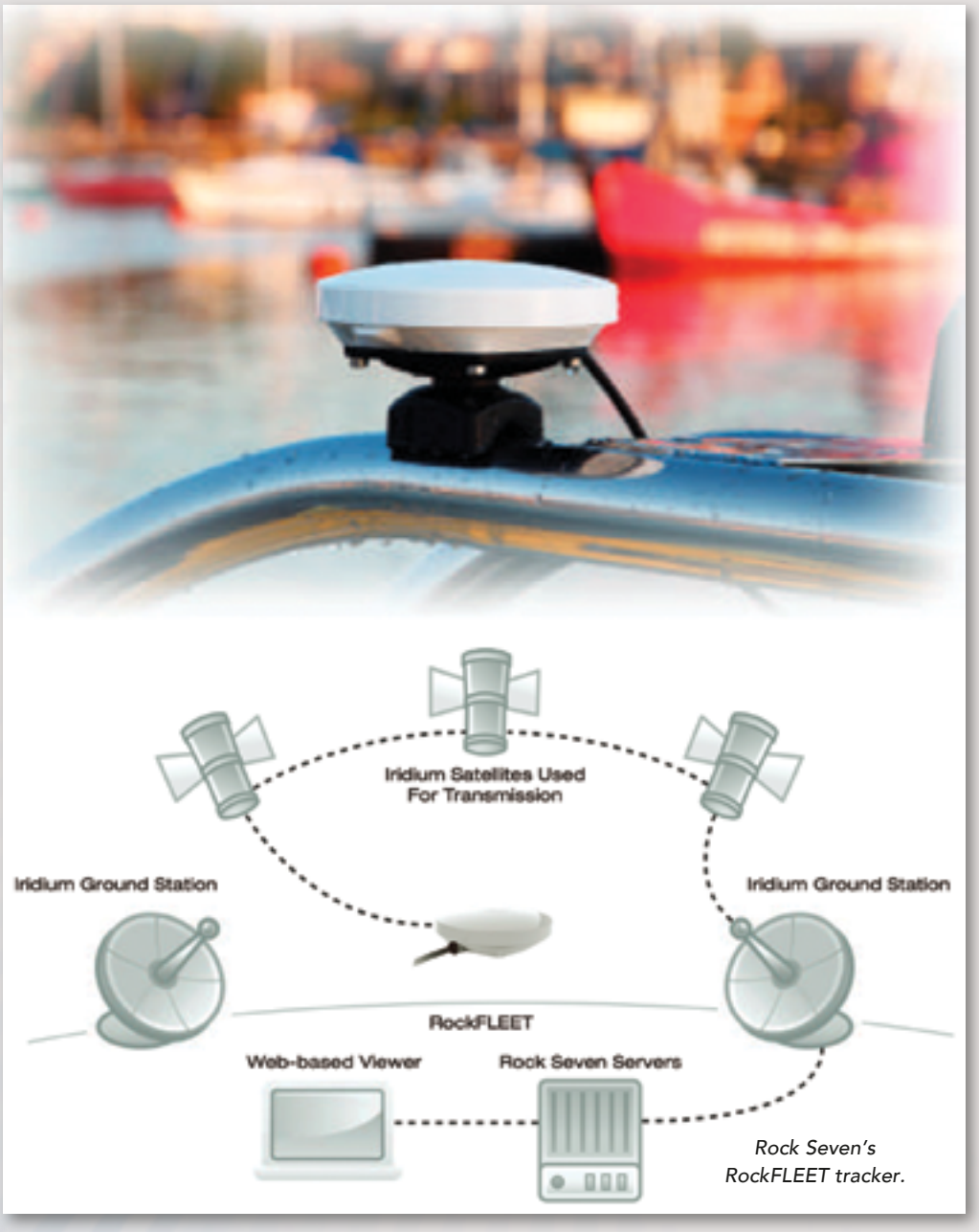
Both parties concluded, with good reason, that there was much to be gained by examining areas wherein they could combine forces, trading insights to hone skill sets and facilitate expansion into other territories. Accordingly, June of 2018 saw the integration of Rock Seven's dual-mode ***Iridium/GSM RockFLEET*** tracker with BSN's cloud-based ***SkyRouter*** tracking, communications and fleet management portal.

The amalgamation of these highly adaptable flagship systems represented a well-considered commingling of core strengths and shared objectives, and continues to do so. It essentially serves as the most complete and customizable single-solution offering available in the sphere of tracking, mapping, two-way messaging and command/control fleet management.

BSN's SkyRouter.

BSN's expanding maritime strategy benefits from RockFLEET's proven worth on a broad range of vessels as a standalone tracker, and Rock Seven gains a significant profile boost by having its products sold into U.S. markets via BSN. The immediate success of this joint venture led to a further development in January of this year, when the announcement was made that Rock Seven's dual-mode RockAIR fleet tracking and messaging device would also be integrated with BSN's SkyRouter.

Since launch, ***RockAIR*** has been steadfastly overturning outmoded notions of tracking and comms capabilities for light aircraft, rotorcraft and land vehicles alike. RockAIR is inconspicuous and effortlessly portable on the one hand, yet the



Rock Seven's RockFLEET tracker.

unit's automatic, least-cost GSM/satellite switching capacity is an invaluable resource. By assimilating it with BSN's SkyRouter portal, both systems achieve a degree of efficiency and flexibility for asset tracking and global communication that is quite unprecedented.

Looking ahead, both BSN and Rock Seven are resolutely focused on strategies aimed at delivering increasingly broad-based, cost-effective and user-friendly products and services for their customers.

Rock Seven is particularly enthused about the new ***Cloudloop*** portal, which is designed to provide a more modern, API-led way for its corporate clients to use Iridium SBD services for IoT, tracking and more.

Rock Seven's RockAIR.

With Cloudloop, owners/operators of Iridium equipment have a single platform through which to manage their contracts, data usage and billing information, with allowance alerts to automatically flag up any instances wherein devices are nearing their data/minutes limit — a handy feature that can also double as a warning against hacking.

The company is also committed to ensuring that its RockBLOCK plug-and-play satellite communication unit continues to deliver in the world of IoT. It has already proven its worth as a key resource in an encouragingly diverse array of enterprises.

These range from the tracking and recovery of a high-altitude balloon on its test outing, with the RockBLOCK conveying detailed flight information throughout, to acting as a failsafe transmitter in the automated, off-grid fire prevention system of a home constructed in a high fire risk zone in Malibu, California.

The system, named ***Hot Shot*** by its electronics engineer creator ***James Dziadulewicz*** (who also built the property), crucially had to work — even if power and cellphone reception in the area went down in the event of a fire.

Via an app designed by an electrical engineer friend, James was able to activate the system from a distance of 54 miles away after its sensors detected that a bush fire was advancing toward his home.

The RockBLOCK operated perfectly in relaying James' command to activate his system's high-pressure sprinklers.

The Malibu, California, fire in 2018.

This action, triggered by James 35 minutes before the fire was due to encroach on his property, cued the sprinklers to drench the house and the surrounding land, with the result that his home was completely untouched by the conflagration. The Hot Shot system is currently patent pending, with orders already being taken — and RockBLOCK functionality is at its heart.

As for Blue Sky Network, 2019 will see the company making concerted efforts to consolidate its standing in the business continuity market. In tandem with its satellite communication equipment manufacturing branch, **Applied Satellite Engineering**, BSN is looking at perfecting systems of prevention and recovery to tackle potential business threats ranging from sabotage to natural disasters.

Via ASE, BSN can offer fixed site terminals for remote communications during normal operation hours or during times of emergency. These terminals include push-to-talk networks over satellites and cross-banding to UHF/VHF, and indoor kits for in-building, in-vessel and/or in-vehicle communication.

Additionally, BSN has just announced the integration of **Olympic Aero Services**' ***Series 606 Additional Telemetry Unit*** (**ATU**) with its SkyRouter portal. The 606 ATU is an **Federal Aviation Authority**-approved system which can record data from a firefighting aircraft and transmit it to a remote portal via the aircraft's *Automated Flight Following* (AFF) system.

SkyRouter is basically an AFF system, and the fact that BSN hardware and software can now transmit

OAS' Series 606 ATU.

ATU data via the Iridium satellite network to the central fire suppression database, represents a major step towards the implementation of a fully-compliant system which satisfies **U.S. Forest Service** regulations.

This development further cements the push for clarity and safety-consciousness exemplified by a recent BSN white paper, *ICAO-GADSS Concept Of Global Flight Tracking* — (***leehamnews.com/wp-content/uploads/2016/06/White-Paper-ICAO-GADSS-vFinal-2016-06-01.pdf***), which spells out the recommendations of **The International Civil Aviation Organization**'s (***ICAO***) Global Aeronautical Distress & Safety System (*GADSS*) initiative, established to 'ensure that no aircraft is lost.'

Real-time aircraft tracking devices enable BSN's aviation customers to meet the ICAO-GADSS requirements with GADSS-compliant products that include the ***DMZX*** and ***HawkEye 7200A*** satellite tracking devices as well as the ***D1000A*** Iridium SATCOM aircraft tracker.

Most recently, BSN further established its leadership position in the aviation market by becoming the **United Nations**' (UN) provider of aircraft global satellite tracking services for UN field missions around the world.

The concentrated skyward gaze displayed by Rock Seven and Blue Sky Network provides a workable metaphor for the capabilities and ambitions of both companies — a measure of what can be achieved by aiming high.

www.rock7.com

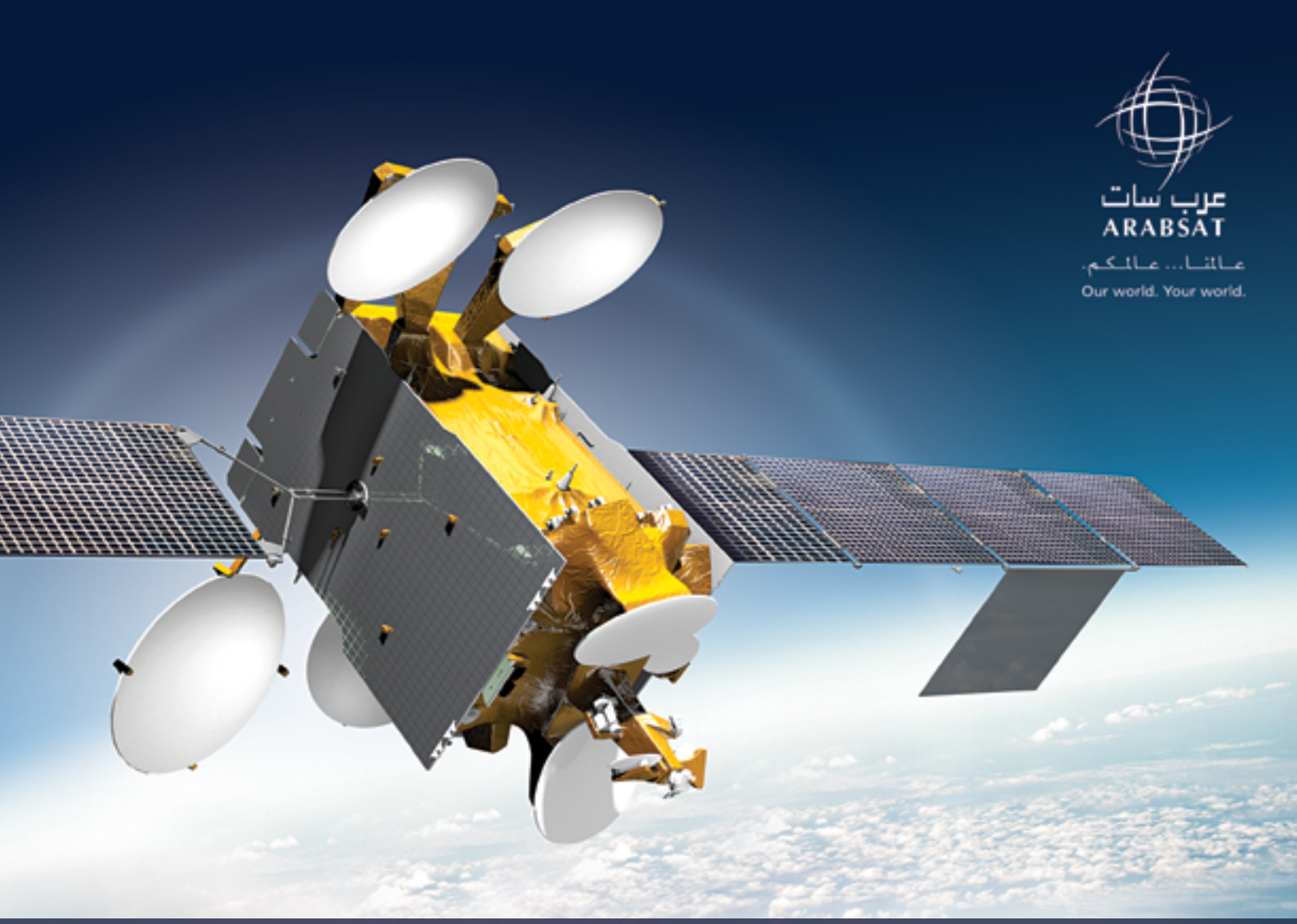
blueskynetwork.com

www.hot-shot.tech

ase-corp.com

ENSURING NO AIRCRAFT IN DISTRESS IS LOST

ICAO-GADSS CONCEPT OF GLOBAL FLIGHT TRACKING



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Smallsats By The Numbers

A discussion of the smallsat industry

By Tara Halt, Aerospace Analyst, Bryce Space and Technology

On October 4th, 1957, the world's first smallsat was launched. Operated by the Soviet Union, Sputnik became the world's first satellite. Sputnik was a smallsat due to the spacecraft's 84 kgs. size, long before such was a commonly used term.

Since the early days of space exploration, smallsats have only been launched in small quantities — that was until recently as, starting in 2012, the number of smallsats launched rapidly increased as **Spire** and **Planet** deployed their large constellations.

Smallsats	Mass Class Name	Kilograms (kg)
	Femto	0.01 - 0.09
	Pico	0.1 - 1
	Nano	1.1 - 10
	Micro	10.1 - 200
	Mini	201 - 600
	Small	601 - 1,200
	Medium	1,201 - 2,500
	Intermediate	2,501 - 4,200
	Large	4,201 - 5,400
	Heavy	5,401 - 7,000
	Extra Heavy	> 7,001

Figure 1. FAA Launch Mass Classes. Source: FAA AST. The Annual Compendium of Commercial Space Transportation 2018

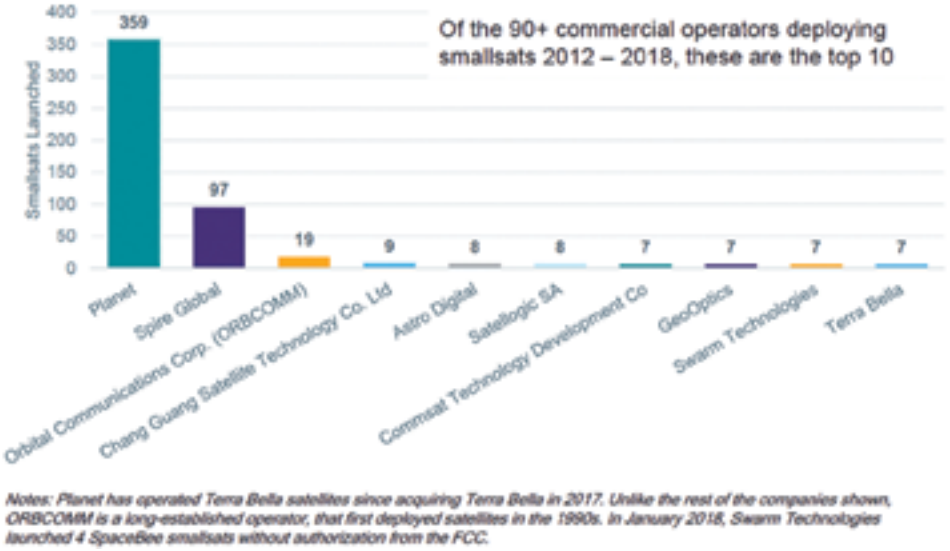


Figure 3. Commercial Operators Launching the Most Smallsats, 2012-2018. Source: Bryce Space and Technology's Smallsats by the Numbers 2019

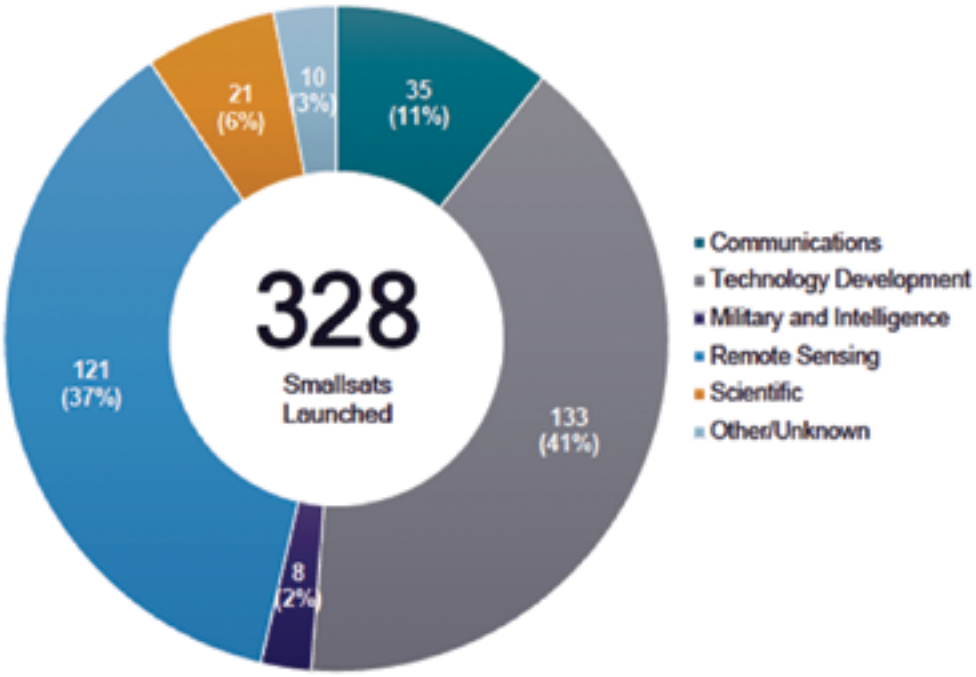
***Smallsats by the Numbers 2019*, Bryce Space and Technology** includes data on commercial, government and academic trends from 2012 to 2018. Bryce's smallsat report includes all satellites 600 kg. and under, launched between 2012 and 2018 (including smallsats on failed launches).

Although definitions vary, 600 kg. and under reflects the five smallest mass classes defined by the Federal Aviation Administration (FAA). Some of the common uses of smallsats include remote sensing, technology development, military/ intelligence, communications, and science.

2018 Review

In 2018, a total of 328 smallsats were launched. This is a slight decrease from 2017 when 338 of the smaller satellites were launched. Before 2017, there was never more than 187 smallsats launched in a single year. Both 2017 and 2018 shattered the previous records by more than 100 satellites.

A majority of the satellites (254) launched in 2018 were used for remote sensing or technology development. 2018 was a banner year for launch with the most orbital launches since 1990. Of the 114 orbital launches in 2018, 43 percent of them carried smallsats.



Commercial Smallsat Trends

Commercial operators are responsible for a large percentage of the smallsats that have been launched since 2012.

Almost 50 percent of all smallsats launched during the 2012 to 2018 timeframe are operated by commercial companies. As of this writing, two companies, Planet and Spire, are responsible for nearly two-thirds of all commercial smallsat launches. In total, 663 commercials smallsats have been launched during the last seven years.

In 2018, Planet launched almost 40 satellites, which is a huge decline from 2017, when almost 150 Planet smallsats were launched. Since completing "*Mission 1*" in Fall 2017, Planet has continued to expand their product offerings using its satellite data.

Generally speaking, Planet's satellites have a three-year lifespan. Assuming Planet plans to replenish their constellation, the expectation is that there will be an increase of Planet satellites launching in 2019 and 2020 as they replace satellites launched in their original constellation.

Planet's constellation is the largest remote sensing constellation in the world. Because of Planet and Spire, remote sensing is the most common use for commercial smallsats (80 percent), followed by technology development (11 percent) and communications (8 percent).

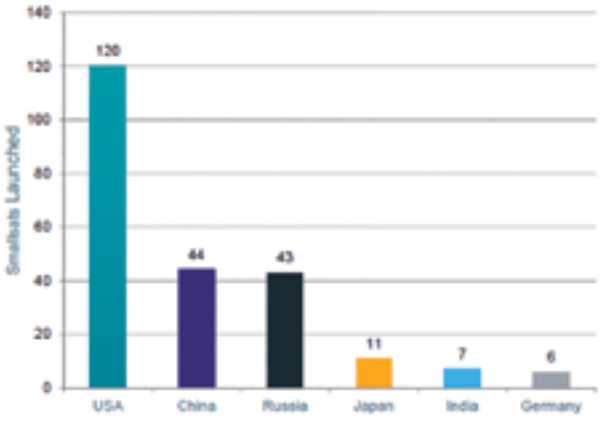
Government (Civil & Military) Smallsat Trends

Since 2012, almost 300 government smallsats have been launched.

The United States leads with 120 government smallsats launched, followed by China (44) and Russia (43). Civil and military organizations from 35 countries have smallsats, most of which operate

three or fewer satellites. A majority of the satellites launched by government organizations are used for technology development, remote sensing as well as scientific observations.

Each year, dozens of new academic and non-profit organizations launch satellites for the first time. The number of academic and non-profit organizations that manufacture and operate smallsats nearly quadrupled from 2012 to 2018.



5 or Fewer Government Smallsats Deployed	
South Korea	Ecuador
Australia	Indonesia
European Space Agency	Spain
Canada	Kazakhstan
Israel	Turkey
Iran	Peru
Brazil	Greece
Algeria	Taiwan
North Korea	Vietnam
Saudi Arabia	Belarus
UAE	Pakistan
Italy	Philippines
France	Colombia
Poland	Malaysia
United Kingdom	

Figure 4. Government Smallsats by Country 2012-2018. Source: Bryce Space and Technology's Smallsats by the Numbers 2019

While smallsats have almost been exclusively used in Earth orbit, in 2018 NASA successfully used its ***MarCO A*** and ***MarCO B*** CubeSats for a deep space mission. The MarCO cubesats were launched to support **NASA**'s ***InSight*** mission, which landed on Mars in November of 2018. The success of these missions may result in further smallsat use in deep space. Plans have been announced for several deep space smallsat missions including 13 CubeSats that will make observations of the Moon on NASA's ***EM-1*** mission.

The **Kyushu Institute of Technology** in Japan has propelled the most academic smallsats to orbit, with 13 satellites launched in the past seven years. Most academic and non-profit organizations have launched only one or two smallsats. Over 370 academic and on-profit smallsats have been launched since 2012, with 80 percent of these smallsats classified as CubeSats.

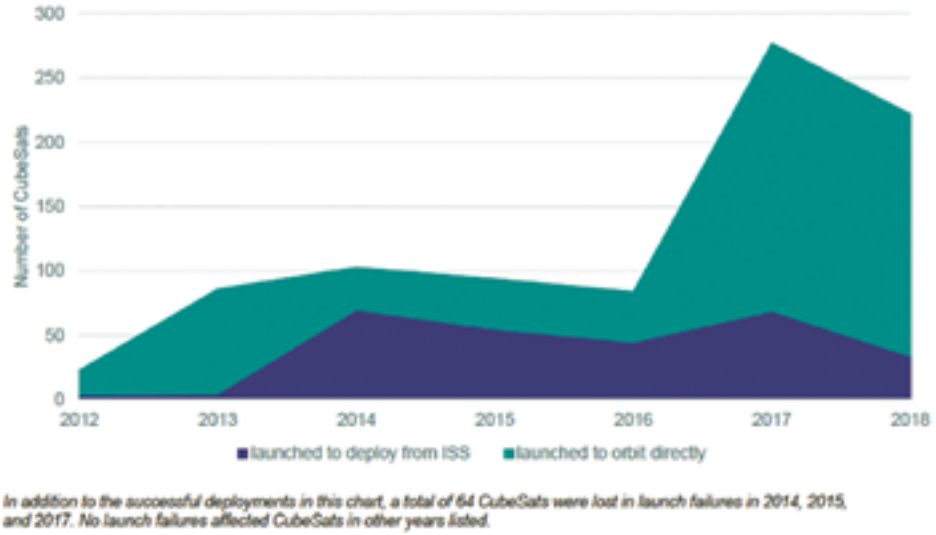


Figure 5. CubeSat Deployment, 2012-2018.
Source: Bryce Space and Technology's Smallsats by the Numbers 2019

Academic and Non-Profit Smallsat Trends

Similar to government smallsats, most academic and non-profit smallsats are used for technology development.

CubeSats

CubeSats are a smallsat that are comprised of 10×10×10 centimeter cubic units. More than 70 percent of smallsats launched are CubeSats, making them by far the most common type of smallsat.

Since 2012, CubeSats have been either launched to orbit directly or deployed from the **International Space Station** (**ISS**). 2017 was a record year for CubeSats, with over 292 satellites launched. CubeSats have, and continue to be, an attractive technology for student and university programs, given their relative accessibility and affordability.

Major Smallsat Constellations

The recent launch of the first satellites of the **OneWeb** constellations may initiate a major phase of communication-focused smallsats.

OneWeb, **SpaceX**, **Telesat**, and others have plans for "*mega-constellations*" of smallsats. Currently, communication satellites comprise a small percentage of smallsats (approximately 7 percent); however, the deployment of large internet constellations could significantly change the make-up of on-orbit smallsat. These plans and their eventually successes remain to be seen.

There is also increased interest in smallsats by the U.S. military, with the **Defense Advanced Research Projects Agency (DARPA)** making recent announcements of demonstration missions under the ***Blackjack*** and ***Casino*** programs. Smallsats provide the potential for more resilient space infrastructure for all types of operators.

The Outlook for 2019

More than 20 smallsats have been launched in 2019, as of the time of this writing.

Several companies, including **OneWeb**, **Planet**, **Spire**, **Satellogic SA**, and **Astrocast SA**, have either successfully launched, or plan to launch, additional smallsats during the year.

Additionally, **Virginia Space**, in partnership with **Northrop Grumman**, **Twiggs Space Lab** and **NASA Wallops** will be launching extremely low profile *ThinSats* that will allow student teams to perform experiments on-orbit. Innovation by commercial, government, academic and non-profit organizations will ensure that 2019 is another exciting year for smallsats!.

Learn more about the smallsat industry by reading Bryce Space and Technology's SmallSats by the Numbers Report 2019 at ***brycetech.com/reports.html***

Tara Halt is an Aerospace Analyst at Bryce Space and Technology, where she supports commercial and government clients, including NASA. Ms. Halt graduated from The George Washington University with a Master's in International Science and Technology Policy with a focus on Space Policy. She also has a Bachelor of Science in Commercial Space Operations from Embry-Riddle Aeronautical University. Ms. Halt is an active member of the Space Generation Advisory Council.

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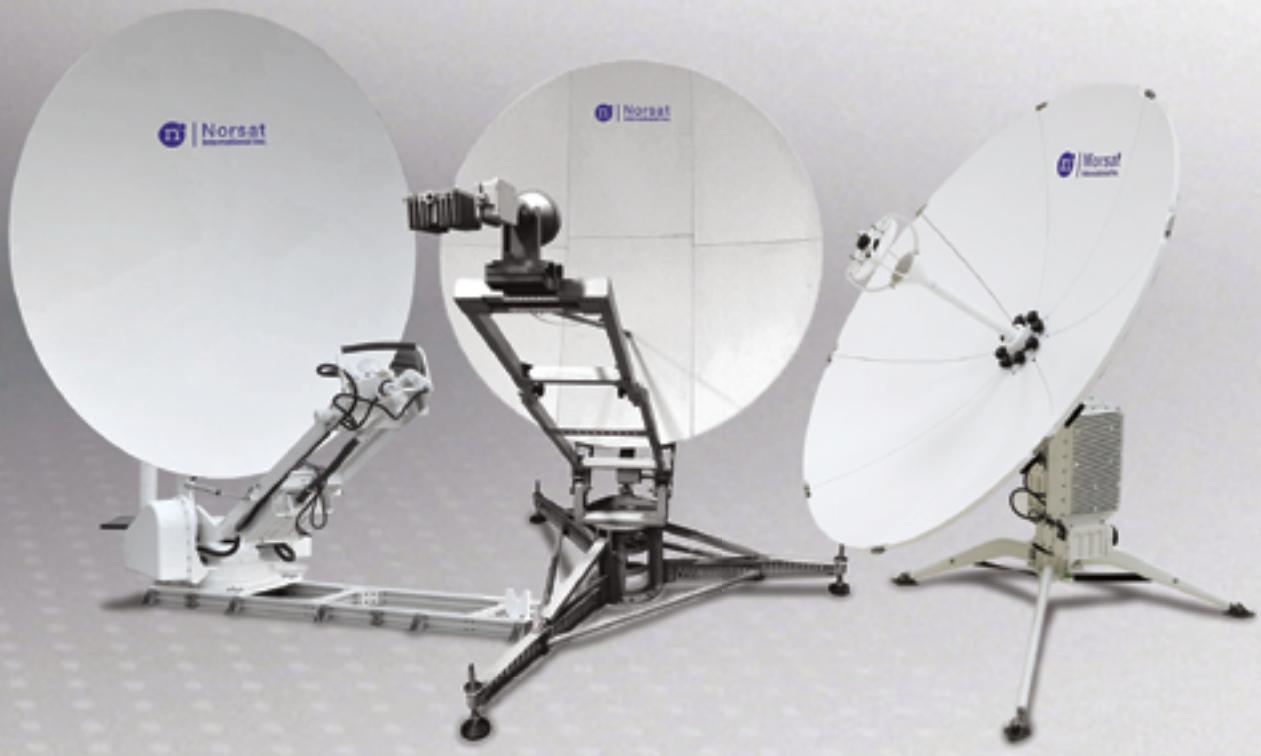

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Denali's Near Miss

The growing problem of space debris

By Payam Banazadeh, Founder and CEO, Capella Space

On January 27th, 2019, early Sunday morning, the company was notified of a potential collision probability with another satellite that was traveling toward the firm's pathfinder craft, *Denali*.

Alerts had been received in the past but these were all for "close-approaches" from other nearby objects traveling at relatively low speeds of no more than 3 meters per second, with a distance of at least 200 meters.

This particular alert was for a head-on impact at a relative speed of nearly 15 kilometers per second (33500 mph) — a velocity that would obliterate ***Denali***, resulting in a massive amount of debris in an increasingly crowded *Low-Earth Orbit* (LEO) and that is a huge problem and a growing source of risk for governments and businesses.

This alert received the company's full attention. Impact was imminent, we had to act fast. By Tuesday morning, four maneuvers were dispatched to raise Denali's orbital altitude. The maneuvers were successful; however, the orbital trajectory of Denali and this approaching smallsat remained still too close for comfort.

As the approach neared, all waited nervously for a safe pass — at 12:22:40 p.m. on January 29, the two satellites would either collide, sending a field of debris hurtling through space, or pass each other by at a close distance. At 12:58 p.m., as Denali came over the hill, we established communication and the catastrophe had been dodged.

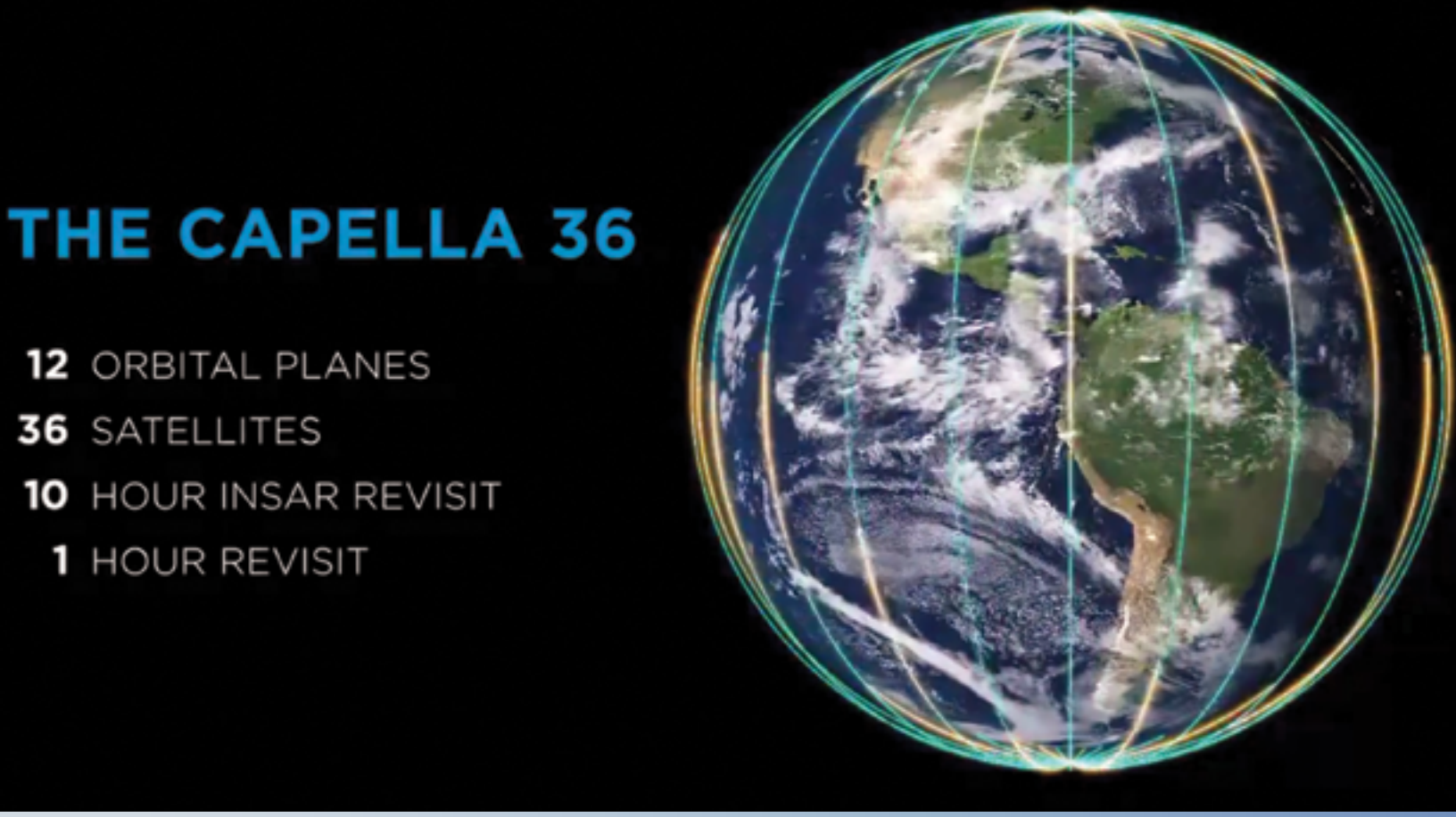
Although talking about space conjures images of great, empty expanses between stars, space is getting crowded. A growing cloud of space debris has been circling the Earth since the Soviet Union launched Sputnik in 1957.

According to the **European Space Agency**, more than 29,000 large pieces of debris are orbiting Earth, everything from 4 inch hunks of metal to entire, defunct satellites and spent fuel canisters. Add in an estimated 670,000 pieces of metal detritus between 1 centimeter and 10 centimeters in size, an estimated 170 million flecks and particles of paint, and untold billions of frozen droplets of coolant and bits of dust smaller than a centimeter, and the operating space of LEO appears to be less of an empty expanse and more of a minefield of disabling debris.

This is not a new problem, but it is a growing one — the threat space debris poses to scientific research, telecommunications and military intelligence has been around for decades. **NASA** was the first space agency to issue mitigation guidelines and the **United Nations** put it on their agenda for action in the early 90s.

Plans to improve monitoring of current debris and reduce on-orbit collision were included in President Trump's initial proposal of a **Space Force** and many experts and companies have proposed solutions to this problem — including deploying a space harpoon — but there seems to no easy answer.

Space is an emerging frontier for commerce, with the potential to advance knowledge and communication capabilities on Earth by leaps and bounds. A company such as **Capella** would not have a smallsat on-orbit, let alone a feasible path toward a 12-plane, high-revisit constellation, if not for the enterprise and imagination of smart companies that possess innovative technologies and solution aspirations. With more rockets lifting off, and more satellites taking flight, the risk for hitting space debris — and creating more in the process — also increases.



The sea change in space innovation has been driving down size which, in turn, enables scale and new possibilities and applications in how space infrastructure is used to explore and monitor conditions on Earth.

Instead of the behemoth satellites of the past, which were often the size of a school bus, new models embed more power into smaller, capital-light packages. Space can now be approached faster and at lower cost, opening up tremendous opportunities for monitoring this planet, but also greater risks of collision.

With increasing activity, the time is ripe to rethink the approaches to designing, deploying, and managing assets on-orbit and to form a more collaborative approach to de-risking an increasingly crowded LEO environment.

Smarter and More Maneuverable

Most smallsats that are launched these days lack any propulsion system and capability to actively and swiftly maneuver around a potential collision. In fact, the satellite that was traveling toward Denali recently had no active means to maneuver and avoid a collision.

If Denali had been a passive satellite with no capability to maneuver itself out of harm's way, this potentially destructive disaster could have easily turned into a major catastrophe in space with consequences far beyond Denali impacting other satellites in orbit.

There is currently no law that requires any satellite to have any maneuverability capability or collision avoidance systems. The only space debris related guideline is to bring down a satellite (either through deflection into space or burn into the atmosphere) within 25 years.

This lack of regulation might have worked okay for the last few decades; however, in the 21st century, where space is open for business, re-think debris and satellite policies and regulations is an absolute must.

Improving Coordination and Communication

Just as airplanes operate globally within the safety and flight regulations outlined by the United Nations-sprung International Civil Aviation Organization, we as a worldwide community of space pioneers and stewards could adopt a collective vision and policy structure for a safe and prosperous low Earth orbit.

To fly harmoniously, all need to play by the same rules — and we need to make sure those rules are legible and enforced, regardless of the flags anyone operates under, or the location of the launch pads.

Plan for Obsolescence

The spacecrafts of yesterday aren't the sole source of the space junk problem. Current and future missions have a real potential to equal or surpass past debris.

Practicing space stewardship means better life-cycle management, pro-active collision avoidance and de-orbiting plans — in other words, before something goes up, there must be e a plan for how that spacecraft is going to come down and how it would maneuver to avoid a potential collision.

There's no magic bullet to offset the space debris problem, but these three improvements together can come close to a solution. We're living in the dawn of a golden age of satellite use and research.

To realize this potential, orbits need to be cleaned up and, when a spacecraft departs those orbits, they should be in better shape than when accessed for the benefit of future generations. This can be accomplished — if we work together.

www.capellaspace.com

Payam Banazadeh is the founder and CEO of Capella Space. He leads the overall strategy and operations of the company. Before Capella, Payam worked at the NASA Jet Propulsion Lab, where his work on two NASA missions was honored with their Mariner Award.

Payam holds a BS in Aerospace Engineering, from the University of Texas at Austin, and an MS in Business and Management from Stanford. Payam was recently named to Forbes "30 Under 30" list and is a fellow of the National Science Foundation.

The Orbital Test Bed

Using hosted payload platforms to deliver missions to space — rapidly and affordly

By Craig Gravelle, Director, Space Systems Strategic Development, General Atomics Electromagnetic Systems (GA-EMS)

High value civil and military payloads and experiments often must wait several years before flying in space ... if they fly at all.

Advances in low cost launch and rideshare approaches have helped, but finding real estate on satellite buses — large and small — continues to provide challenges to schedule and cost.

Operational payloads, such as the **Aireon** air traffic surveillance system on ***Iridium NEXT*** satellites, have demonstrated benefits of constellation-wide commercially hosted payloads. Experimenters and principal investigators, however, face daunting challenges to hosting their 'one-time' demonstration and experimental payloads on large satellites. They are often subject to overly involved and extraneous compatibility requirements with primary payloads, and a negligible ability to effect schedule and launch dates.

Similarly, procuring a dedicated smaller satellite from industry providers to support payload requirements demands increased investment and oversight, and resultant longer timelines to get a payload to orbit.

General Atomics Electromagnetic Systems (**GA-EMS**) is uniquely positioned to meet these challenges through a strategy of modular, scalable satellite designs and hosted payload platforms that can be optimized to suit the needs of multiple customers.

With a rich heritage in satellite design and operational flight experience, GA-EMS offers a broad portfolio of bus sizes and capabilities, from **Low Earth Orbit** (**LEO**) CubeSats to 600 kilogram platforms that can be tailored to a payload provider's unique mission needs.

GA-EMS' service approach allows the company to work closely with customers to negotiate the best solution, which can also include launch coordination and on-orbit mission control services, to deliver their payloads when and where they are needed.

The Mission Operations Center. Photo is courtesy of GA-EMS.

GA-EMS' **Orbital Test Bed** (***OTB***) spacecraft (*artistic rendition of the OTB is presented on the previous page and is courtesy of GA-EMS...*) are providing a much needed capability to rapidly and affordably deliver customer payloads into a broad range of Low Earth Orbits. The flexible, modular, and scalable architecture of the OTB platform is designed to be optimized for high performance missions and a broad range of payloads.

OTB's versatility enables the launch of single or multiple payloads on a space platform, offering a more cost-effective solution to meet a wide variety of government, commercial, and academic technology demonstration requirements.

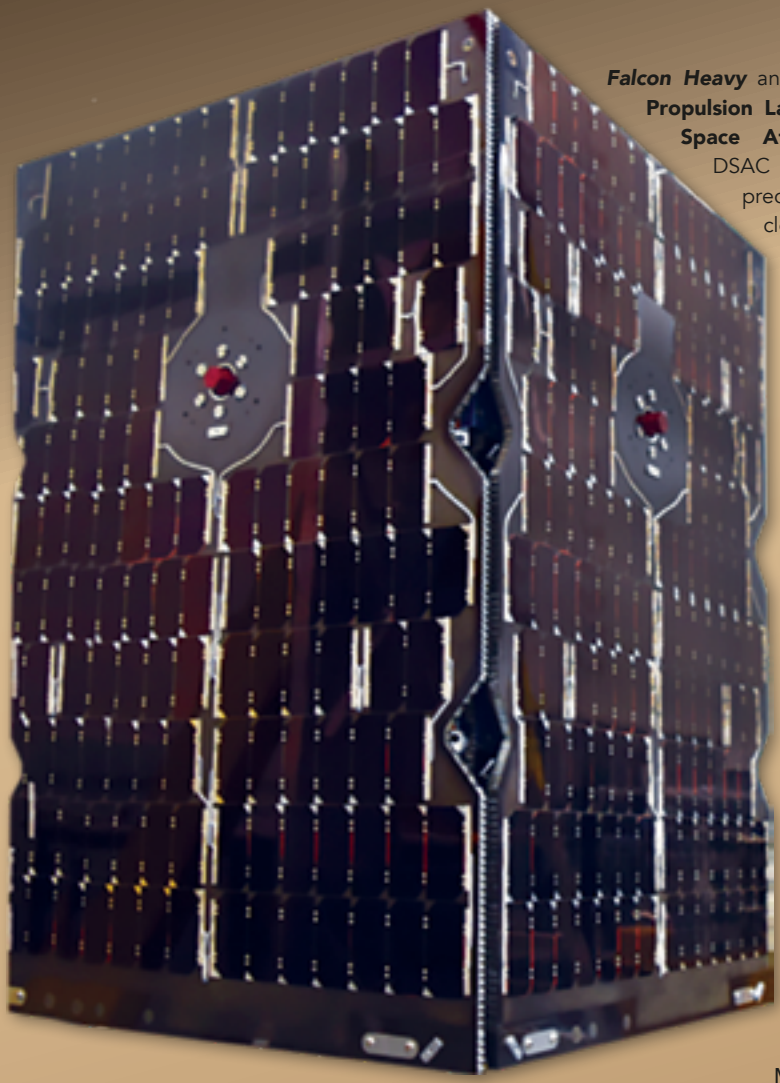
OTB Hosted Payloads

The United States Government (USG) provides several avenues for rapidly and affordably flying space experiments and payloads. Most notable are **NASA**'s *Rapid Spacecraft Development Organization* (RSDO) program and the **Department of Defense** (**DoD**) Space Test Program (*STP*).

The **United States Air Force (USAF) Space & Missile Systems Center** (**SMC**) Hosted Payload Solutions (*HoPS*) program provides a contracting capability to standardize processes and interfaces for placing military capabilities aboard commercial satellites. The OTB program is complementary to these programs and effectively uses them to further optimize the procurement process.

For military payloads, STP has been providing flight opportunities for missions on the *Space Experiments Review Board* (SERB) priority list for more than 50 years. The *Orbital Test Bed* contracting approach is designed to streamline acquisition and reduce costs. The approach breaks from the current paradigm of selling a spacecraft to customers who — unlike for other commodities — can't get the spacecraft back or resell it.

For OTB missions, GA-EMS owns the spacecraft and recovers cost by providing flight services to the hosted payload providers. This enables a '*lean forward*' procurement strategy that allows GA-EMS to start the planning for the next mission while working early to broker with and coordinate between interested payload providers.



A "fully dressed" OTB. Photo is courtesy of GA-EMS.

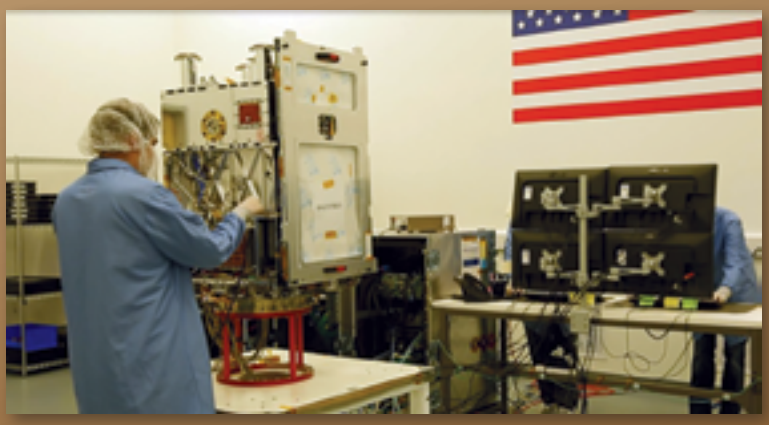
The first or '*anchor*' payload provider is typically the most instrumental in defining the spacecraft and associated capabilities. However, GA-EMS retains the flexibility to enhance the bus design to accommodate additional hosted payloads without compromising the service provided to established payload providers.

GA-EMS has been contracted for OTB platforms that demonstrate the flexibility and scalability of the OTB approach. The first OTB spacecraft will be launched in 2019 on the next **SpaceX** ***Falcon Heavy*** and hosts the **NASA Jet Propulsion Laboratory**'s (JPL) **Deep Space Atomic Clock** (***DSAC***). DSAC is a miniaturized, ultra-precise, mercury-ion atomic clock that, while hosted on OTB, will demonstrate its functionality and utility for one-way-based navigation.

This ESPA-class OTB also hosts additional payloads and experiments including an **Air Force Research Laboratory** (**AFRL**) Modular Solar Array, the USAF Academy Integrated Miniature Electrostatic Analyzer (*iMESA-R*). The primary payload suite consists of a *radiation effects monitor* (RadMon), a programmable receiver (*FlexRx*) and **Celestis** cremains.

Planned for launch in 2022, another OTB spacecraft is being designed to host the NASA Langley, JPL-built, **Multi-Angle Imager for Aerosols** (*MAIA*) payload. MAIA will characterize the sizes, compositions and quantities of particulate matter in air pollution and the link with health issues. At 280 kilograms, this OTB spacecraft demonstrates the flexibility of the hosted payload service to tailor a solution to suit the large, unique MAIA payload.

GA-EMS is also designing and building a third OTB spacecraft for a primary payload called the **Remote Sensing Payload** (*ReSI*). ReSI will provide reflectometry data of signals from **Global Navigation Sensing System** (**GNSS**) satellites.



The OTB lab. Photo is courtesy of GA-EMS.

Through the HoPS contracting mechanism, the USAF's SMC contracted for services to host and operate the **Advanced Data Collection System** (*A-DCS*) payload for **NOAA/CNES**. A-DCS supports the ***Argos*** worldwide location and data collection system by providing data used for studying oceans and atmospheric conditions; preserving and monitoring wildlife; managing water resources; and monitoring volcanoes, fishing fleets and shipments of dangerous goods.

This OTB mission is planned for launch in early 2021 and is approximately two years after SMC contracted with GA-EMS for the hosting service, once again demonstrating the quick reaction capability of the OTB approach.

The Orbital Test Bed satellites are designed and built in the company's Englewood, Colorado, facility. The **Mission Operations Center** (*MOC*) is also located in this facility to provide customers with control, operation and data download services for on-orbit payloads. GA-EMS is supporting launch and mission operations at their MOC for the first OTB and will also be the primary operations center for the OTB missions supporting the MAIA and ReSI missions.

GA-EMS is the spacecraft manufacturer for **Draper Laboratory**'s **NASA Commercial Lunar Payload Services** (*CLPS*) program. The team will support NASA in the delivery of small rovers and instruments to meet lunar science and exploration needs, advance development of lunar landers for human missions, and conduct research on the moon's surface ahead of a human return. GA-EMS will apply its manufacturing and satellite design expertise to deliver CLPS spacecraft supporting NASA's next mission to the moon.

GA-EMS is planning for future Orbital Test Bed missions and is working with primary, secondary and dedicated payload providers to define their service needs. Drawing from a broad portfolio of satellite platforms, early customer involvement in planning efforts will result in optimized platforms that meet payload and mission needs rapidly and more affordably.

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Craig Gravelle is the Director, Space Systems Strategic Development at General Atomics Electromagnetic Systems. Mr. Gravelle is responsible for the growth of the GA-EMS space systems business for U.S. Department of Defense and civil government programs. Mr. Gravelle has more than 35 years of experience and has held senior management and executive positions in a variety of companies ranging from start-ups to large aerospace companies. He has a broad range of industry experience developing new business opportunities with the intelligence community, U.S. Air Force, international clients, and commercial space systems customers.

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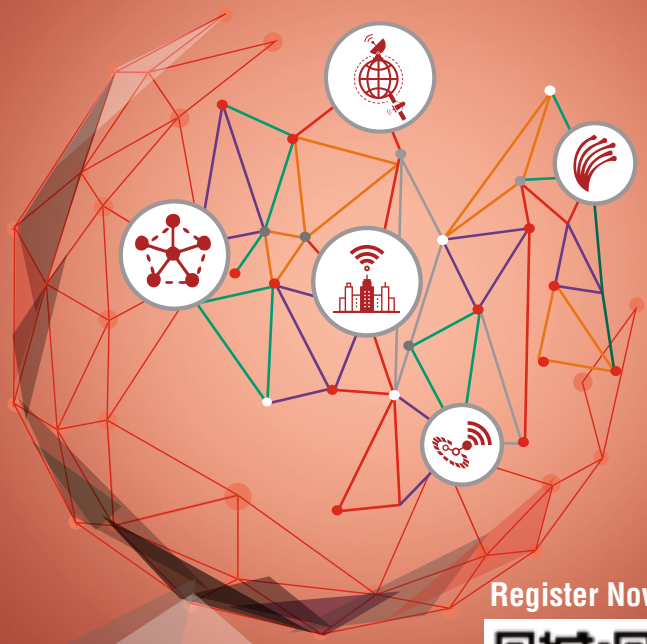

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Democratizing The Link Budget

A reliable and accurate tool to help maximize ROI

By José Torres, Global Sales Director, Integrasys

The satellite industry has witnessed an impressive pace of innovation over recent years. High Throughput Satellite (HTS) is one example of a technology that has revolutionized the industry, making it much more affordable than ever before to deliver reliable capacity, even to the most remote locations.

The number of mega constellation launches are on the rise, with many more on the horizon, enabling Internet of Things (*IoT*) services on a massive scale, as well as an entire host of other meaningful services.

Satellite continues to retain its relevance and importance in the modern, always connected world, and is able to power a number of next generation services, thanks to ever-increasing number of innovative technologies and products.

However, these innovations can also require more complexity, which means that equally innovative solutions are needed to help operators and users effectively manage their operations.

Managing Complexity

Managing complexities should encompass the entire satellite workflow and make it far easier to setup satellite antennas, reduce operator errors and ensure entire networks are continuously and automatically monitored.

Integrasys has already worked, and continues to do so, with a number of satellite operators to drastically reduce running costs through better setup and monitoring. Yet, there is one area that remains complicated and that is the process of buying and selling satellite capacity.

As most *SatMagazine* readers probably already know, buying and selling satellite capacity is managed using link budget calculations in order to account for gains and losses on any given satellite link. However, few outside of this exacting process know exactly how to accomplish this task, as the process is quite complex and requires expert knowledge.

This also means time is required and the correct resources must be applied to the process... and as all know, time is in short supply for most operators. With delayed link budget calculations come postponements in new customer contracts.

Incorrect computations result in an unsuitable satellite selection and that leads to signal degradation. Correct calculations, on the other hand, and completing a link budget quickly and effectively, equates to a satellite operator maximizing revenue and providing the correct capacity to the customer every time.

Beam Budget

Integrasys recently announced the launch of a simple yet accurate link budget tool, ***Beam Budget***. This product aims to democratize link budget calculations, making it possible for anyone to perform and understand these important calculations.

There are a number of factors that make link budgets complex and those elements have been positively addressed with this tool:

Multiple Parameters

One of the biggest challenges with a link budget is the sheer volume of parameters that need to be input in order to obtain an accurate calculation.

In most cases, this work requires at least 50 parameters that include:

- *Uplink power amplifier gain and noise factors*
- *Transmit and receive antenna gain*
- *Slant angles and corresponding atmospheric loss over distance*
- *Climactic attenuation factors*

- *Satellite transponder noise levels and power gains*
- *Receive antenna and amplifier gains and noise factors*
- *Cable losses*
- *Adjacent satellite interference levels*
- *Intermodulation interferences.*

This work generally needs to be done separately, for both the uplink and downlink frequencies. With Beam Budget, the company wanted to introduce a tool that could provide highly accurate results with fewer inputs. This tool can provide more than 75 results from just 25 inputs.

Ease of Use

In addition to the need for multiple parameters, the other main complication in performing link budget calculations is that traditional tools are generally quite difficult to use and understand.

Until now, only trained link budgets experts were able to perform the calculations and then read and understand what the results mean. Due to press of business for most operators, and a lack of resources, delays are caused in waiting for link budget results and that equates to new customer contract signing delays. Additionally, most customers are unable to understand the results of the calculations and it can be quite challenging for them to be certain of the advised satellite selection.

With Beam Budget, Integrasys has stripped the complication away and has created a tool that anyone can use — an automatic and graphically detailed report is created in less than a minute.

The company also wanted to ensure that easy-to-understand reports could be exported and shared with ease. These reports are accompanied by an executive summary that briefly explains the suitability — or unsuitability — of the available links. It is also really simple to select the desired location on a map as well as being able to save favorite setups for easy retrieval.

Currently, if a company representative is visiting a client, they will need to have the link budget calculations already completed to accompany them on a sales visit. If a customer has questions concerning different configurations, these would then need to be taken away to be recalculated and then returned to that customer. With Beam Budget, representatives can log onto the web-based tool, calculate the link budgets at the customer's location and quickly show them the results.

Accuracy and Coverage

In spite of multiple parameters, traditional link budget work is not always as accurate as it should, and must, be. The challenge for Integrasys in developing this product was to ensure that all possible frequency bands and types of satellites were covered in a single tool, rather than having to further complicate matters using multiple tools.

Beam Budget is available for every frequency band and also enables users to upload different types of satellite data. Every modulation is also supported. The result is the most accurate link budget calculation product possible.

Maximizing ROI

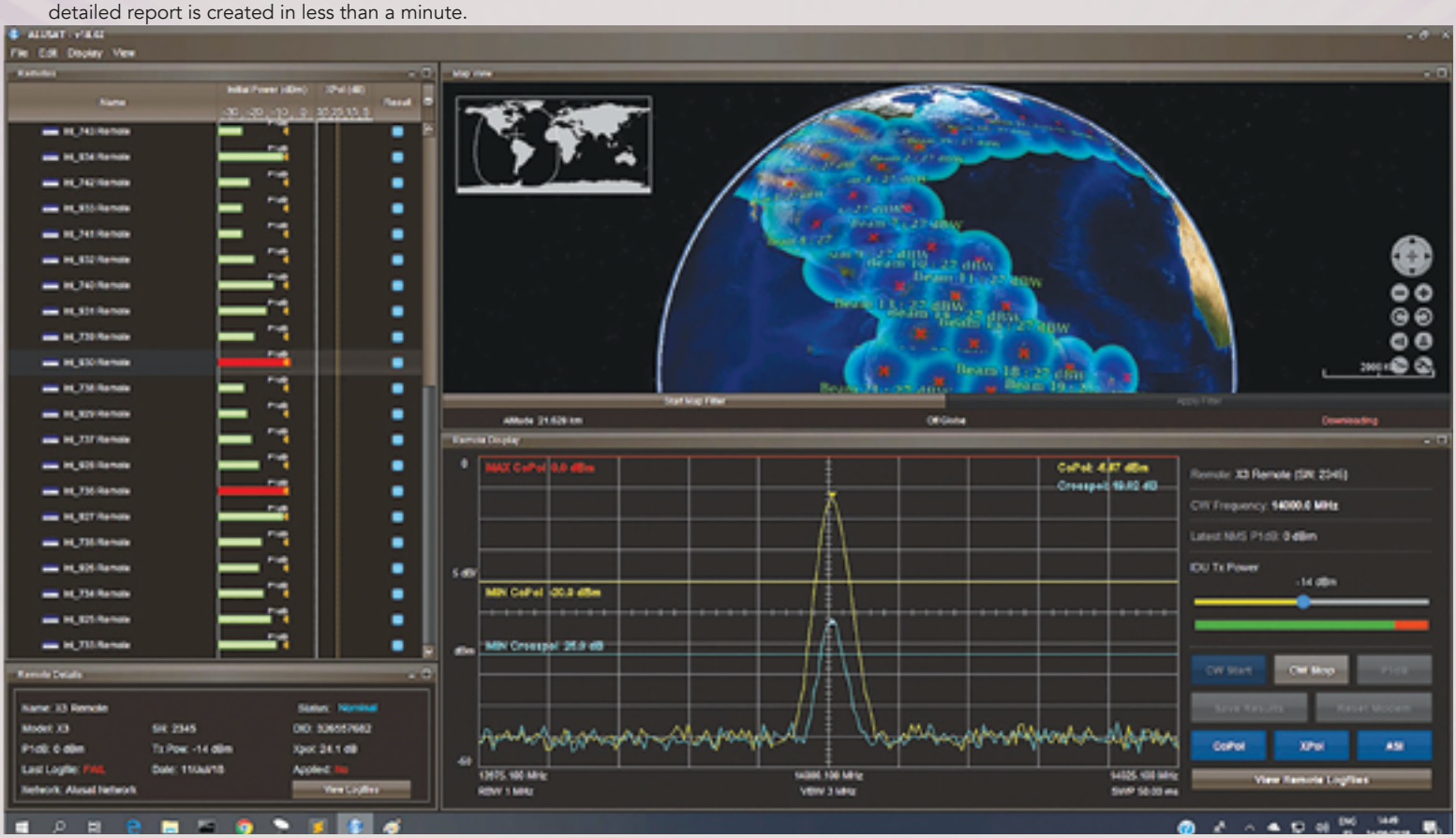
There can be no denying that link budget is a crucial part of buying and selling satellite capacity — these calculations enable satellite operators to confidently establish new satellite networks to ensure the best performance possible for a client company.

Established networks use link budgets to calculate and demonstrate suitabilities for prospective customers. Satellite users need these tools to ensure the service they have selected is the correct choice.

If the link budget cannot be performed or completed quickly enough, such could result in a costly, lost opportunity and revenue. Equally, if a customer does come on board without an accurate calculation, they may quickly take their business elsewhere if the end result does not match what they require.

Fast and accurate link budget calculations are a must — by making this tool accessible to anyone within an organization, as well as making it easy for stakeholders to understand the completed results, satellite operators can greatly improve their efficiency and have full confidence in Link Budget's results — and that, ultimately, is going to help them win new business and maximize their return on investment.

www.integrasys-space.com



Satellites and the Beautiful Game

By Society of Satellite Professionals International (SSPI)

World Cup, Phillip Stewart, Flickr Creative Commons, commercial use permitted.

The World Cup is the planet's most widely viewed sporting event. The 2010 World Cup, held in South Africa, was broadcast to 204 countries on 245 different channels. The 2018 World Cup attracted an audience of more than three billion viewers.

All of those eyeballs staring at screens also make the World Cup an extremely lucrative event. The sale of broadcast rights to the 2018 and 2022 World Cups earned FIFA, soccer's governing body, $1.85 billion.

However, the rights are just the start. Broadcasters are willing to pay so much because the World Cup is uniquely valuable to advertisers.

The 2006 World Cup generated another $1 billion in TV commercials and other advertising, and spending rises 5 to 10 percent, on average, with each successive event. Add it up and the television coverage of recent World Cups was probably worth more than $4 billion — not bad for 30 days of fast-paced sport.

The World's Water Cooler

How do all those people get to see the most popular game in the world?

Some coverage travels over optical fiber to broadcast centers. However, satellite is the essential contributor, because of the number of games in different locations that must be covered in a short window of time.

Satellite and the World Cup have deep common roots. In 1970, the official ball for the World Cup was provided by Adidas. To make sure that the ball would show up well on the black-and-white TVs of the day, Adidas designed a ball with alternating black and white patterns, which has since become the football standard. Adidas dubbed the ball "Telstar" for its likeness to Bell Telephone's then-famous satellite, which relayed the first transatlantic live TV signal.

In addition to high reliability and TV-friendly bandwidth, satellite is flexible. A TV signal can go up on a satellite in hours or days and reach nearly any place on the planet.

Thousands of Hours and Megahertz

That is why the satellite operator Intelsat devoted nine satellites and another operator, Eutelsat, a further four spacecraft to handle coverage of the 2010 World Cup in South Africa.

Before the 2014 World Cup, the satellite operator SES estimated that it would deliver more than 30,000 hours of coverage from 12 sports venues across Brazil. Intelsat committed another 500 MHz of capacity to handle more than 50,000 hours of TV programming from Rio de Janeiro, while SES stepped up with a 450 MHz commitment.

Delivering that immensely popular programming takes the full capabilities and reach of those operator's fleets, which are about evenly divided between the lower C- and higher Ku-band frequencies.

Take away satellites, or let anything seriously interfere with their signals, and screens go dark around the world. That would mean not just unhappy fans but a financial impact in the billions of U.S. dollars.

This article was produced for SatMagazine by the Society of Satellite Professionals International.

See more stories and videos of satellite making a better world at ***www.bettersatelliteworld.com***.

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2019 Space & Satellite Hall of Fame Inductees Greg Wyler, Matt Desch and Henry Goldberg

The 2019 Hall of Fame Celebration will be held on May 7th, 2019, breaking with years of winter tradition. Tickets on sale now! Visit satellitehalloffame.com to learn more.

Greg Wyler

Matt Desch

Henry Goldberg

The 2019 Hall of Fame Inductees

You Can Do... What? From Where?

From satellites to data to actionable greenhouse gases insight

By Jean-Francois Gauthier, MBA, Director of Business Development, GHGSat

When GHGSat launched their first satellite in June of 2016, the challenge was for most of the company's potential customers to fully grasp how greenhouse gas emissions from their facilities could be identified and measured from a satellite in space.

By now, most are familiar with the concept of satellites providing everything from phone service to colorful pictures of the Earth; however, looking at gases in the Earth's atmosphere had, until then, been the specialization of space agencies such as NASA and ESA to the tune of hundreds of millions of dollars per satellite in the name of climate science.

A World's First

GHGSat, a small, private, Canadian company, changed that narrative when ***GHGSat-D***, affectionately known as ***Claire***, was launched into orbit and started providing data on *greenhouse gas concentrations* (GHG), something few believed could even be accomplished.

To this day, GHGSat-D remains the world's first and only satellite with a spatial resolution (<50 meters) specifically designed to resolve emissions from individual facilities.

Orbiting the Earth 15 times a day, Claire looks at the world with her patented spectrometer instrument in 12x12 km. images, each containing more than 200,000 pixels with information on GHG concentrations. To date, she has made over 4,000+ observations of carbon dioxide and methane emissions directly from hundreds of sites across the world — industries where greenhouse gas emissions are common, such as oil and gas, waste management, mining, power generation and agriculture.

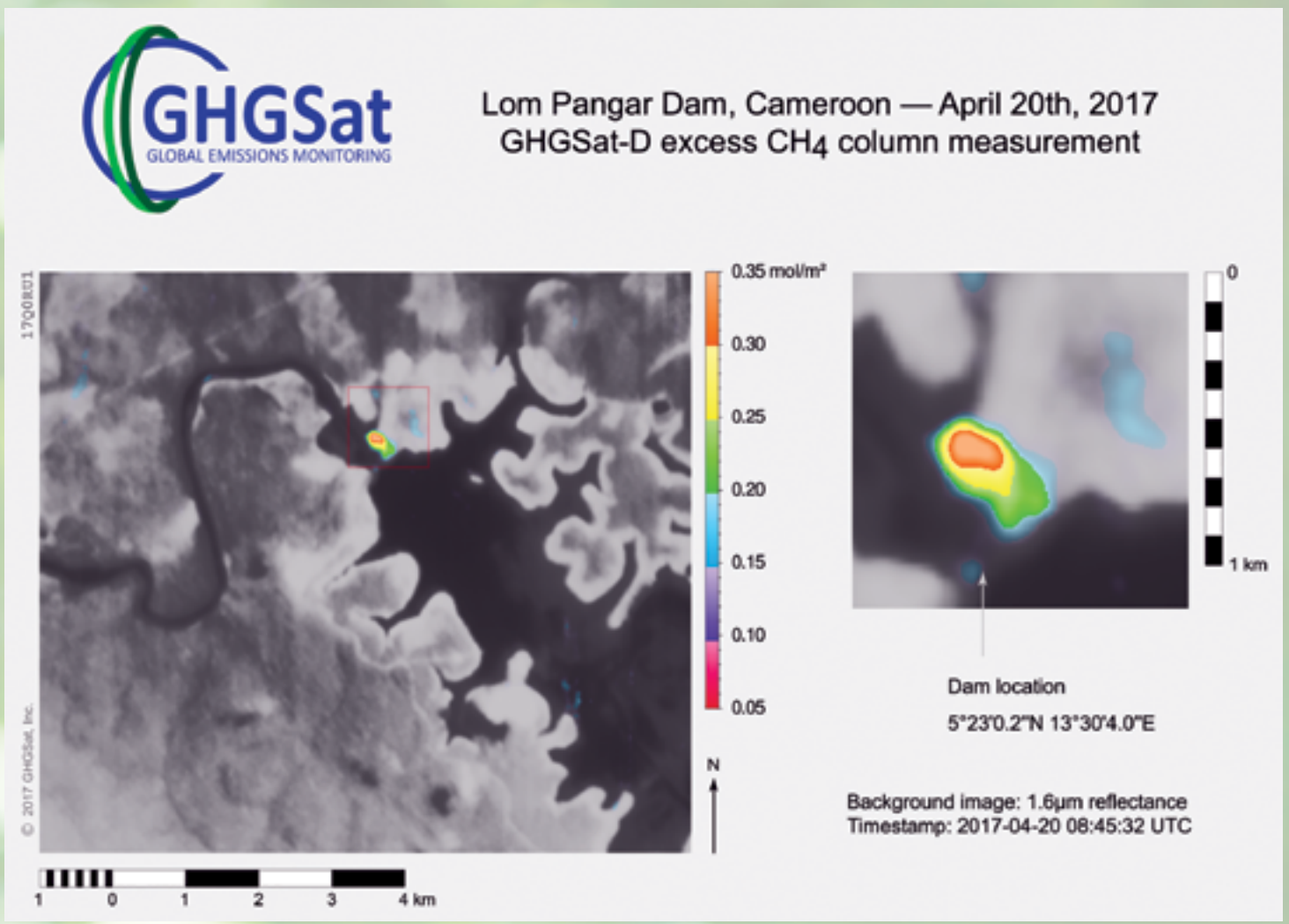
All of Claire's objectives during the monitoring of gases have exceeded expectations. The process revealed truly amazing results never seen before from space, such as this observation revealed of methane emissions from a hydroelectric dam in Africa.

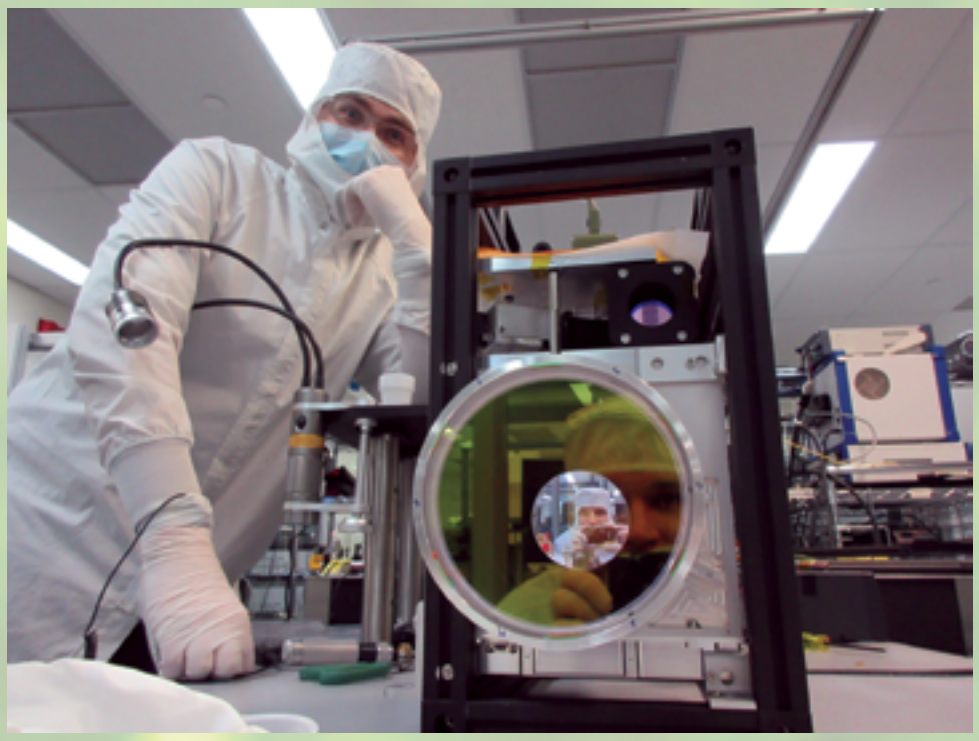
The satellite also helped to prove that there was a real business case for the data and insight generated by serving GHGSat's first customers. More importantly, Claire provided critical information on its performance and allowed GHGSat scientists to draw lessons that are now being built into the company's second satellite.

The Family Is Growing

GHGSat-C1 is scheduled to be launched on a Vega rocket from French Guyana in August of 2019.

This second-generation satellite is expected to provide a tenfold improvement in performance compared to its predecessor, including a finer spatial resolution and a lower detection threshold. GHGSat-C1 will also carry an experimental optical downlink payload that will provide significantly increased data downlink capacity.





The payload integration for GHGSat-C is completed. Photo is courtesy of GHGSat.

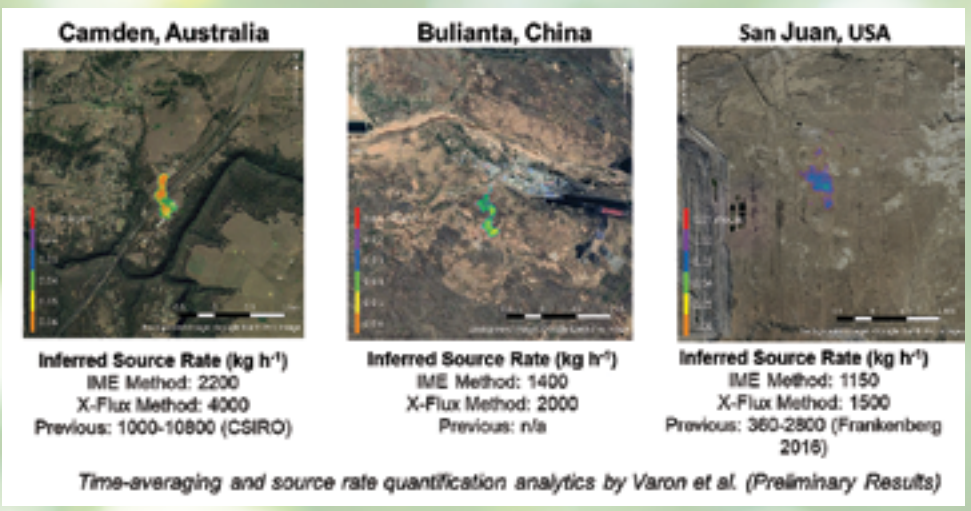
Not far behind in production is ***GHGSat-C2***, the company's third satellite, scheduled to launch in 2020 to serve the growing demand for the company's services. Similar in design to C1, C2 will be the first to carry a version of GHGSat's patented instrument built by **ABB Canada**, a world class supplier of optical space instruments such as the one onboard the ***GOSAT-2*** satellite, a scientific greenhouse gas study spacecraft recently launched by the **Japanese Space Agency** (***JAXA***).

GHGSat-C2 sets the stage for the remainder of GHGSat's planned constellation of satellites by increasing the scalability and manufacturability of the design by introducing new suppliers, as well.

From Satellites To Data To Actionable Insight

GHGSat quickly recognized that, while the data from the firm's satellites is unique, most customers prefer to be provided with actionable insight rather than vast amounts of information they must then try to interpret. The company is, therefore, investing in developing advanced analytics tools based on artificial intelligence (AI) and machine learning which can provide significant added value to its customers beyond the emissions data it generates. By combining its products with other sources of data, for example, data derived from other satellites, airborne systems or even databases, GHGSat caters to the exact needs of customers and provides solutions to their problems.

One example of these tools is shown in ***the image below*** — by averaging multiple observations of the same site over time, it is possible to enhance the plume and significantly reduce the noise. This application is especially useful in providing a more accurate estimate of sources which may be just below the detection threshold of a single observation.



What's Next?

Based on the success of Claire and the strong market demand for products and services, especially in monitoring methane emissions, GHGSat is aggressively accelerating the plan to deploy a full constellation of satellites.

The first step in that direction was taken in the fall of 2018 when a ***request for interest*** (RFI) was issued to select suppliers capable of building at least 10 additional satellites. GHGSat is currently reviewing the responses and expects to move rapidly in contracting a supplier later in 2019.

In parallel with these activities, GHGSat is also developing an airborne version of the sensor found on its satellites, scheduled to be ready for operational deployment in the Fall of 2019. This capability, intended to work in tandem with its satellites, will provide better spatial resolution and a lower detection threshold to periodically complement the observations from space.

This is an important component of a tiered observation system for methane emissions from the oil and gas industry that promises to identify the vast majority of the leaks in the most effective and affordable way possible. Under such a scheme, very frequent, low cost satellite observations to capture the large to medium leaks are supplemented with less frequent, but more expensive, airborne measurements and ground campaigns to identify the smaller leaks.

GHGSat's own aircraft mounted instrument will provide a unique advantage over other airborne sensors when combined with its satellite data because both sets of data will be generated from the same type of sensor, thereby eliminating the need for conversions.

One thing is for certain — 2019 is going to be GHGSat's most exciting year yet.

www.ghgsat.com

Jean-Francois Gauthier is a mechanical engineer and lifelong space geek with over 15 years of experience in the commercial space industry in various capacities including design and test, project management and sales and marketing. He holds a Bachelor of Engineering from Dalhousie University and an MBA from Wilfrid Laurier University. He is also a graduate of the International Space University's Summer Session Program (2006). In October 2016, he joined GHGSat to help commercialize the products and services from their breakthrough satellite around the world.

The Streak Continues...

for GMV within the global control center market

By Miguel Ángel Molina, Commercial Director for Space, GMV

For yet another year, GMV has been able to maintain a leading position in the worldwide satellite control center market.

With new orders signed, the company's cumulative number of customers has grown to more than 34 satellite telecom operators. New customers last year included **PSN** and **KACST**, which selected **GMV** as ground segment provider for almost 350 satellites, including their new ***PSN VI***, ***Star One D2*** and ***Turksat 5A-5B***.

Today, nearly 250 of these satellites are operational and are being controlled with GMV satellite ground segment systems — incorporated last year were ***Yahsat Alyah3***, ***Hispasat 30W-6*** and ***SES 12***. In addition, GMV has been able to maintain this level of activity with major space agencies across the world in different domains, including **ESA**, **EUMETSAT**, **CNES**, **DLR**, **ROSA**; **Roscosmos**, **NASA**, **KARI**, **SANSA** and others.

After more than 30 years in the satellite ground segment business, the company perfectly understands customers' needs in terms of robustness, reliability and performance, in order to ensure service continuity, integrity and effective operations. The firm's business model is based on flight-proven products that cover the complete operational needs of customers, including real time TM/TC systems, flight dynamics and orbit management, ground-station monitoring and control, mission planning, payload configuration and capacity management, mission management, etc.

GMV products provide off-the-shelf support for controlling the spacecraft buses of the main spacecraft manufacturers, including **Airbus**, **Thales Alenia Space**, **OHB**, **Boeing Commercial Satellite Services**, **Lockheed Martin Corporation**, **Mitsubishi Electric Corporation**, **Northrop Grumman**, **Maxar Space Systems** and **ISS Reshetnev**.

Considerable investments have been made by the company in the product portfolio to make the technologies better and richer, including new features that are in line with market needs, particularly in the areas of large fleet management, new advanced/flexible payloads management, full electric propulsion and collision-risk assessment services, among others. GMV is also heavily investing in the next-generation core of products, using the most advanced software engineering disciplines and tools.

Over the last few years, the space debris field has drawn satellite operators' attention due to the growing population of uncontrolled objects orbiting the Earth, all of which pose an increasing risk of collision with operational satellites.

Accordingly, with space becoming increasingly crowded, the company decided to develop new systems and services to assess the risk of collision or radio interference, performing the required avoidance maneuvers.

To mitigate this major threat, GMV has started to provide some customers with a service from the firm's **focusoc** (***focus Operations Center***) based on an ad-hoc augmented catalogue derived from the *Special Perturbations* (SP) catalog provided by **JSpOC** (***Joint Spacecraft Operations Center***).

GMV is targeting a cost-effective solution that is tailored to customer needs (in terms of availability, accuracy, timeliness, etc.) while avoiding superfluous functions and excessive performance features that are not required for the delivery of a set of *Conjunction Assessment* (CA) and *Collision Avoidance* (COLA) services perfectly suited to their needs.

The main objective of the CA service is to detect upcoming conjunctions of operational satellites with other space objects, assess the associated collision risk and support collision avoidance operations in case of high probability. A second service level can be activated upon demand and consists of the collection of optical data for collision risk assessment refinement.

The focusoc services are available through the service desk with 24x7 access for operators. Additionally, GMV provides specific manned support on a daily basis, mainly by email and telephone. At present, the company is providing this service in a trial period — 13 satellite operators are currently assessing the focusoc service. GMV will continue investing effort in this initiative to satisfy the high expectations generated among the satellite operator community.

Mega-constellations, of course, is another key area where the firm is making a quantum leap, developing a single control center that will be able to fly thousands of spacecraft. GMV's new satellite control center includes different solutions derived from its in-house real-time product line, ***hifly***, enabling the monitoring and control of such a big number of satellites and adding specific features in terms of automation, with the new feature ***flyplan***, and the fleet awareness and global knowledge of the state of the constellation provided by the new system ***fleetDashboard***.

GMV was already trading in the constellations market with systems provided to **Globalstar** or **O3b** for constellation management and orbit control. These new features opened the door to new players that are now appearing in the market such as **OneWeb**.

The new payloads concept, and particularly the flexibility required by satellite operators, is also giving the firm the opportunity to develop new features and phase them into the ***smartsuite*** family. These new features are the development and validation process, and GMV will soon be demonstrating the company's adaptation to the new payload configuration and operation challenges required by the upgrading of satellite capabilities to meet ongoing market needs.

Electric propulsion is another area of major interest. GMV was also already trading in this market, providing products compatible with the major satellite manufacturers for routine operations where electric propulsion can be regularly used for full or partial orbit control, then phasing in further capabilities for inclination, eccentric and drift control.

Today, electric propulsion is also evolving to provide full electric propulsion capabilities, where the LEOP phase has also been applying this technology during several months to reach geostationary orbit raising. GMV is improving the focussuite product family to incorporate these new features, ensuring compatibility with different satellite manufacturers.

Finally, another noteworthy event last year was the holding of the company's seventh ***GMV Users Conference*** (GUC), dealing with ground segment products and services for space missions. Held in the national hotel complex (Parador) of Alcalá de Henares (Madrid, Spain) from November 28 to 30, 2018, the event was attended by more than 80 representatives from 35+ different organizations, including space agencies, satellite manufacturers and telecommunications operators.

For three days, participants had the opportunity of attending different technological presentations, including the description of the new functions of GMV's products as well as the roadmap of their future developments.

They were also able to share their operational experiences and participate in debates and round tables on current subjects that affect the sector, namely the automation of operations, fleet management, new technologies applied to ground management systems both satellite and payload, space debris monitoring, online security and new challenges in the provision of orbital control systems, especially in the use of low-thrust electric propulsion systems.

GMV's ambition is to continue serving existing and new customers and to provide them with better products to support their operations in the most effective way — count on GMV to deliver the solutions.

www.gmv.com/en/Sectors/space/

SATCOM Disruption

Smallsats spark innovation throughout the industry

By Jeffrey Osborne, Vice President, Strategy and Business Development, Kepler Communications

Using shoebox-sized satellites, Kepler Communications is redefining access to global connectivity with low-cost, rapidly deployable technology.

Organizations and individuals who live and work in populous urban regions of the globe enjoy unprecedented access to connectivity. In "*wired*" centers, access to on-demand bandwidth has streamlined operations, revolutionized business and built an insatiable demand for more and better digital applications.

However, communication services outside of cities has not kept pace. Even with large cellular networks and the proliferation of fiber optics, there are many areas where lack of access to reliable high-throughput data services is holding back essential activities.

Satellites are still required to fill global connectivity gaps, and new technological advancements are bringing enhanced communications capabilities to regions that are currently underserved.

Filling the Polar Communications Gap

Some satellite operators are taking advantage of standardized CubeSat platforms to quickly and inexpensively deliver satellites to orbit.

From their Toronto office, **Kepler Communications** has leapfrogged the competition by using smallsat platforms to meet the growing need for connectivity in underserved markets. Having already begun launching their planned 140-satellite constellation, the company is serving clients that require wideband connectivity for polar operations, which are outside the coverage of traditional satellites.

As sea ice retreats and there is an increase in activity at the poles, the demand for bandwidth grows. Industries, such as shipping, natural resources, tourism, science, and governments, all operate at extreme latitudes with an insatiable hunger for bandwidth.

For shipping in the northern hemisphere, the biggest news item during the past decade has been the expansion of northern routes for commercial shipping. The amount of shipping traffic in the Arctic circle has been steadily increasing over the past few years and many long-range weather models predict that even the *Transpolar Sea Route*, which passes directly over the north pole, may become a viable route for shipping traffic.

Once considered impassable, these waters are expected to witness increasing levels of traffic over the coming decades.

However, as Arctic shipping is now possible, such does not mean navigation is easy to accomplish, as Arctic weather is extremely unpredictable. To this date, vessel operators in the Arctic rely mostly on low-res ice flow imaging to assess the route conditions. This imaging assists in identifying the status of pressured ice and helps to make decisions on the most desirable route.

If available, high-bandwidth connectivity could allow shippers to source high-res imagery to improve navigation through these icy waters. However, at the Earth's extremes, high-throughput connectivity still seems far from possible and represents a daily challenge that is faced by many other industries that operate in these high latitudes.

Artistic rendition of a Kepler smallsat on-orbit.

Oil and gas, transportation and tourism, research and resource exploration, all encounter the same limitations where access to bandwidth through existent services can allow for no more than 10 GBs of data a day.

The usual go-to for communications technology in remote locations is satellite. All that's required is a clear view of the satellite in the sky. However, because of the curve of the globe, access to geostationary orbiting (GEO) satellites is problematic from Arctic latitudes because they are all located high above the equator.

At the Earth's poles, a signal from GEO can easily be blocked by local obstacles such as trees, mountains, rolling sea waves and, eventually, the curvature of the Earth. The only available satellite solution that provides pole-to-pole coverage is characterized as having low bandwidth and high costs, making that option unappealing for most applications.

A new communication service that uses high-bandwidth, polar-orbiting satellites is set to significantly increase the capability onboard vessels to assist them in safely navigating the Arctic, enabling mariners' access to high-res ice flow imaging, top-notch weather prediction, route data to make intelligent decisions, as well as onboard entertainment.

Kepler's constellation of small ***Low Earth Orbit*** (LEO) satellites is providing a solution to connectivity at extreme latitudes. Each satellite passes the poles every 90 minutes, and with two satellites now in service and a third on the way in the coming months, Kepler's ***PolarConnect*** solution delivers high-throughput store-and-forward capabilities.

To make use of PolarConnect, users can repurpose their existing steerable VSAT antennas to move from 10 to 75 GB of data per day. The service is initially tailored toward delay-tolerant data transfer, such as multimedia, large research file, hydrographic data, or even emails. As additional, rapidly-deployable LEO satellites are added to the network, available throughput increases and network latency decreases.

The Difference of Small LEO Satellites

Taking advantage of smallsat platforms gives Kepler the ability to rapidly integrate new technology and capabilities into their platform.

Traditional satellites require a decade or more to develop and can cost hundreds of millions to billions of dollars to get into service. This methodology imposes the need for the satellite infrastructure to remain in service for a decade or more just to recoup their capital cost. Ultimately, this means that SATCOM customers often are using 10 to 20 year old technology.

On the contrary, smallsats require a fraction of the cost and can be delivered into service within months. This drastically increases the rate of new technology adoption for the satcom industry.

LEO and GEO networks have many distinctions that can make them better suited for specific applications. For instance, as GEO satellites are parked at a fixed location in the sky, a simple static satellite dish is needed for fixed applications (such as broadcasting television stations or radio communications from permanent sites).

Conversely, LEOs "move" in relation to a fixed ground spot, necessitating a more complex mobile tracking antenna for high-throughput applications. Therefore, LEO networks are more applicable for mobile applications where the need for a tracking antenna also exists when using GEO networks

Essentially, a single GEO satellite is able to deliver real-time communications to a large geographic region. In contrast, a large number of satellites are required to provide persistent communications through LEO networks.

Nevertheless, a single LEO satellite is able to transfer delay-tolerant data in a store-and-forward fashion. This capability can increase the total bandwidth delivered to the end customer as well as be used to improve the quality of an existent, real-time GEO service by offloading non-time critical data transfers.

Kepler's PolarConnect solution functions essentially as a remote dropbox for large data files that are too expensive and consume too much bandwidth to send via real-time GEO links.

Future Applications

Looking to the future, in the coming years Kepler will be adding to the company's initial wideband data service a narrowband offering to connect Internet of Things (*IoT*) devices. Currently, IoT growth is hampered by the fact that cellular networks lack a global standard.

As of this writing, the increasing necessity for a standardized global network remains as one of the top hurdles to overcome for IoT device manufacturers. With dozens of different LTE frequency bands used globally, no single wireless module is capable of connecting across all the networks, and across all borders. This creates a challenge when deploying IoT solutions that need to work seamlessly around the planet.

Kepler developing solution to this problem is through the use of smallsatss and a low-power, low-cost, ultra-small, bi-directional transceiver to bring cellular-like connectivity to millions of devices in the IoT market.

According to *Jeffrey Osborne*, Kepler's Vice President of Strategy and Business Development, "*The real applications for narrowband services are going to be in providing cellular-like connectivity, which broadly means MB/month bandwidth, bi-directional communications for firmware updates, data acknowledgements and command, low power consumption, and a small form factor. This narrowband product will find application in everything from asset monitoring to smart metering, and can only be offered through a LEO system.*"

Everything Kepler accomplishes is with an eye toward the firm's ultimate goal of in-space connectivity — Kepler is intent on doing this sustainably. With their recent $16 million Series A round of investment, the company will start to roll-out their 15 satellite constellation that will be focused on wideband data services. Incrementally, the company will transition toward delivering cellular-quality narrowband connectivity in future satellites.

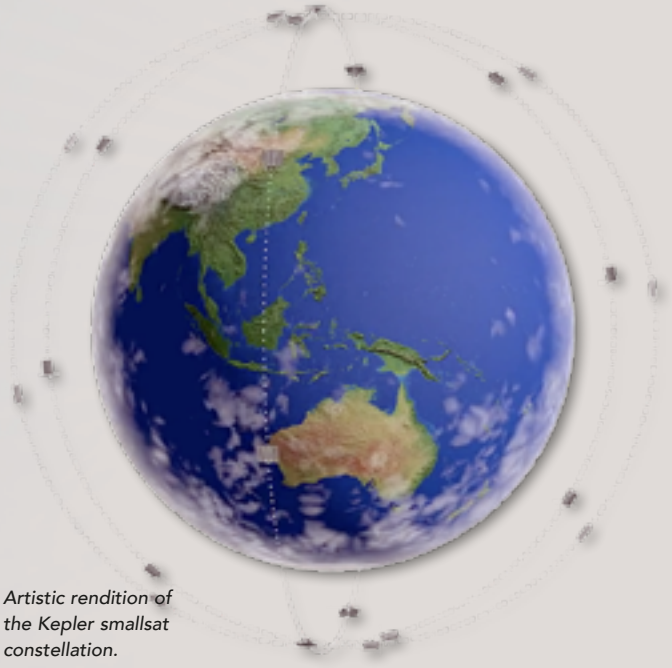
Kepler's accomplishments, to date, are a testament to the core strength of being able to build, launch, and operate highly capable communication satellites quickly. A principal desire for Kepler is to continue to strengthen existing relationships and to build new partnerships in the space industry, taking advantage of Kepler's core competency, that being to be able to collaboratively reach the goal of in-space connectivity.

www.keplercommunications.com/solutions/polarconnect

Jeffrey has led Kepler's business initiatives, helping to secure millions in commercial and government contracts.

Jeffrey's ability to think outside of the box and take risks in a pragmatic manner is a refreshing spin from traditional views of business development.

He holds a Bachelor's in Mechanical Engineering from Queen's University, and a Master's in Space Science from the International Space University. Before starting Kepler, he founded and ran a number of student teams at the University of Toronto developing suborbital rockets and small satellites.



Artistic rendition of the Kepler smallsat constellation.

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What's Next For NewSpace?

The sustainable future of space via AI and electric propulsion

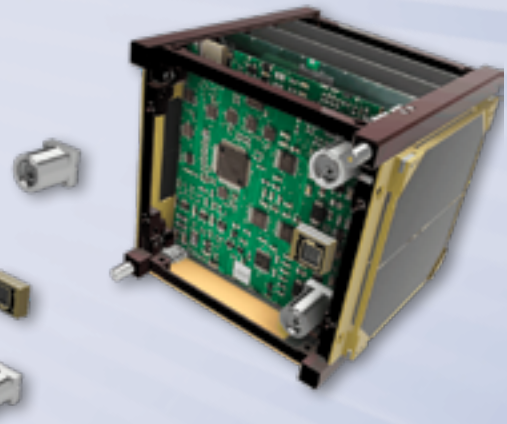
By István Lőrincz, Chief Business Officer, Morpheus Space

By the dawn of the second quarter of this century, huge satellite constellations will dominate the private space industry. The question is not "when" but "how" this will happen, as there are many serious issues that will require nimble solutions.

As was seen countless times within other industries where a fast-paced disruption occurred, the focus on short-term goals tend to leave the long-term consequences in the background. In space, this is not a luxury any have and such certainly cannot allow for the repetition of past mistakes due to shortsightedness (*e.g.*, Westford Needles).

Sustainability needs to be one of the top-level requirements in every constellation project. Most know that, in a majority of cases, sustainability does not contribute to quick profitable returns. Companies usually consider the matter to be a burden on their business models. Thus, there is hardly any acceptable answer to the usual question of why a company should spend resources now to avoid the continuing build-up of space debris, which certainly have the potential of making entire orbits unusable in the future.

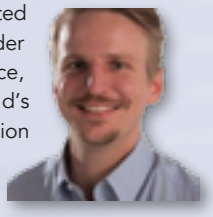
The team at **Morpheus Space** were determined to find a way to turn the tables and change the way the NewSpace industry looks at sustainable strategies. After talking to some of the leading companies in the industry, the team realized that raising awareness about these critical issues is simply not enough — the increase in public awareness only takes the industry halfway there. The remainder has to be achieved by company self-motivation, which always leads back to profitability, the strongest motivator within a modern company.



"As a propulsion company, Morpheus Space could identify early on that mobility for nano-satellites has been ignored for such a long time that the potential advantages it could bring to a NewSpace business were not fully analyzed," said ***István Lőrincz***, Chief Business Officer at Morpheus Space. *"Hence, an opportunity presented itself, which had the potential to give the industry the final nudge over the edge to adapt sustainability, not as an explicit goal but as a clear consequence of increasing profitability."*

He added, *"A current and very serious problem in the space industry is the ever-growing space debris. To continue to use space in the future, the debris must be disposed of much faster as that is the case naturally. We, at Morpheus Space, have aligned our core values with those of the UN when we speak about a sustainable future in space and on Earth. Our technology can be used for this purpose. With NanoFEEP, a small CubeSat who would otherwise be in orbit for 25 years could be propelled back into the atmosphere within 2 years. With MultiFEEP, one can even dispose of a*

6U CubeSat within 2 years, which would otherwise orbit for 1000 years as a space debris. Morpheus Space supports sustainability in space and on Earth by opening up possibilities for the industry to optimize satellite operations."



This journey for the firm started when ***Daniel Bock***, Founder and CEO of Morpheus Space, conceptualized the world's smallest electric propulsion system during his student years at the TU Dresden almost a decade ago. His ambitions drove him to design the most efficient, miniaturized, ion beam thruster the space industry had ever seen, called ***NanoFEEP***.

As time passed and Daniel began to see the end of the research project, he started to piece together a highly competent team of experts, with a goal in mind to build a company that had the potential to be a major player in the industry.

Once only a vision, and now a space-qualified product after years of tireless work, this engineering marvel became an overnight success after it was turned on for the first time on-orbit onboard the ***UWE-4*** satellite.

"*Thinking back on my student years, I never would have dreamed that one day my ideas would be materialized and put into orbit. It is a very humbling and gratifying moment at the same time,*" said Daniel, after experiencing the success of the on-orbit demonstration of his NanoFEEP thruster. "*This marks the first and most important step towards our vision of Agile Constellations." The much needed flight heritage for the Morpheus Space thruster technology had finally opened up new possibilities for nano-satellite operations."*

He then noted, "*Our Mission is to pioneer a new trend in the space industry, where micro launchers are the go-to in-orbit transports for nanosatellite missions, since the Morpheus Space satellites will not be dependent anymore on the big rockets to deliver them in their desired orbit altitude. Our patented electric propulsion technology is able to significantly modify the orbits of small satellites, significantly lower the launch costs, and most notably enable agile constellations; meaning that Morpheus designed satellites can continuously adapt their orbits and* even add new satellites to the constellation itself."

In order to offer propulsion capability to the most commonly used range of smallsat sizes, the team designed a second thruster, closely based on NanoFEEP, called ***MultiFEEP***, essentially a highly efficient clustering of seven NanoFEEPs with a few extra features, such as thrust vectoring.

With this approach, they achieved about an order of magnitude higher performance, while significantly reducing total volume, mass and power consumption compared to the same number of individual NanoFEEPs put together.

When propulsion is mentioned in the NewSpace community, the majority of the engineers think about straightforward on-orbit maneuvers for which it could be used for, such as orbit raising, de-orbiting or collision avoidance.

While in most cases, these capabilities can be beneficial for a business from a financial point of view, they also mean an overall increased project complexity, increased risk and most importantly, they require specialized personnel.

As a bottom line, in most cases the necessary resources spent actually do balance out the benefits gained. There are two major ways to tip this balance in a company's favor, namely to introduce more use-cases and decrease the necessary resources for individual companies.

Morpheus Space has introduced the concept of ***Agile Constellations*** to the public through the **European Space Agency** during one of this year's events. That marked a turning point in the way satellite operations are thought about and the abilities of constellations equipped with high delta-V propulsion systems.

Through this service, individual satellites within a constellation become connected in such a way that they fulfill certain mission objectives through cooperation in the most efficient way possible.

This is achieved through their proprietary artificial intelligence (AI), which can take over mission planning and execution for constellations that are equipped with Morpheus Space propulsion systems. The primary role of the AI is to find the most efficient way to rearrange a complete satellite constellation based on a set of predefined objectives.

A couple of examples for these objectives can be the application of fixed revisit frequencies (observational resolution) or the examination of frequently moving points of interest.

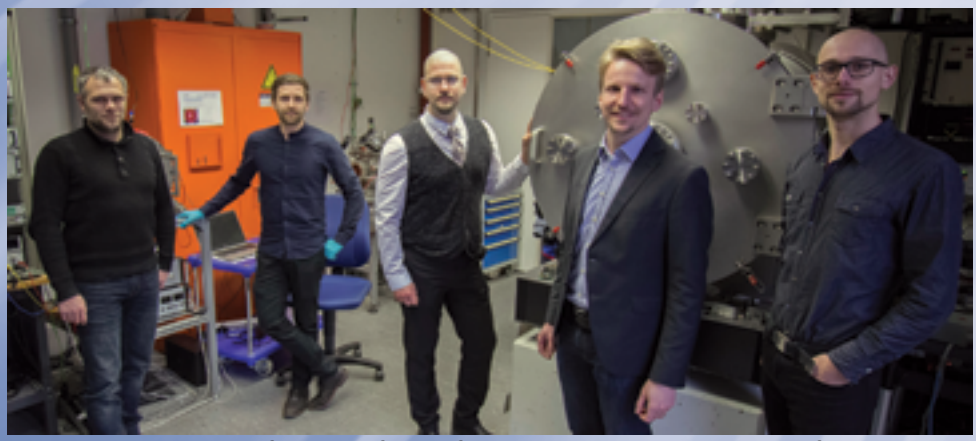
Collision avoidance maneuvers will also be highly complex in the near future, as moving even one or two satellites out of sync within a very large constellation could mean short service interruptions — or potentially worse consequences that clearly have a negative impact upon businesses.

Morpheus Space's solutions, combined together, empower satellite constellations with the potential to surpass the capabilities of large scale, conventional satellites and require but a fraction of their costs, all the while opening up new business models and opportunities, thus disrupting the NewSpace industry.

By following this vision, the most important goal can be reached by the entire industry, namely sustainability. Hence, the chance of collisions will be reduced to almost zero by an autonomous avoidance system and the de-orbiting maneuver will have an insignificant impact upon the satellite design, mission planning or total cost.

In this way, humanity can reach a point where space debris is looked upon as a relic left behind by past generations.

morpheus-space.com



The Morpheus Space founders, from left to right: Christian Boy, Head of Production, Christian Schunk, CTO, István Lőrincz, CBO, Daniel Bock, CEO, Philipp Laufer, Head of R&D — Professor Martin Tajmar, Advisor (not in image)

Achieving An Elusive Goal

A sustainable business case for smallsat missions

By Anita Bernie, Head of Strategy and Executive activities, KISPE

Despite the growing interest and investment in the industry, there aren't many success stories about smallsat mission sustainability. The team at KISPE have identified a critical price-performance gap in the smallsat market that isn't currently being addressed and one that can only be delivered by disrupting the current satellite production mindsets.

This article introduces the work of the **KISPE Group**, discusses their assessment of the smallsat market and associated challenges, and discusses a novel approach to creating viable smallsat missions.

Delivering Trusted, Bespoke Services

KISPE was founded by Dr. ***John Paffett***, who started a group of specialist companies to accelerate the development and introduction of innovative solutions, knowledge and consultancy in the fields of space systems, telecommunications and electronics.

"*KISPE is establishing a reputation as a 'force multiplier' in the industry,*" said Paffett. "*By providing timely, targeted, tailored support and expertise at all stages of the programmatic lifecycle, we enable our partners to make critical progress on current and urgent needs as well as build momentum to achieve longer-term objectives. Working as consultants, partners, and as embedded team members, we provide specialized services that allow our clients to maintain competitiveness and responsiveness to their own end customers.*

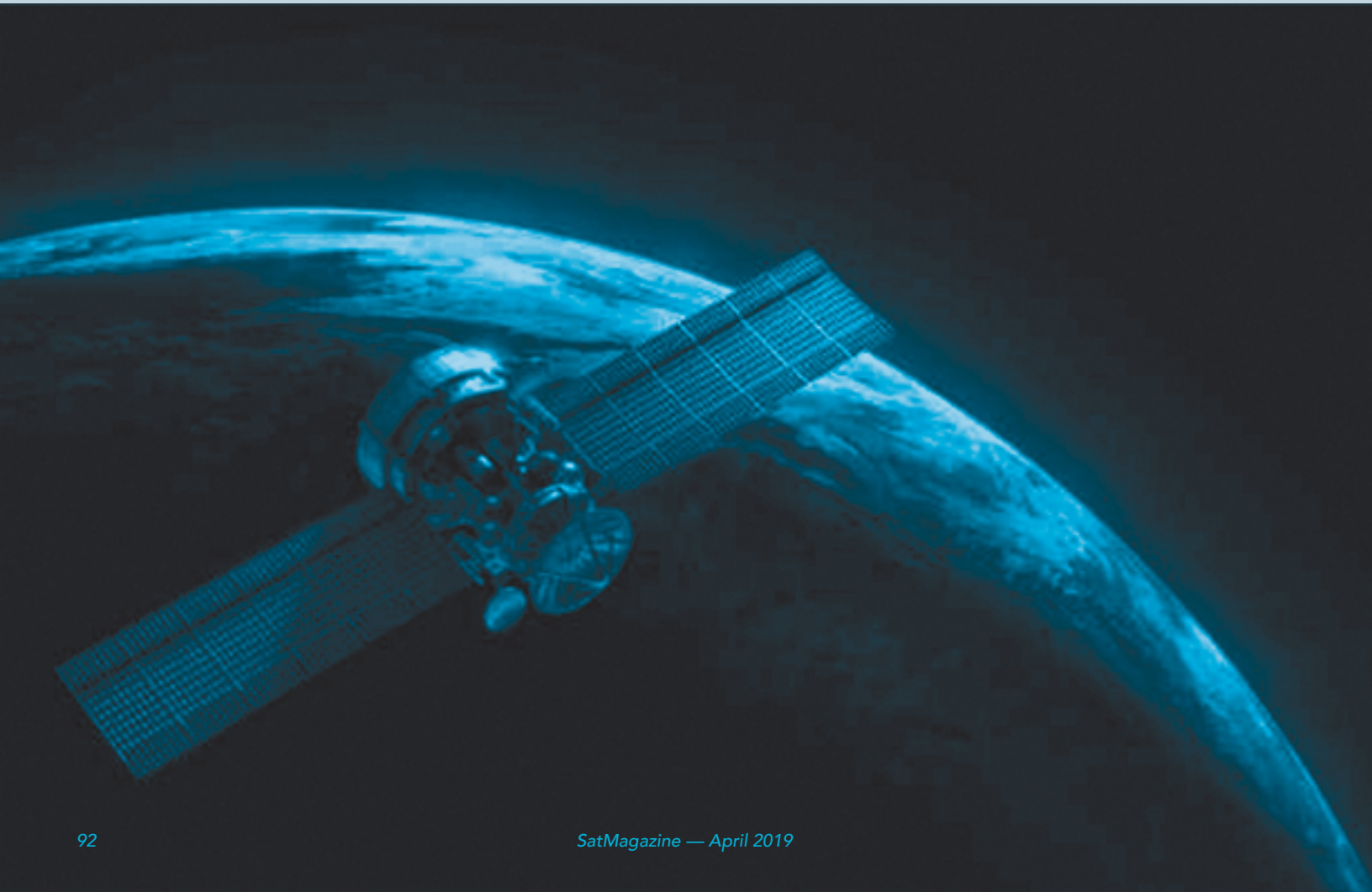
"*Perhaps counter-intuitively, we adopt a 'bare minimum' approach with our customers, focusing on the critical value-adding elements that cannot be done by anyone else. This approach allows us to stay lean and agile, while helping as many teams as possible to make an impact in their specific domains.*"

KISPE supports a wide variety and diversity of complex and challenging projects throughout the value chain, from component suppliers, payload and subsystem builders through to integrators, launchers and operators and services providers, and which all share a common theme: Helping customers to close viable and sustainable business cases.

Based in Farnborough, UK, the team is staffed with a growing number of smallsat experts, selected for their experience, know-how, innovative mindset and love of solving hard problems. Plans are underway to acquire additional office space to accommodate new permanent hires and interns and to set up a lab for the team to perform in-house development, demonstration, integration and test activities.

Enabling Mission Success

KISPE Space Systems Limited ("KISPE Space") was established as a stand-alone entity within the KISPE Group, dedicated to providing bespoke end-to-end engineering solutions and services for space missions and space-enabled programs.



With a vision to advance the responsible and sustainable use and exploitation of space, KISPE Space focuses on the elements that are at the heart of developing cost-effective and performant solutions and missions, but which are generally difficult to accomplish efficiently: systems engineering, systems integration and project execution. KISPE Space works on projects that address the full end-to-end space mission value chain, from payloads and subsystems, through to spacecraft, missions, launch and operations.

The company focuses on a value-creation imperative, the application, the application of a rigorous approach to problem evaluation and an innovative attitude to developing solutions, all notable reasons why customers decide to work with KISPE Space. Furthermore:

- *KISPE Space's multi-skilled team allows the company to adapt the scope and scale of their specialized technical, programmatic, commercial, strategic and training contributions to suit the specific needs of each customer.*
- *The KISPE Space team's breadth of mission experience, depth of engineering expertise and its relationships with all levels and segments of the space industry value chain and ecosystem creates the foundation for a holistic, end-to-end systems thinking approach to address the unique requirements and constraints of every project.*
- *A "vendor-agnostic" approach, and not being tied to any specific vendor, technology or system allows KISPE Space to scan the space industry and other innovative sectors for current and emerging technologies and capabilities, in order to identify the beneficial elements that can be integrated to create a "best of breed" solution that can create differentiation and value for its customers.*

Some examples of current and recent projects for customers in the USA, Europe and Asia include:

Mission and System activities for payload, equipment, satellite and launch providers:

- *Concept development*
- *Analysis and design*
- *AIT planning and execution*
- *Industry technology and capability evaluation*
- *Supplier evaluation*
- *Payload, equipment and technology evaluation*
- *Technology and system evaluation and down selection.*

Procurement and Proposal Support for contracting authorities and for vendors:

- *Generation of procurement documentation for contracting authority partners*
- *Independent evaluation of vendor submissions for contracting authorities*
- *Proposal writing on behalf of vendor customer partners*
- *Business case due diligence on behalf of contracting authorities.*

Strategy and business development activities:

- *Industrial capability portfolio evaluation*
- *Organization technology evaluation and roadmap development*
- *Developing business growth strategies*
- *Creating geographical expansion plans*
- *Business Development and relationship management on behalf of customers*
- *Tailored training and development for industry experts and new entrants.*

The team's blend of hands-on, end-to-end mission experience, exposure to customer challenges and understanding of proven and emerging technologies has allowed KISPE to develop a unique perspective on the status of the smallsat industry and stimulated the team to develop a new approach to addressing the discontinuities in the market.

Empowering the next wave of smallsat disruption

The KISPE team's experiences in the smallsat industry has led them to conclude that a ceiling is being reached for the price-performance point that can be achieved with the current classical production technologies and methods.

While the recent rapid growth in the use of smallsats has been encouraging, most smallsats are beyond the direct reach of many who could benefit from their commercial value due to their initial unaffordability, the challenges in being able to maximize the full system capabilities and the difficulty in sustaining long-term financial sustainability throughout mission life.

There exists a clear need for a lower-cost 25 to 250 kg. mass class microsatellite platform that can deliver the robustness, flexibility, scalability and performance characteristics that can enable a diversity of commercial and operational missions and applications — and which, most importantly, is affordable to manufacture in small quantities.

KISPE's conclusion is aligned with many of the views expressed during the ***SmallSat Show*** in Silicon Valley in February 2018. Several panel sessions addressed the current state and future prospects of the industry, with some commentators highlighting the fact that many of the current business cases are not sustainable in the long term.

Despite the growing demand for satellite-derived services and applications, an absence of profitability and investor returns exists, even in the face of intensifying activity in high-volume manufacturing in an attempt to leverage economies of scale in the production process.

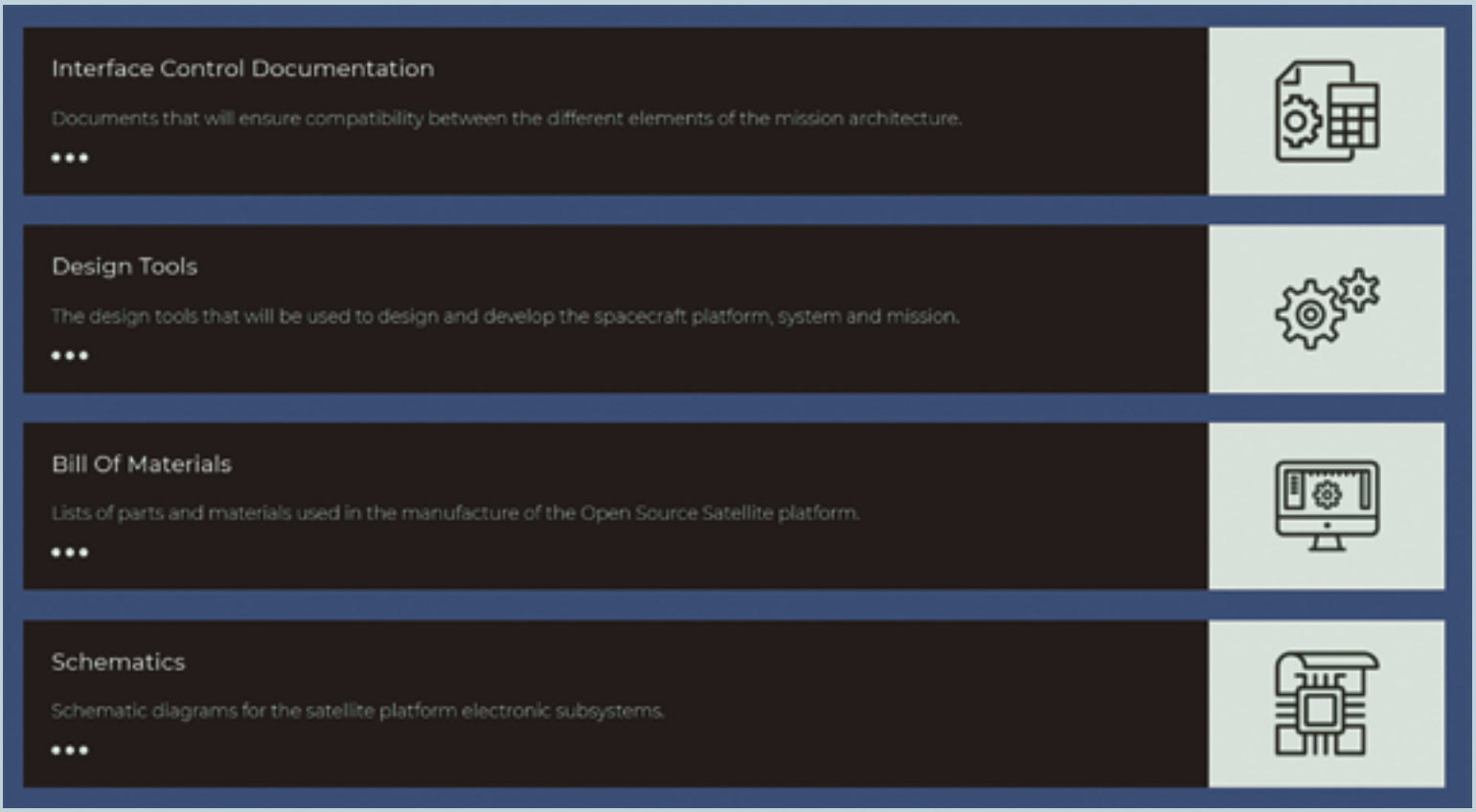
KISPE's view is that, in practice, the high-volume manufacturing approach is not a sustainable model for most smallsat missions:

- *The high upfront costs associated with setting up volume manufacturing facilities; and the need for extensive commitments from the supporting supply chain and investors are beyond the financial capabilities of all but a few consortia.*
- *The highly-speculative "build it and they will come - eventually" approach that appears to be the basis of several planned systems is extremely risky when the target market isn't necessarily fully identified and stimulated, exposing the implementation team to a long and uncertain timeline to financial break-even.*
- *The cost of the NRE to achieve a highly-optimized mass-production design has a chance of achieving the necessary price:performance trade-off; however, the high degree of optimization for a large constellation platform often means that it is costly to adapt and repurpose the design for a different mission, driving the cost of a customized solution beyond the constellation unit price.*

KISPE is tackling the challenge of improving the cost-effectiveness of the design, manufacture, launch and operation phases of low volume satellite programs.

There have been some advances in recent years throughout the satellite industry to such using **Commercial-Off-The-Shelf** (*COTS*) parts and improving manufacturing and assembly processes, to drive down costs through economies of scale. However, focusing only on "*industrialization*" is too simplistic an approach and does not foster the necessary holistic systems architecture and stakeholder thinking, nor drive the unit costs down to a point where small quantities of satellites can be sustainably manufactured "*On Demand*" rather than as a large and expensive production run.

There are a wealth of new innovations that are being enabled by **Industry 4.0** (*techradar.com/news/what-is-industry-40-everything-you-need-to-know*) that can truly revolutionize the way that smallsat missions are implemented, with the potential to realize the 10x improvement in the price:performance point that is required to bring



the total mission lifetime cost down to a level that is affordable, accessible and commercially viable for a wider global community.

The complementary drivers of market demand and enabling technologies inspired KISPE to create the ***Open Source Satellite Program***. The intersection of smallsats and open source thinking creates a springboard for the development of a community-based approach to delivering space and space-enabled systems that are more affordable and accessible.

Smallsat Performance at a Cubesat Price

KISPE is developing a microsatellite platform that will disrupt the current traditional thinking about how smallsats are produced, the missions that they can support and increase the democratization of space by leveraging the enablers that are being introduced in the Fourth Industrial Revolution, underpinned by an open source implementation approach.

KISPE believes that the way to maximize the accessibility, affordability and flexibility of small spacecraft is to develop a fully open source satellite platform: through the accomplishment of this development, the entire end to end life cycle of the mission will be enabled and delivered using open source and commercial off the shelf tools, processes, parts and technologies.

The Open Source Satellite Program will help to maximize the benefits of science and technology for society. This new design approach takes a step closer to the commoditization of a satellite bus, while at the simultaneously providing a means for tailoring the solution to meet specific mission needs without incurring significant non-recurring engineering costs. The Open Source Satellite design will be freely accessible by the people who can directly benefit from the solution.

The goal of the Open Source Satellite Program is to develop an accessible, highly capable, cost-effective, modular, microsatellite platform; a basis from which people can readily develop future space-based systems. The aim is to harness the cross-cutting potential of technological advances and processes from diverse industries, to adopt an open source approach to achieve a price performance point that truly makes space more affordable and to develop a next-generation low-cost smallsat platform with the following target characteristics:

- *A performant microsatellite at a cubesat price*
- *Launch mass 25 to 250 kg.*
- *>70% payload mass fraction*
- *Payload volume 600x600x450mm*
- *Payload power 10W to 1kW;*
- *3-axis stabilized*
- *Adaptable pointing knowledge, control and agility*
- *Orbit 400 to 850 km.; 5-7 year lifetime*
- *<14 month recurrent schedule.*
- *US 1 million for a 50 kg. variant, GBP 1 million for a 100 kg. variant.*

The Open Source Satellite Program will take advantage of the digitization advances that exist in a range of diverse yet complementary fields to develop a solution that is highly-integrated at the physical and functional level within the spacecraft, and which is produced using highly integrated digital tools, to create:

- *A fully open source, flexible, efficient fail-safe microsatellite platform, that is capable, modular and robust*
- *A platform that can be readily tailored for different missions, upgraded and configured after launch and operate with multiple ground station networks*
- *A platform developed using COTS parts, processes and tools*
- *A design that will be made available to the smallsat community, to catalyze new ideas and opportunities.*

One of the key drivers for the approach is to improve affordability by eliminating labor costs from all stages of the mission lifecycle. This will be achieved by:

- *Fusing digital and physical technologies*
- *Going beyond the simplistic approach of using COTS parts*
- *Using COTS design and development tools throughout the full end to end mission lifecycle*
- *Leveraging proven and emerging terrestrial technologies*
- *Applying established and new industry processes*
- *Implementing transparent platform-payload interfaces*
- *Achieving a high degree of physical and functional integration in the core platform design*
- *Reducing "touch time" throughout all phases of development and mission operations.*

One of the most exciting elements of the Open Source Satellite Program is the potential for building a global Open Source Satellite ecosystem. Dr. Paffett said, "*We have a vision to create a community that can freely follow, participate, contribute and exploit the design. It's the main reason that we've put significant effort into creating our new website; we've designed it to be a hub to serve the smallsat community. I'm really excited about the collaborative nature of what we're doing with the Open Source Satellite Program, the potential for improving the design with community inputs as well as stimulating new ideas and opportunities that will bring the benefits of space to many more people.*"

Information will be released about the Open Source Satellite design and the programmatic activities as the team progresses through the milestones, from design and development through to launch and mission operations.

The resources that will be available for public access will include: design drawings, schematics, parts lists, board layouts, software source code and manufacturing information. The entire satellite platform design will made available on the website, 12 months after launch of the first Open Source Satellite mission.

Paffett continued that the company is seeking the participation of individuals, teams and organizations that are interested in being involved and playing a part in the successes of the Open Source Satellite program. KISPE is planning early releases of information for strategic sponsors and partners.

He added, "*Please get in touch to find out more to support and realize the benefits from the Open Source Satellite Program.*"

Visit the Open Source Satellite Program website and register to be notified when new updates are released:
www.opensourcesatellite.org
LinkedIn
www.linkedin.com/company/open-source-satellite
and
www.linkedin.com/company/kispe

Twitter
twitter.com/SatelliteOpen

Career opportunities at KISPE
www.kispe.co.uk/careers/

Anita Bernie MBA, is the former Director of Exploration Missions at SSTL, responsible for the strategy and implementation of commercial services to enable the development of sustainable activities at the moon and Mars.

Prior to that she was Director of Platforms and Demonstration missions at SSTL, leading the development and delivery of systems and capabilities for spacecraft ranging from 5kg to 3,000kg to address operational and demonstration missions for communications, Earth Observation, space situational awareness and in-orbit servicing applications in LEO, MEO and GEO.

Focus: Telesat LEO

The why's and wherefore's

by Michael Schwartz, Senior Vice President, Corporate and Business Development, Telesat

Telesat is a Canadian satellite operator established in 1969 that has initiated one of the most exciting, privately-led space projects in history. Given that so many want to know more about who's behind the Telesat LEO program, this article is a brief introduction to the company and the firm's LEO project.

Telesat is one of the largest, most successful providers of satellite communications in the world. Headquartered in Ottawa, Canada, Telesat owns and operates a global fleet of 17 GEO satellites along with a robust teleport and terrestrial infrastructure that is seamlessly integrated with the fleet. With these high performing space and ground assets, Telesat provides reliable and secure communications solutions — nationally, regionally and globally — to broadcast, telecom, corporate and government customers worldwide.

Telesat's success has been driven by the company's deep technical expertise, backed by an industry leading consultancy and R&D Lab as well as a customer-oriented culture that gives customers a strong voice in the development of new products and services.

Relying on these capabilities, Telesat has established a long history of industry-leading innovation, both technical and commercial — a record that has spurred the company's growth since its inception.

In 2018, Telesat launched its Phase 1 LEO satellite: the start of a new global constellation that will revolutionize the delivery of high capacity broadband by leveraging Telesat's patent-pending orbital architecture and global priority spectrum rights.

Also in 2018, Telesat launched two, new, High Throughput Satellites (HTS): ***Telstar 19 VANTAGE*** that serves growing consumer, enterprise and mobility markets across the Americas and Atlantic, and ***Telstar 18 VANTAGE*** that replaces and expands on Telstar 18 to meet growing demand for mobility, enterprise and telecom services across Asia Pacific.

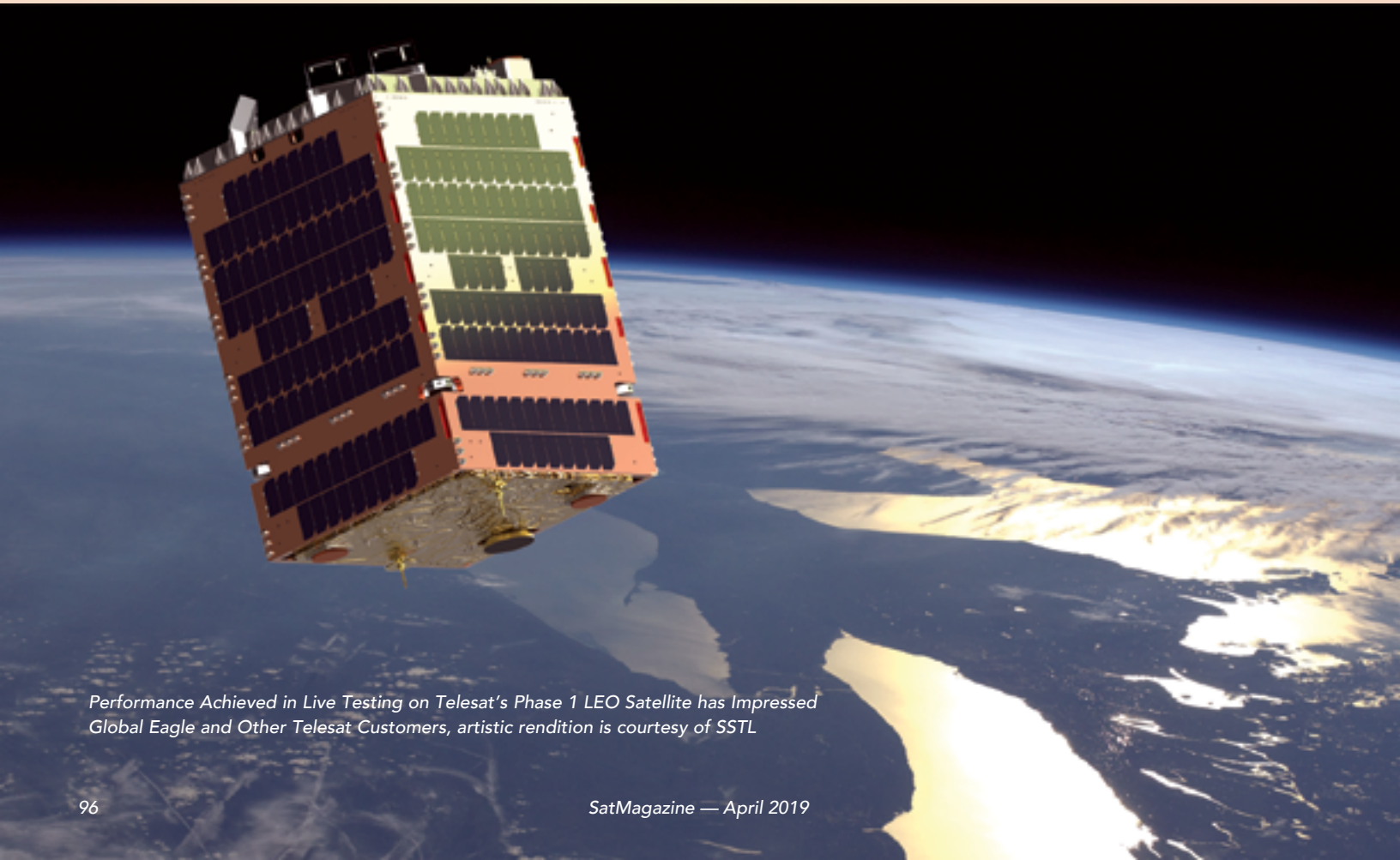
GEO HTS such as these deliver higher data speeds with lower rates to satellite markets worldwide, which have led to significant increases in global demand for satellite capacity — more than doubling the last five years in Gbps of delivered throughput, per **Euroconsult**.

However, customer requirements are continuing to evolve, including the need for greater capacity, lower costs, and round trip latency on par with advanced terrestrial networks.

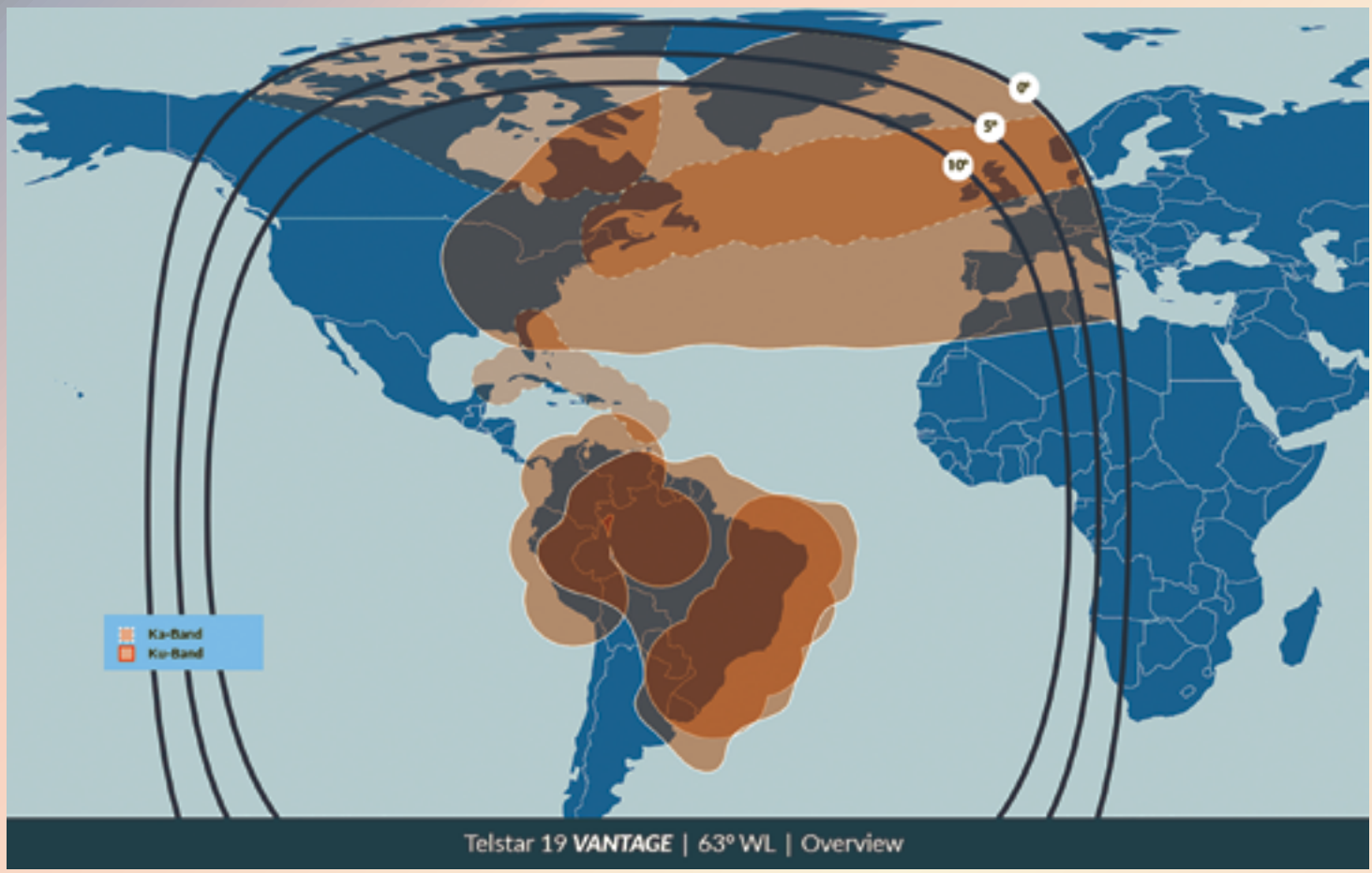
After discussions with major customers that serve some of the largest users of satellite broadband in mobility, telecom and government markets, Telesat concluded that within a few years, even terabit class satellites, operating in GEO or MEO, will not be able to provide the performance customers need to remain competitive.

Telesat's LEO Decision

From these customer discussions, clear but challenging goals emerged for Telesat: identify the key service and economic features needed to give customers a strong and sustainable competitive advantage in their markets; develop an optimal architecture for such a system; and establish a plan for its implementation and deployment. Two key industry trends shaped Telesat's LEO decision:



Performance Achieved in Live Testing on Telesat's Phase 1 LEO Satellite has Impressed Global Eagle and Other Telesat Customers, artistic rendition is courtesy of SSTL



Telesat's New Telstar 19 VANTAGE Satellite, Launched July 2018 to 63 West, Is Bringing High Throughput Ku and Ka-band Capacity across the Americas and Atlantic. Infographic is courtesy of the company.

- *Demand for broadband connectivity from customers in corporate, mobility, government and telecom markets is both accelerating and changing – customers increasingly require high throughput, low latency, improved resilience and increased security.*

- *Rapid advances in satellite technology are enabling deployment of new, space-based networks that can provide huge leaps in performance at far lower costs.*

"*It became clear to Telesat that we needed to develop a completely new satellite network to give our customers a sustainable advantage by offering superior speed, capacity, performance and low costs – a standards-based network that would integrate seamlessly into the global telecom infrastructure,*" said ***Dave Wendling***, Telesat's Chief Technical Officer. "*When we factored in the growing importance of low latency applications, both for commercial and government markets, an advanced LEO constellation was clearly the best solution. It wasn't long before Telesat's focus shifted from strategic considerations – 'what do we do to best serve our customers in the changing industry environment?' – to more implementation and execution – 'what's the best way to design and build this new capability?'*"

Erwin Hudson, Vice President Telesat LEO, added, "*To develop a new, space-based network that meets the requirements of our customers and which major telcos will choose to include in their core infrastructure, we have to deliver a level of performance that transparently integrates next-generation satellite and terrestrial networks. That superior performance — high capacity, speed, reliability and security with round trip latency comparable to, or even faster than fiber — can only be made available by an advanced LEO system. It cannot be done at GEO or MEO. Telesat LEO will be a huge leap forward in satellite broadband services on a global basis and will result in a new era of compelling economics and faster growth for the satellite industry.*"

Telesat started the development of a LEO system as early as 2014, but it was in 2018 that progress with Telesat's LEO constellation became more visible. Highlights achieved over the past year include:

- *The launch of Telesat's Phase 1 LEO satellite*
- *The down-selection to two prime contractor teams to further develop the system design*
- *Completion of several successful on-orbit tests with Telesat's Phase 1 LEO satellite.*

Telesat has attracted strong recognition as a leader in LEO in the satellite industry as well as beyond — for example, in October 2018, members of the **Massachusetts Institute of Technology**'s (*MIT*) ***Department of Aeronautics and Astronautics*** published an independent study highlighting the superior design of Telesat's LEO constellation, concluding that "*Telesat's system performs significantly better than the competition.*"

Global Eagle Entertainment (***GEE***), a longstanding Telesat GEO customer, has recognized the importance of LEO and has demonstrated future generation, in-flight entertainment services over Telesat's Phase 1 LEO satellite using a GEE test aircraft.

GEE Chief Executive ***Josh Marks*** commented, "*The performance advantage we're seeing from LEO has already got us convinced that this is the future. Anybody who isn't thinking that LEO is going to be part of their solutions at this point is, I think, making a mistake.*"

Telesat LEO Performance Advantages

Telesat continues to evaluate customer needs

High Throughput	Gigabits per second (Gbps) links available to individual customers along with multiple Terabits per second (Tbps) of total system capacity	**Low Cost**	Megabit per second (Mbps) pricing comparable to, or lower than, the lowest cost space systems available today or in development
Flexible & Focused	Dynamically allocated capacity wherever it's needed, providing the ability to serve areas of high demand	**Low Latency**	Typical round trip latency of 30-50 msec, more than 10 times better than GEO satellites
Global Connectivity	Patent-pending constellation design combining polar and inclined orbits providing coverage from the equator to the poles	**Flexible Terminals**	High throughput to small antennas, open architecture for easy integration and interoperability
Security and Resiliency	Optical inter-satellite links for direct global connectivity on a single network to any location. Multiple satellites available to each user regardless of location.	**Plug & Play**	Software controlled network delivering Carrier Ethernet service per Metro Ethernet Forum (MEF) standards allows quick deployment, seamless integration and dynamic control

as the design of the Telesat LEO constellation is finalized. The result of this design and development process is a truly innovative LEO system with a number of key performance advantages, as seen in the chart above.

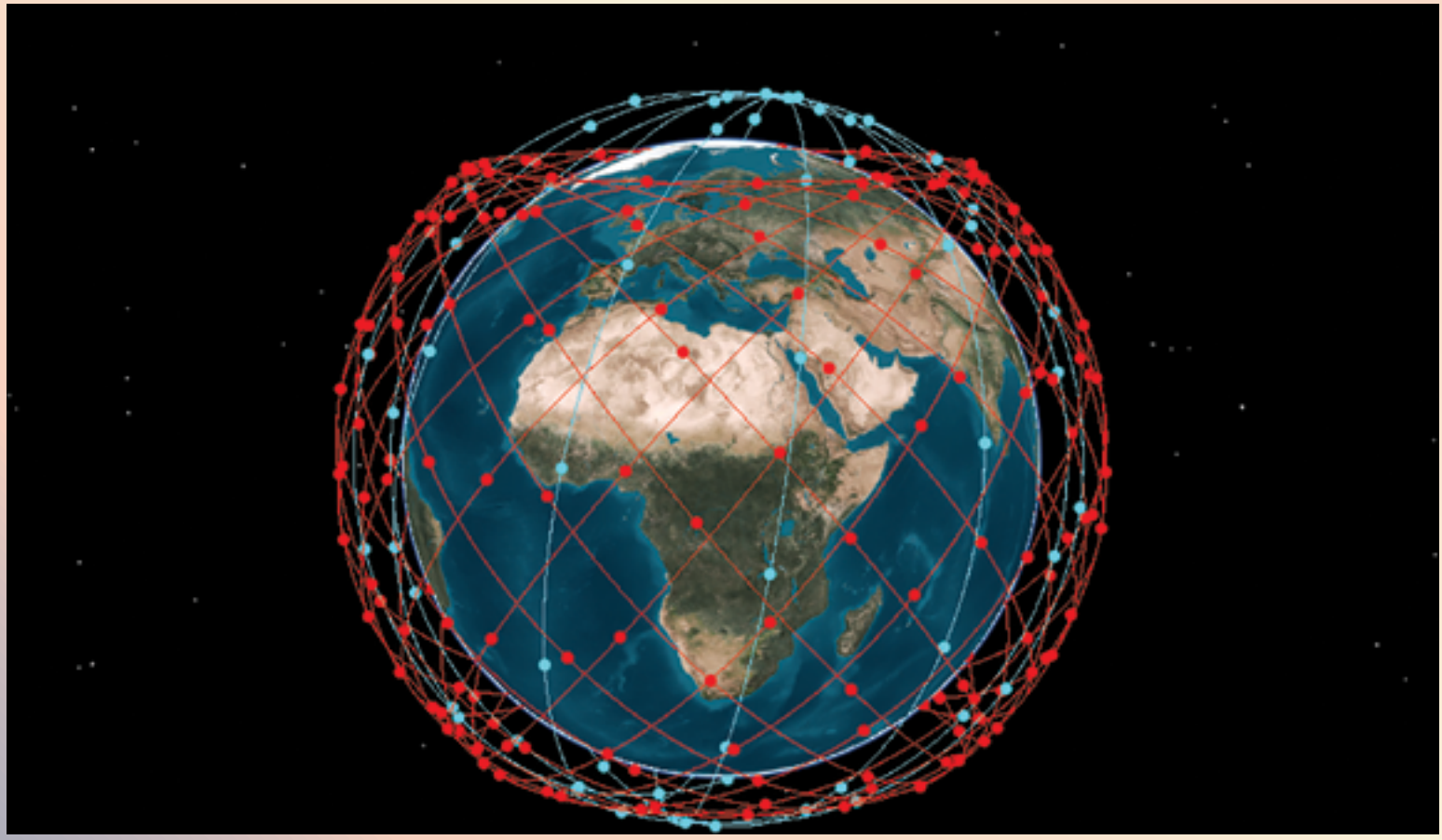
Among the most important advantages of Telesat's LEO constellation is its compliance with Metro Ethernet Forum (*MEF*) standards.

Erwin Hudson explained that, "*Designing our LEO system to be compliant with MEF standards is a powerful advantage that will allow Telesat LEO services to integrate seamlessly into existing networks. This standards-based approach will allow Telesat LEO to be a core component in the broadband infrastructure of our customers versus an independent or stand-alone proprietary network. We also expect to see widespread adoption of standards-based LEO connectivity in communications services around the world which will be another factor in Telesat LEO becoming more fully integrated in future networks of our commercial and government customers.*"

Multiple Market Needs Addressed

Telesat LEO will serve users anywhere on the globe that need fiber quality connectivity but do not have affordable access to fiber. Telesat will provide a wholesale service initially targeting mobility, telecom and government service providers.

- ***Mobility***
  Telesat LEO's unsurpassed combination of high throughput, low latency, affordability and full global coverage will allow aeronautical and maritime service providers to deliver an unsurpassed user experience to their customers, including vessels sailing the far reaches of the ocean and aircraft flying polar routes.



Telesat LEO will also concentrate capacity into areas of highest demand, such as major airports and seaports, providing substantially more capacity than available from other systems.

- ***Carrier Backhaul and Enterprise Connectivity***
Nearly half of the world's population lives outside urban areas where affordable and high quality Internet to the home or 4G/5G mobile networks may not be widespread. A critical gap is the lack of cost effective and quality backhaul connecting remote areas to the urban fiber backbone.

Telesat LEO will be truly transformative by offering such a solution. Flexible deployment means underserved or unconnected communities will be on-air quickly, avoiding the long lead times associated with fiber or microwave deployments.

Rural institutions (e.g., schools, hospitals) and remote enterprises (e.g., mines, factories) will have high speed connectivity just like their urban counterparts.

In areas with fiber infrastructure, Telesat LEO will serve as a flexible back-up option to maintain connectivity during fiber outages. Benefits in terms of economic growth due to ubiquitous quality connectivity and improvements in education and healthcare would soon follow.

- ***Government and Defense***
Defense agencies (e.g., U.S. Department of Defense (DoD)) are exploring innovative approaches to leverage the advantages of next-generation broadband LEO mega constellations, especially the low latency and high resiliency that results from their distributed architecture and full global, pole-to-pole coverage.

Several programs have been launched to pave the way for this 'pivot to LEO' from traditional architectures. The DARPA Blackjack program and the Air Force Research Labs DEUCSI (Defense Experimentation using Commercial Satellite Internet) are investigating the promise of LEO broadband for a variety of missions.

For instance, next-generation Unmanned Aerial Systems need hundreds of megabits of throughput with very low latency for high quality real time operations — LEO broadband systems will enable those applications.

In addition, the government satellite market when served by advanced LEO constellations is expected to grow far larger than it is today. The expanded government market will include highly reliable broadband for defense as well as other sovereign applications (e.g., diplomatic communications, border control and protection).

Continued Momentum

Telesat generated widespread interest in its LEO constellation in early 2019 by making announcements regarding partnerships with leaders in the tech industry.

Telesat announced an agreement with **Alphabet**'s **Loon** to design a network operating system for Telesat's LEO constellation. The operating system ensures that data is constantly flowing across the network, even as satellites and terminals change position and orientation.

Telesat also entered into a launch services agreement with **Blue Origin**, a company founded and backed by Amazon founder, ***Jeff Bezos***. This agreement paves the way for their powerful ***New Glenn*** rocket to play a key role in deployment of Telesat's global LEO satellite constellation.

New Glenn will provide Telesat with significant economies of scale as its LEO constellation is deployed early next decade. The agreement is flexible and non-exclusive, allowing Telesat to contract with additional launch providers.

The ***Telesat LEO Risk Management Project*** announced mid-2018 with the selection of two contractor teams — **Airbus Defence and Space** and a consortium of **Thales Alenia Space** and **Maxar Technologies**, continues into this year.

In January, both teams reported successful completion of System Requirements Reviews, furthering the system design and establishing a technical framework for the implementation and manufacturing phase of the program. Telesat expects to carry out a competitive proposal process and downselect to one of the two teams later this year.

"The innovative solutions of both contractor teams give us high confidence that the cost and performance goals set for Telesat LEO can be achieved," said ***Erwin Hudson***. *"Working with these outstanding manufacturers not only reduces project risk but gives Telesat access to the latest space-based technologies from true industry leaders."*

Beyond building a world class team for its LEO program, Telesat will advance its system design, and continue to conduct tests with both customers and supplier partners using its Phase 1 LEO satellite. Additional industry firsts and continued leadership are expected from Telesat and its LEO constellation in 2019 through the launch of the company's satellites and service availability in the early 2020s.

www.telesat.com

Michael C. Schwartz is Telesat's Senior Vice President, Corporate and Business Development. He plays a key role in advancing Telesat's strategic objectives by leveraging the company's orbital assets, forming alliances and pursuing business development and M&A opportunities. He rejoined Telesat in the fall of 2015 after three years at Sprint Corp. where he served as their Senior Vice President, Corporate Strategy and Development.

Prior to Sprint, Mr. Schwartz was Telesat's Vice President, Marketing, Corporate Development & Regulatory. Previously, Mr. Schwartz was Senior Vice President of Marketing and Corporate Development of SES New Skies, was co-founder of an Internet infrastructure company and held senior positions at AT&T Wireless Services, including Vice President of Acquisitions and Development.

Michael Schwartz graduated magna cum laude from Harvard University in physics and magna cum laude from Harvard Law School.

New Market Opportunities For Smallsats

Market maturation fuels continuing sector growth

By Caleb Williams, Lead Economic Analyst, and Stephanie DelPozzo, Economic Analyst, SpaceWorks

The small satellite sector continues to enjoy increasing popularity as operators turn to smaller form-factors to achieve less expensive and more responsive access to space.

Based on the most recent insights from industry consulting firm **SpaceWorks**, the smallsat market is expected to continue its current growth trajectory in the near-term, fueled by maturing market segments and new satellite applications. SpaceWorks ***9th Annual Nano/Microsatellite Market Forecast***, released earlier this year, predicts as many as 2,800 spacecraft between 1 to 50 kg. will launch over the next five years.

As expected, the industry corrected after a record launch year in 2017, sending 20 percent less nano/microsatellites to orbit in 2018; however, future potential for the sector remains high. A flurry of launches in Q4 of 2018 helped sustain overall market performance and brought with them a number of industry success stories: **Rocket Lab**'s ***Electron*** saw its first (and second) commercial launches, the long-awaited **Spaceflight *SSO-A*** finally took flight and Russia's ***Soyuz*** showed the launch vehicle has no intention of giving up its share of smallsat launches without a fight.

2018 was also an evolutionary year for the satellite Internet-of-Things (*IoT*) market, with seven different commercial operators launching their first satellite last year — five of the seven even registering more than one satellite.

Growth in this segment is already surpassing what was seen in the early days of the Earth Observation/Remote Sensing segment and promises to be a major driver of overall sector expansion in the future.

Increasing global demand in down-stream data analytics and communications applications are driving much of the segment's growth, but competition from large LEO broadband constellations will require these operators to differentiate their offerings in order to stay relevant in the long-term.

In spite of meteoric growth over the past decade, some segments appear to be starting to push the boundaries of the nanosatellite form-factor.

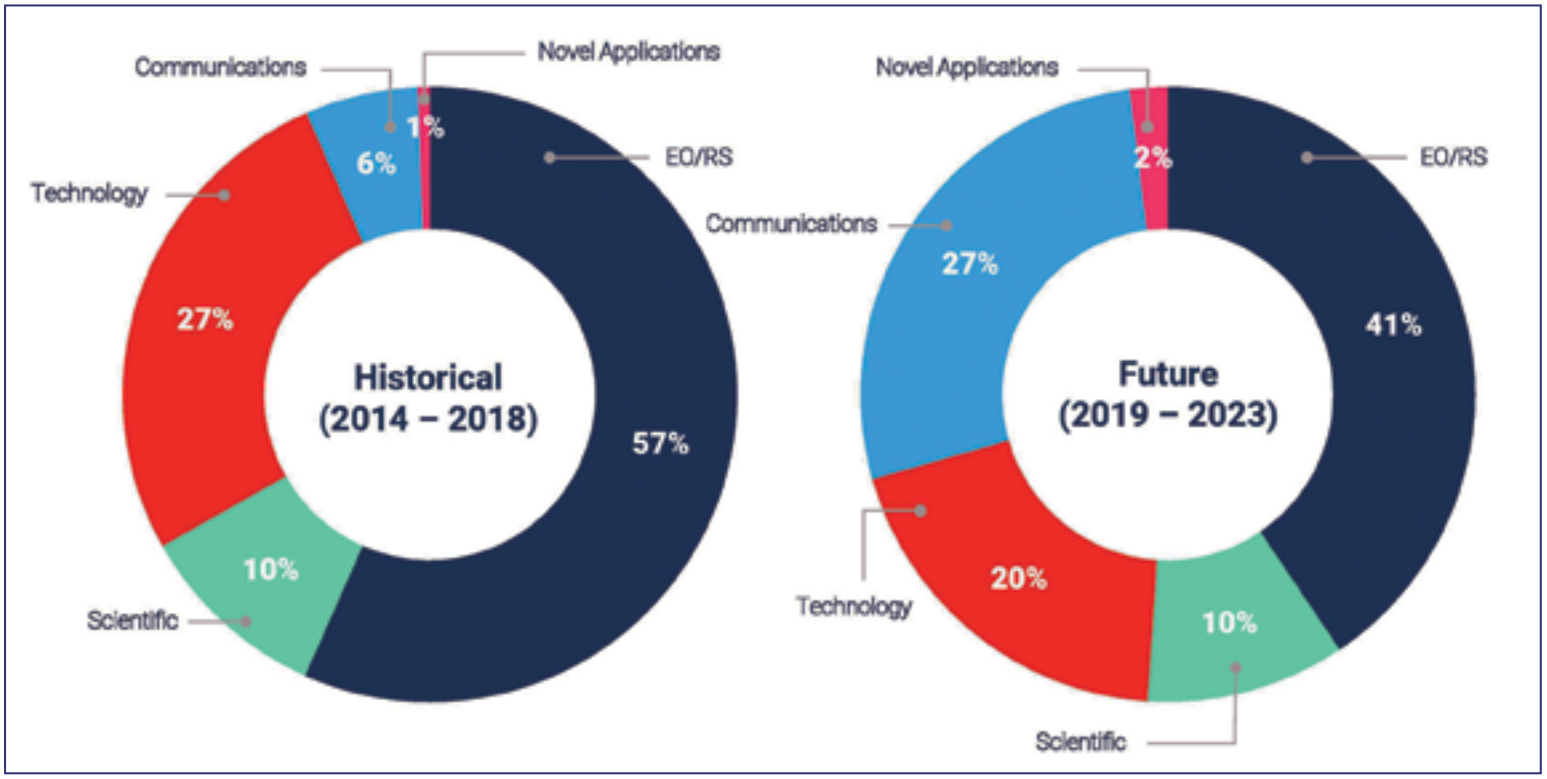
Interestingly, microsatellites (10 to 50 kg.) defied the overall market decline in 2018, seeing a 25 percent increase in satellites launched. This trend is poised to continue as civil and military operators begin embracing the use of smallsats to meet key scientific and national security objectives.

With customer demand pushing the market toward more capable payloads, growth in the microsatellite segment is expected to reach double digits as more operators adopt larger smallsat form factors.

Even with operators looking toward larger form-factors to accommodate more demanding payloads, nano/microsatellites are demonstrating enhanced capabilities that make them particularly attractive for certain applications.

Of particular note is the rapid progress of commercial satellite IoT ventures, mostly restricted to the nano/microsatellite segment. These satellites, intended for communications and IoT applications, are expected to account for as much as 25 percent of the satellites launched over the next five years and, going forward, are anticipated to play a critical role in the growth of the overall nano/microsatellite segment.

In contrast, Earth Observation (EO) and Remote Sensing operators, historically the dominant players within the sector, are expected to decrease their market share by more than 15 percent during the same time period.



Sub-segments, such as low-resolution optical imagery, are starting to reach saturation and EO and Remote Sensing operators are turning toward new applications — such as GPS Occultation, ADS-B, live-video and others — to help diversify their revenue streams.

Nano/Microsatellite Application Trends

Overall demand within the nano/microsatellite segment remains strong and SpaceWorks' analysts are predicting 294 spacecraft to launch in 2019. Compared to last year's forecast, projections for 2019 have been revised to reflect changes in both application and operator trends.

Though still dominated primarily by commercial operators, the nano/microsatellite segment is seeing broader interest from government entities, including for expensive interplanetary science missions (***e.g.***, **NASA JPL**'s ***MarCO*** mission).

In 2018, more satellites launched beyond LEO than in the last five years combined. Enhanced capabilities, new technologies and greater component reliability are all driving the increase in interplanetary CubeSat missions, and this trend is expected to continue, with as many as 35 nano/microsatellites expected to launch beyond LEO by 2023.

It appears, at least for the time being, that government demand in the smallsat sector is restricted primarily to the civil operators segment. Despite vocal declarations, military operators have been slow to adopt these smallsat form-factors, and their interest seems little more than one of curiosity at this point.

Limitations in CubeSat payload capabilities are likely driving military operators to concentrate their attention on microsatellites in the 50 to 300 kg. range, rather than the 1 to 50 kg. range.

As technology modularization and miniaturization continues, this trend may change rapidly — smallsat manufacturers who are ready to capitalize on military opportunities once they arise are likely to be generously rewarded.

2019 Nano/Microsatellite Forecast

Increased launch consistency for small satellites, as well as new applications, are enabling future growth across the nano/microsatellite sector.

Several operators launched their first satellites in 2018 and many others began the initial roll-out of their larger constellations, creating confidence in SpaceWorks' analysts and industry investors for near-term growth.

Overall, increasing market maturity is expected to unlock new opportunities for market growth in the small satellite sector.

Across all parts of the smallsat value chain, companies are beginning to demonstrate improved reliability, consistency, and sustainability.

Down-stream market applications, such as data analytics, are the critical benefactors of this changing industry landscape, and their success will dictate the future potential of the upstream market.

For more research, analysis, and commentary regarding the small satellite and commercial space markets, please visit ***www.spaceworks.aero/insights***.

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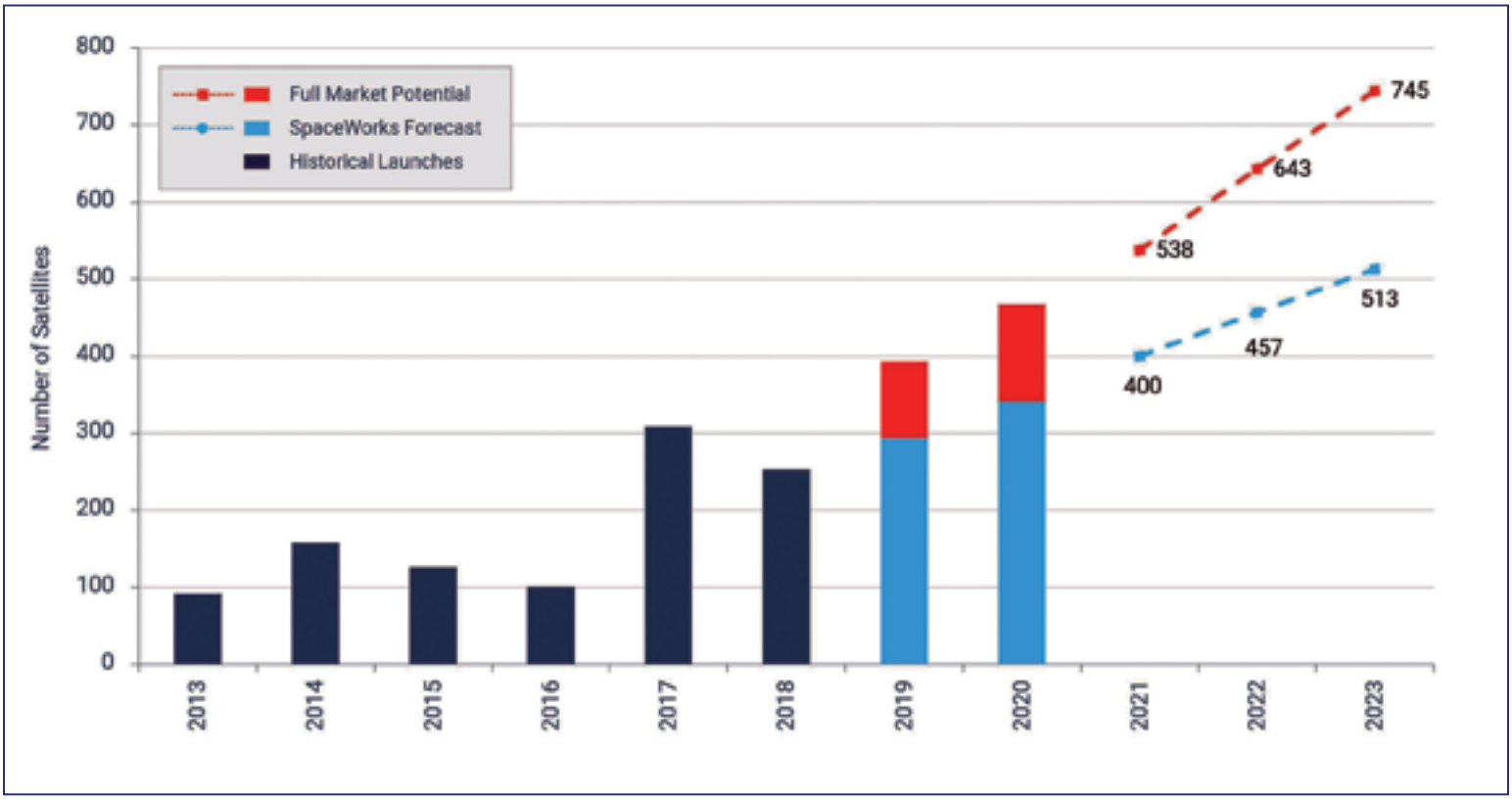

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