Worldwide Satellite Magazine — February 2018

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SmallSat Issue

A OneWeb satellite on orbit.
Image is courtesy of OneWeb.

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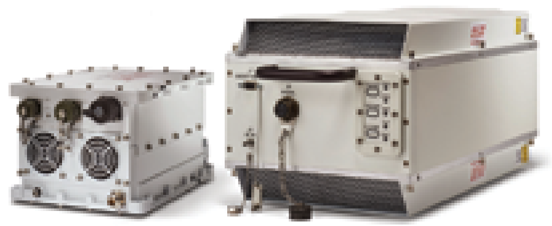

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February 2018

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Launch success for two SSTL-built smallsats

Surrey Satellite Technology Ltd. (SSTL) announced the successful launch of CARBONITE-2, an Earth Observation (EO) technology demonstration mission owned and operated by SSTL, and of the Telesat LEO Phase 1 communications satellite, an important milestone in Telesat's plans to deploy a global LEO constellation for broadband communications services around the world.

These two small SSTL satellites were launched into a 505 km. sun-synchronous orbit (SSO) on board a PSLV launch vehicle from the Satash Dhawan Space Center in Sriharikota, India, on January 12, 2018, at UTC/GMT 03:59. Following separation from the launch vehicle, SSTL is pleased to confirm that successful contact was made with both satellites and all initial system checks for both spacecraft are nominal.

CARBONITE-2 is a technology demonstration mission that will demo a low cost video-from-orbit solution using Commercial-Off-The-Shelf (COTS) technologies. The 100 kg. spacecraft flies a COTS telescope and HD video, both of which have been adapted for a space environment and integrated into a custom built framework. The imaging system is designed to deliver 1m resolution images and color HD video clips with a swath width of 5km.

Under a contract announced in November 2017, SSTL will supply British company Earth-i with CARBONITE-2 data for proving tasking, downlinking and image processing in preparation for a constellation of five CARBONITE series satellites.

CARBONITE-2 flight-ready at SSTL. Image credit SSTL/Beaucroft Photography

CARBONITE-2 is the second technology demonstration satellite in the series to be launched by SSTL; the first, CARBONITE-1, was launched in 2015 and achieved full mission success by demonstrating the concept of a low-cost COTS video-from-orbit solution.

The CARBONITE-2 satellite flies enhanced avionics to provide increased data storage, faster data downlink, improved pointing accuracy, and a full color HD video camera. SSTL's CARBONITE series of spacecraft have been specifically designed for large constellations.

The simplified, rapid-build platform design incorporates SSTL's flight-proven avionics and a large payload accommodation area to fly a variety of Earth observation sensors.

The Telesat LEO Phase 1 satellite, which will allow Telesat to test key performance parameters of its next generation global LEO constellation, has a mass of 168kg and was manufactured by SSTL in the UK. SSTL's spacecraft operators will complete commissioning and orbit-raising maneuvers for the satellite from SSTL's Spacecraft Operations Centre in Guildford.

Photo of the Telesat LEO Phase 1 satellite. Image credit SSTL/Kathryn Graham.

Once the Telesat LEO Phase 1 satellite has reached its final planned orbit, command will be handed over to Telesat for in-orbit operation using the Ka band payload from Telesat's ground station at Allan Park in Canada.

Sir Martin Sweeting, Executive Chairman of SSTL, said that this launch marks the start of two new pioneering missions: a technology demonstration for CARBONITE-2 and the initial deployment of Telesat's global LEO constellation with their Phase 1 LEO satellite. He was particularly pleased that SSTL's space technology expertise will be advancing NewSpace applications in both high throughput broadband and low cost video-from-orbit.

www.sstl.co.uk

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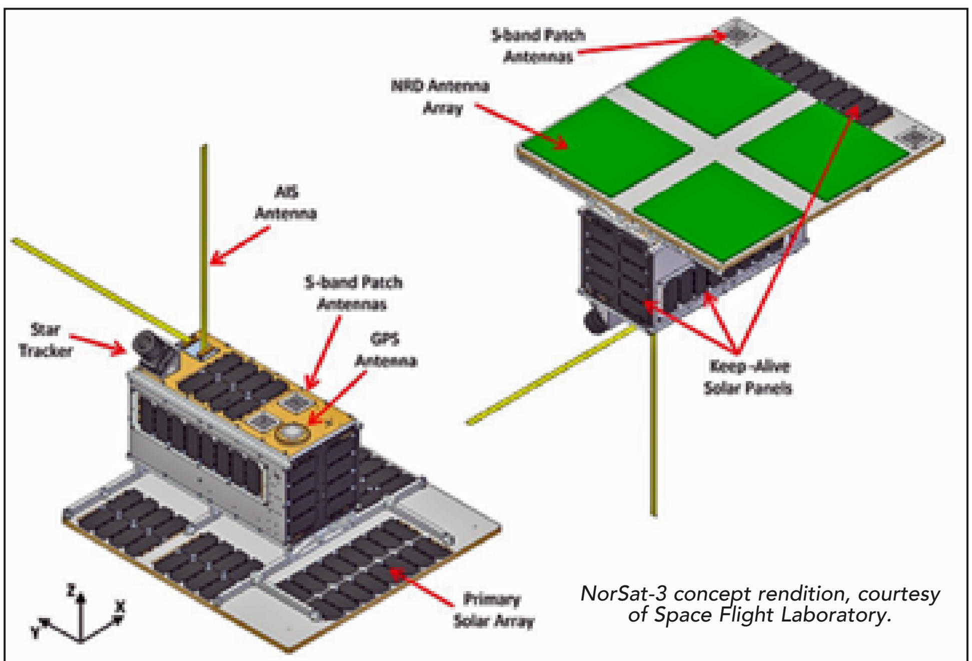
Space Flight Laboratory now engaged in Norsat-3 smallsat build

The Space Flight Laboratory (SFL) at the University of Toronto Institute for Aerospace Studies (UTIAS) has announced that NorSat-3, a 15 kilogram microsatellite, has been ordered by the Norwegian Space Center and that construction is well underway — NorSat-3 follows from the successful NorSat-1 and NorSat-2 satellites that were also built by SFL.

This satellite will carry an experimental navigation radar detector to augment ship detection capabilities from its Automatic Identification System (AIS) receiver. NorSat-3 will add another satellite to Norway's assets in space — four in total so far, all producing data related to maritime traffic monitoring. Combining a navigation radar detector and AIS receiver will potentially provide much better maritime awareness for the Norwegian Coastal Administration, Armed Forces and other maritime authorities.

The satellite is funded by the Norwegian Coastal Administration and managed by the Norwegian Space Center. The Norwegian Defence Research Establishment (FFI) is leading the development of the radar detector payload which is funded by the Ministry of Defence. NorSat-3 is a civilian satellite designed to capture signals from civilian navigation radar.

Automatic Identification System (AIS) message reception alone may not provide a complete picture of maritime traffic. The problem of missing or manipulated AIS messages can only be addressed through the use of supplemental sensing technology. In the case of NorSat-3, a navigation radar detector provides some supplemental support for more accurate ship detection and identification. The detection of navigation radar from ships will provide the ability to verify the accuracy of received AIS messages and also the ability to detect ships whose AIS messages have not been received.



NorSat-3 concept rendition, courtesy of Space Flight Laboratory.

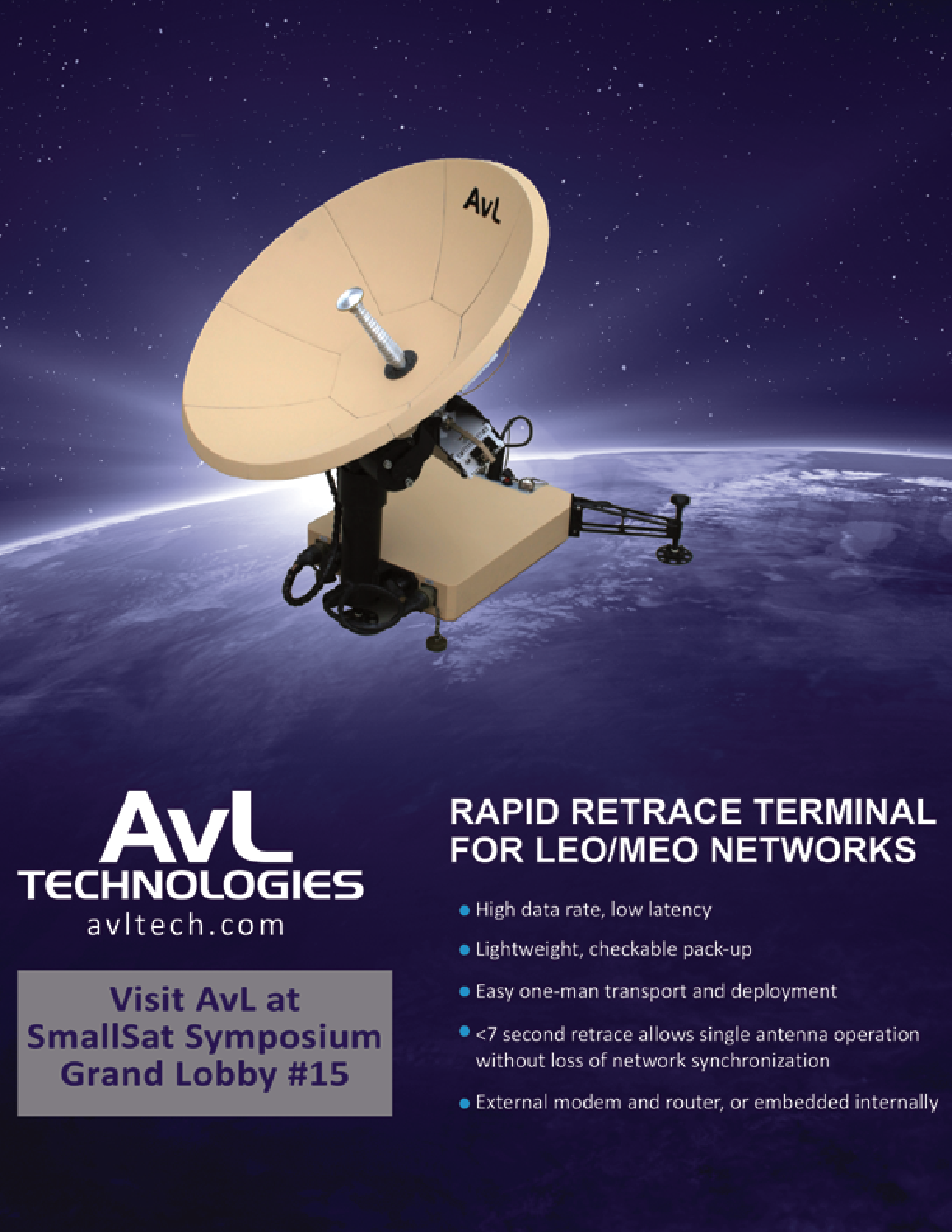
NorSat-3 represents another barrier breaking, paradigm-shifting advance in smaller satellites using SFL's next-generation Earth Monitoring and Observation (NEMO) platform.

SFL built the NorSat-1 and -2 smallsats on behalf of the Norwegian Space Center with support from the Norwegian Coastal Authority, Space Norway, and the European Space Agency. The two smallsats were launched on July 14, 2017. Each weighs approximately 15 kilograms, with main body dimensions of 20x30x40cm.

NorSat-1 and -2 carry state-of-the-art Automatic Identification System (AIS) receivers built by Kongsberg Seatex to acquire messages from maritime vessels. In addition, NorSat-2 has a VHF Data Exchange (VDE) payload that enables higher bandwidth two-way communication with ships. Adding VDE enables increased messaging capacity, better reliability of message delivery, and increased range of ship-to-shore and ship-to-ship communication beyond direct line of sight.

SFL builds big performance into smaller, lower cost satellites and are built with advanced power systems, stringent attitude control and high-volume data capacity that are striking relative to the budget. SFL arranges launches globally and maintains a mission control center accessing ground stations worldwide. The pioneering and barrier breaking work of SFL is a key enabler to tomorrow's cost aggressive satellite constellations.

www.utias-sfl.net/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Space launch market estimated to reach $27.18 billion by 2025

A new research report, now available from ASDReports, is entitled "*Space Launch Services Market by Service Type (Pre-Launch, Post-Launch), Payload (Satellite, Human Spacecraft, Cargo, Testing Probes, Stratollite), End User, Orbit, Launch Vehicle Size, Launch Platform, and Region - Global Forecast to 2025***."**

The space launch services market is estimated to be USD 8.88 billion in 2017 and is projected to reach USD 27.18 billion by 2025, at a CAGR of 15.01 percent during the forecast period.

The increase in demand for small satellites (smallsats), rise in space exploration activities, and technological advancements to develop low-cost launch vehicles are key factors driving the growth of the space launch services market.

Based on service type, the pre-launch segment is expected to lead the space launch services market from 2017 to 2025. The growth of the pre-launch services segment can be attributed to an increase in the number of launch service providers and reduction in the price of launch and integration services that include flight hardware support and mission management.

In addition, technological advances in space systems have led to expanding the capabilities of payloads, thereby contributing to the growth of the pre-launch services segment of this market.

Based on payload, the satellite segment of the space launch services market is expected to grow at the highest CAGR from 201 to 2025.

The increased demand for Earth observation (EO) and communication satellites has led to the growth of the satellite segment. These satellites are intended for monitoring the Earth's surface to obtain valuable information for mapping, mineral exploration, land-use planning, and resource management, among other activities.

Based on launch vehicle size, the small lift launch vehicles segment is projected to lead the space launch services market from 2017 to 2025.

The increasing deployment of small satellites for commercial and military applications and rising investments for the development of small launch vehicles are factors contributing to the growth of the small lift launch vehicles segment of the space launch services market.

North America is estimated to lead the space launch services market in 2017. The increasing demand for launch services for satellites, human spacecraft, and space probes is projected to drive the growth of the space launch services market in North America. In addition, increased investments in space probe missions are further contributing to the growth of the space launch services market in this region.

Antrix Corporation (India), Arianespace (France), Boeing (US), China Great Wall Industry Corporation (China), EUROCKOT (Germany), ILS International (US), Lockheed Martin (US), Mitsubishi Heavy Industries (Japan), Orbital ATK (US), Space Exploration Technologies (US), Space International Services (Russia), Spaceflight (US), Starsem (France) and United Launch Alliance (US) are key players operating in the space launch services market.

Download information regarding this informative report at ***www.asdreports.com/market-research-report-436017/space-launch-services-market-global-forecast?utm_source=ASDNews&utm_medium=affiliate&utm_campaign=ASDNews_PRS&utm_content=title_tekstlink***

Also of interest could be ASDReports' *Global Small Satellites Market — Analysis and Forecast: 2017 to 2021***.**

The small satellites market has witnessed a high growth rate owing to the advancements in satellite miniaturization, increasing capability of electronic technology, ascending demand for small satellite constellations, and increase in the deployment of small satellites for commercial end users.

Recent innovations in smallsat subsystems have enabled them to reach a wider segment of consumers in the satellite industry. The companies are developing relatively low-cost small satellites which facilitate services almost equivalent to the traditional big satellites that serve government agencies or public sector industries. This, in effect, is expected to increase competition in the near future as well as facilitate the use of smallsats for varied applications.

In terms of revenue, the small satellites market generated $2,528.1 million during 2016.

To learn more, access ***www.asdreports.com/market-research-report-436233/global-small-satellites-market-analysis-forecast***

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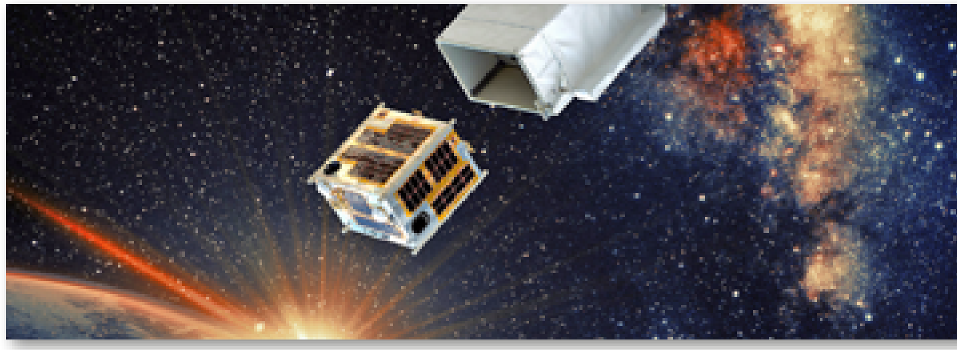
Clyde Space acquired by ÅAC Microtec AB



The Swedish space tech company ÅAC Microtec AB ("AAC") has entered into a share sale and purchase agreement to acquire 100 percent of the shares in UK based Clyde Space Ltd ("Clyde Space") (the "Transaction"), a leading player in the global, high-growth smallsat market.

The acquisition will be paid for with 30,466,326 newly issued shares in AAC and GBP 2 million in cash, equivalent to approximately SEK 294 million (at a share price of 8.90 SEK/share). After completion of the acquisition, Clyde Space owners will hold 49 percent of AAC. The company employs 77 individuals in Glasgow, Scotland.

Clyde Space has supplied complete platforms as well as more than 2,000 subsystems for small spacecraft. In the cubesat sector, Clyde Space is a market leader, supporting between 30 and 40 percent of all current and past missions.

For the period Q1-Q3 2017, Clyde Space's revenues amounted to approximately GBP 3.98 million, corresponding to approximately million SEK 45 million. EBITDA for the same period amounted to approximately GBP -0.03 million.

aacmicrotec.com
www.clyde.space

Launcher for smallsats considered for development by ISRO

A low-cost small satellite launcher that could be capable of putting 500 to 600 kg. satellites into close Earth orbits could well be the next item on the menu of the Indian Space Research Organisation (ISRO).

Since 1999, ISRO's PSLV rockets have launched 209 small satellites from 28 countries for a fee | Photo Credit: PTI

Preliminary work to design and develop an ambitious small launch vehicle began about three months ago, said K. Sivan, Director of ISRO's rocket development node, Vikram Sarabhai Space Center (VSCC). Its design will enable a handful of engineers to assemble it within a week.

VSSC has designed the vehicle using the rocket technology that it already has and is awaiting ISRO's approval. "*We are looking at having a demonstration launch in a year, in the 2018-19 time frame*," Dr. Sivan told The Hindu news publisher.

The development cost would be kept low at a few crore as the new launcher's requirement of advanced electronics is considerably lower.

The launch fee that customers would have to pay would also be reduced, which is what all space agencies aim at: low-cost access to space.

Since 1999, ISRO's PSLV rockets have launched 209 smallsats from 28 countries for a fee; they have been for experimental, university or remote-sensing uses.

In February of 2017, a PSLV carried a record 104 satellites to space. The next launch will carry some 30 small customer satellites to space — their weights ranging from 1 to 100 kg.

Today, it takes 300-plus engineers and about 40 days to assemble a PSLV. A small launcher that can be ready perhaps in as few as three days by a small team would make a big difference in the market, as well as to the launch provider, according to Dr. Sivan.

For one plus, satellite operators need not wait one or two years to launch their spacecraft. In shared space rides, satellites going on the same rocket must have compatible sizes and shapes. The thinking, he said, is why waste a big vehicle for a small job?

Secondly, a ride on small launchers could even be a ninth or tenth of the present cost. ISRO, he said, will not be the first to think of a small launcher.

"*Globally, the small satellites market is booming as they are used for various applications. Some of ISRO's satellites are also going to reduce in mass. As such, worldwide, operators and private players are developing small launchers to capture the market at a much lower cost*," Dr. Sivan explained.

Global space industry consulting firm Euroconsult estimated in July that 6,200 smallsats — many of them constellations — would be launched during the 2017 to 2026 timeframe and touch a market value of $30 billion — up from $8.9 billion in the last decade.

www.isro.gov.in

Article sourced from The Hindu*, authored by Madhumathi D.S*

How to Achieve Flawless Delivery To Phased Array Antennas on Moving Vehicles

Phased array antennas on moving vehicles are faced with unique challenges.

Emerging LEO and MEO constellations are poised to bring high throughput and low-latency connectivity to moving vehicles globally. MEO and LEO satellites are much smaller, in lower orbits, and use much less power than GEO satellites.

To realize their potential, these constellations must master the potential offered by delivery to low-cost, smart, phased array antennas (aka, Flat Plate Antennas, FPAs) on fixed sites and moving vehicles. The first generation of FPAs are having a difficult time doing this.

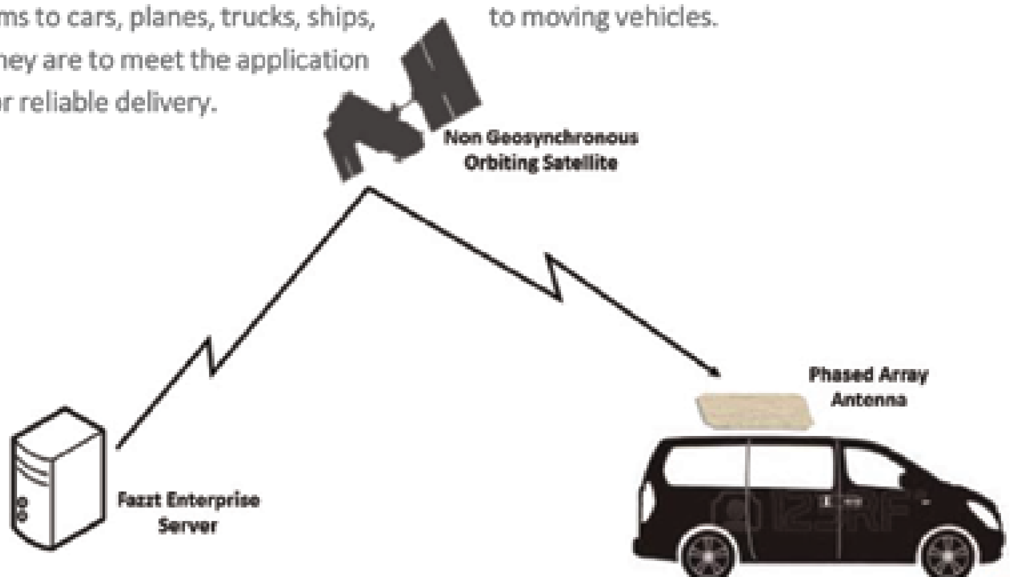
The FPAs are small, ultra-thin, light, flat, without any mechanical moving parts – instead relying on electronic beam steering. In mass production, the pricing of FPAs can potentially approach a very attractive $300.

However, early tests reveal these beam steering, phased array antennas need to improve -- to carry large files and live video streams to cars, planes, trucks, ships, trains on the move – if they are to meet the application owners' requirements for reliable delivery.

These orbiting satellites, traveling at speeds of about 17,500 mph relative to the earth, often must deliver large files and high-resolution video streams into vehicles that may also be moving at high speed – perhaps in bad weather, on inclines, etc., creating fading, shadowing, and elevation angle issues.

To make delivery even more difficult, the broadcast can be captured by anyone with readily available tools. That means content must be secured with strong encryption (for example, 256-bit AES), which means small errors may render the delivered content undecipherable.

KenCast has begun to enable various early applications with innovative Forward Error Correction (FEC) software tools. They supplement the capabilities of phased array antennas, providing insurance as necessary, even when serious damage to content is encountered in delivery of secured content from the MEO and LEO constellations to moving vehicles.



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Arianespace signs an Intelsat two satellite launch contract

Arianespace has signed an agreement to launch two satellites for longtime customer Intelsat, one of the world's largest satellite operators.

This contract continues the longstanding relationship between Intelsat and Arianespace that dates back to 1983.

The first launch will carry the Galaxy 30 satellite together with the Orbital ATK Mission Extension Vehicle-2 (MEV- 2) as a stacked pair.

Galaxy 30 will be the first replacement satellite for the North American Galaxy Fleet and in addition to its C-band payload, Galaxy 30 will include Ku- and Ka-band payloads to support broadband applications in North America.

The launch of Galaxy 30 demonstrates Intelsat's commitment to its distribution neighborhoods, which has an unmatched penetration of cable headends in the United States. Galaxy 30 is based on Orbital ATK's GEOStar-2™ satellite platform.

The MEV-2 satellite is owned by Orbital ATK's Space Logistics LLC subsidiary. Intelsat will be the first customer of the MEV-2. The MEV-2 provides life-extending services by taking over the orbit maintenance and attitude control functions of a client's spacecraft.

Under the contract, Arianespace will also launch an additional satellite for Intelsat in the second half of 2020.

Arianespace will launch the first pair of satellites, Intelsat's Galaxy 30 satellite and the MEV-2, in early 2020 from Europe's Spaceport in South America aboard an Ariane 5 launch vehicle.

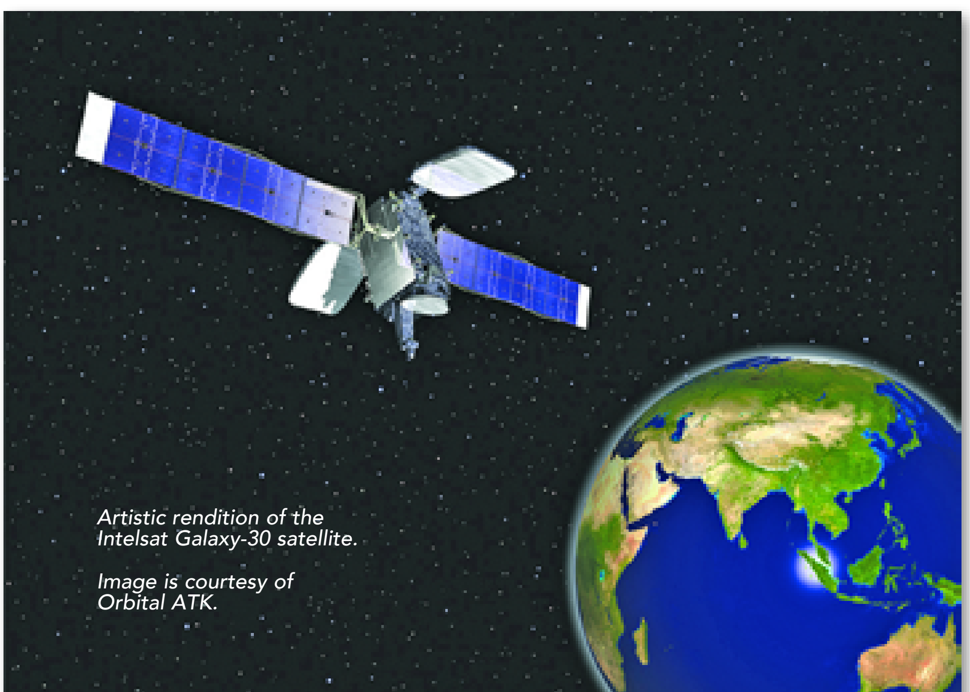
Stéphane Israël, CEO of Arianespace, said that his company is honored yet again to be selected by Intelsat for the safe and timely delivery of its satellites. Going back nearly four decades, a relationship of mutual confidence with Intelsat has always been enjoyed.

Israël added that Arianespace is proud to be able to perpetuate this epic friendship with two more launches, one of which will feature stacked payloads in the upper position of the Ariane 5, proof of the company's ability to bring to the table the most innovative solutions for customers.

Ken Lee, SVP, Space Systems at Intelsat, added that Arianespace has been one of Intelsat's most long-standing and trusted partners. Since 2016, Arianespace has successfully completed five missions on behalf of Intelsat, including four that included the company's next-generation Intelsat Epic^{NG} spacecrafts.

www.arianespace.com

www.intelsat.com



Artistic rendition of the Intelsat Galaxy-30 satellite.

Image is courtesy of Orbital ATK.

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ViaSat-2's Beta services started

Viasat Inc. has initiated beta service on the ViaSat-2 satellite and has affirmed plans for full commercial service launch in February 2018.

The ViaSat-2 satellite system is expected to significantly improve speeds, reduce costs and expand the footprint of broadband services across North America, Central America, the Caribbean, a portion of northern South America, as well as the primary aeronautical and maritime routes across the Atlantic Ocean between North America and Europe.

To date, Viasat has successfully completed a number of key performance tests on the ViaSat-2 satellite and end-to-end network, including demonstrating downstream speeds of over 100 Mbps to production consumer terminals.

The satellite ground network and other networking technologies are performing better than initially planned as measured in successful alpha testing.

The satellite will continue to undergo testing during the beta service period, as Boeing has identified — as of this writing — an on orbit antenna issue, which has caused some spot beams to perform differently than they did during ground testing. Boeing, with Viasat's support, is working to determine the root cause of the issue and to identify corrective measures.

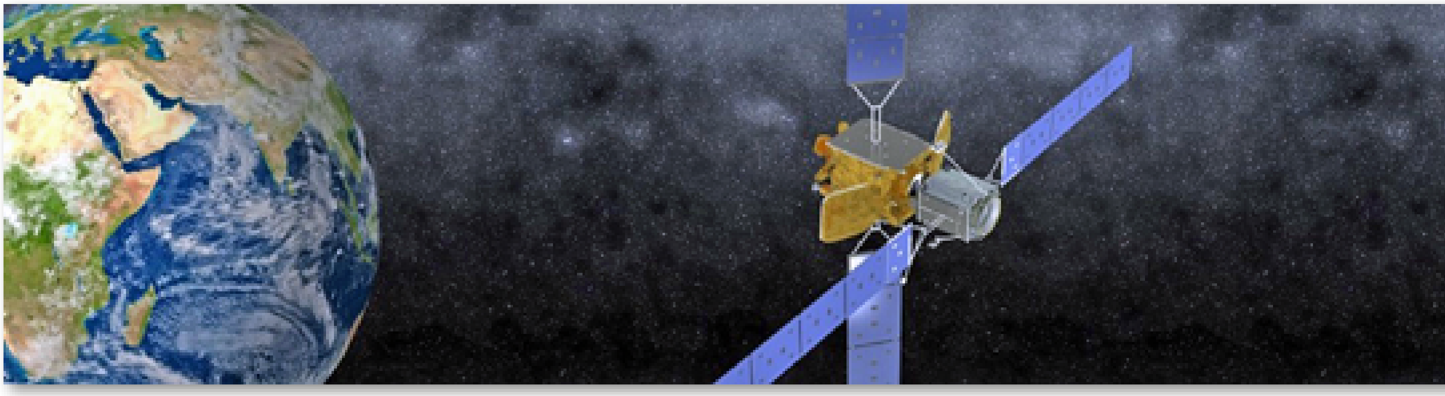
Based on measured data and analysis of the current on orbit performance of the satellite as well as the network as a whole, Viasat believes the issue will not impact the coverage area of the satellite, or materially impact the planned services and the expected financial results from the ViaSat-2 system.

Mark Dankberg, chairman and CEO, Viasat said that the company's advanced ground network, coupled with the flexibility features of the ViaSat-2 satellite, will help to manage the impact from the identified antenna issue, if needed.

The Company will provide an update on the status of the ViaSat-2 service launch plans and ViaSat-1 based market testing of these plans at the next regularly scheduled earnings conference call, planned for early February 2018.

www.viasat.com

Intelsat orders a second Orbital ATK Mission Extension Vehicle (MEV)



Orbital ATK has been awarded a contract for a second Mission Extension Vehicle (MEV-2).

The vehicle was ordered by Intelsat S.A. to provide life extension services for an Intelsat satellite.

Orbital ATK is now producing MEV-1, the industry's first commercial in-space satellite servicing system, for Intelsat with launch scheduled for late 2018.

Under this new agreement, Orbital ATK will manufacture, test and launch MEV-2 and begin mission extension services in mid-2020.

The production of the second MEV is part of Orbital ATK's longer-range plan to establish a fleet of in-orbit servicing vehicles that can address diverse space logistics needs including repair, assembly, refueling and in-space transportation.

Through its Space Logistics subsidiary, Orbital ATK will introduce in-orbit commercial satellite servicing with MEV-1 late this year.

The MEV is based on the company's GEOStar™ spacecraft platform and controlled by the company's satellite operations team.

The MEV uses a reliable, low-risk docking system that attaches to existing features on a customer's satellite, and provides life-extending services by taking over the orbit maintenance and attitude control functions of the client's spacecraft.

Each MEV vehicle has a 15 year design life with the ability to perform numerous dockings and repositionings during its life span.

The work performed on MEV-2 will span multiple locations across the company. Orbital ATK's spacecraft components division will be responsible for manufacturing the structures, propellant tanks and solar arrays at the company's locations in San Diego and Goleta, California.

The Rendezvous, Proximity Operations and Docking (RPOD) laboratory, located at the company's headquarters in Dulles, Virginia, will test the sensors, actuators and control algorithms that allow the MEV to approach and dock with the client spacecraft.

Orbital ATK plans to expand its satellite servicing capabilities to address additional on orbit needs of their customers.

The company is investing significant internal capital and, through a NASA Space Act Agreement, working with U.S. government agencies to develop and implement new capabilities for the MEV fleet. These include next-generation life extension and repair vehicles, in-orbit assembly of large space structures and cargo delivery and related services to deep space gateways, such as in lunar orbit.

Ken Lee, Intelsat's SVP, Space Systems, offered that Intelsat was an early proponent of the potential for mission extension technology. In-orbit life extension, such as that provided by the company's two contracts with Orbital ATK, provides additional flexibility to Orbital ATK's fleet management, allowing the firm to direct capital to new satellites while continuing to generate economic value from satellites on orbit.

Tom Wilson, President of Orbital ATK's Space Logistics, LLC subsidiary, added that work on MEV-1 is progressing rapidly toward a late 2018 launch, with system-level testing starting this spring. With the launch of MEV-2, Orbital ATK will continue to pioneer in-space satellite servicing for commercial operators. Intelsat's commitment to a second MEV demonstrates the market demand for servicing vehicles as well as customer confidence in this product.

www.orbitalatk.com

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New Aitech Remote I/O Unit Available...

Aitech Defense Systems Inc. has developed a new method of providing high performance, application-specific remote I/O management through the use of expansion modules, or "slices," in the new rugged, space-qualified Ai-RIO.

Through unit's modular, small form-factor (SFF) structure, the remote I/O interface unit (RIU) is a system-of-systems that provides a new level of scalable intelligence that meets specific user requirements and adapts to evolving application needs.

- *Scalable intelligence through highly integrated module 'slices' that add functionality as needed*
- *Dual-core P1020 Power PC and rad-tolerant FPGAs for powerful performance in space and defense applications*
- *Expandable with up to eight inter-networked units in compact form factor*
- *Different I/O configurations enable flexible design*
- *3.75 lbs with extremely low power dissipation of 12 W typical*

The Ai-RIO is an extremely high density, low power rugged sub-system that provides exceptional, user-specific functionality. This compact unit occupies very little space in a variety of aerospace, defense and military applications and is ideally suited for vehicle platform flight control, attitude and navigation controls, servo-valve and thrust vector control (TVC), robotic motor control, video and image processing and storage, data telemetry, platform stabilization, communications and telematics, high speed data recorders, booster and launch propulsion and thruster control, remote sensor and effector monitoring and much more.

The Ai-RIO is easy expandable, with up to eight units networked together, for unprecedented functionality in a compact space. Added capabilities include I/O, power switching, mass/SD FLASH memory and other functionalities.

Offering one of the widest ranges of I/O available in a SFF platform, the remote I/O sub-system includes a Gb Ethernet port with precision time sync IEEE-1588 support, ten RS-422 ports (eight of which are RS-422/485), an additional eight LVDS or RS-422/485 UARTS as well as four SpaceWire ports with LVDS I/O, two CANbus ports and sixteen GPIO in two blocks of eight.

Using Aitech's RIO-NET client/server software as well as additional memory and I/O arrays, the new unit can serve as a standalone command and data handling (C&DH) platform or networked remote command/response I/O unit.

Meets High Performance Demands of Rugged Applications
The compact, rugged Ai-RIO features a powerful radiation-qualified, dual-core PowerPC processor with two rad-tolerant FPGAs.

All internal electronics are conduction-cooled and mechanically fixed and housed within a sealed, EMI/EMC Faraday cage for maximum thermal transfer.

The housing is constructed of 6061/T6 flight grade aluminum and is based on a common 5.5" x 5.5" x 1.2" small form factor.

The expansion modules can be single- or double width, incorporating one or two PWBs, respectively, measuring between 1" and 2", depending on connector width and type and module/"slice" board count.

External connectors can be either micro D-Subs for space applications or standard micro MIL-DTL-38999 circular military connectors for use in defense environments. The base unit configuration weight of an Ai-RIO is only 3.75 lbs with a power dissipation of less than 12 W.

Additional System Support
Each of the two e500 cores within the processor are monitored by its own watchdog timer that generates an internal CPU interrupt after the first expiration period or a hardware reset after a second timeout.

A third external watchdog timer is located in the rad-tolerant FPGA that, when enabled, resets the entire subsystem after the first expiration period of the internal timers.

The Ai-RIO features onboard temperature sensors as well as A/D voltage and current monitoring with built-in test (BIT) for high reliability.

The unit has been tested and characterized directly by Aitech for radiation effects over 25 krads (Si) TID at varied flux rates.

The P1020 processor is immune to latch up, with other components meeting the heavy ion Linear Energy Transfer threshold (LETth) of at least 37 MeV-cm2/mg.

rugged.com/ai-rio-remote-io-subsystem

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New SSPI report from their Making Leaders series

The Space & Satellite Professionals International (SSPI) has released a new report, ***How to Bring New Hires on Board: From Promise to Purpose*****.**

In this nine page report, written for anyone who manages talent for a living, SSPI distills lessons from some of the smartest and most experienced people in talent management about what every company, large and small, can do to maximize the chance for a new hire to become a permanent contributor, a high performer and even a leader of the pack.

The report is the most recent release from SSPI's Making Leaders series, which features webinars and reports that offer guidance on managing people, from recruiting and engaging new hires to managing talent for results. Previous releases in the series include in-depth reports such as *Launch Failure: Can We Attract and Retain the Talent That Powers Innovation?* and webinars such as *Hire Potential or Hire Experience? How to Balance Short-Term and Long-Term Gain*s.

Employee Benefit News reported last year that it costs 33 percent of a worker's annual salary to hire a replacement if that worker leaves noted SSPI executive director, Robert Bell.

Bell also added that their study also concluded that 75 percent of the causes of employee turnover are preventable. SSPI's new report focuses on what every company can do in the first crucial days of an employee's tenure to make sure you can keep the talent that will power your company's success.

Founded in 1983, Space & Satellite Professionals International () is on a mission to make the space and satellite industry one of the world's best at attracting and engaging the talent that powers innovation. With more than 3,700 members in 40 nations, it is the largest space and satellite industry association in the world.

www.sspi.org

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BIS Research tackles the SmallSat market, 2017 to 2021, in new report

According to a market intelligence report by BIS Research titled "Global Small Satellites Market, Analysis & Forecast, 2017-2021", the global market is expected to reach $10.10 billion by 2021, growing at a CAGR of 31.9 percent during the forecast period, 2017 to 2021.

In the recent years, small satellites (smallsats) have gained traction owing to the significant mass reduction in the subsystems and components along with higher cost-efficiency. The interest in smallsats has increased significantly during the last few years.

Over the past decade, nearly $2.5 billion has been invested in small satellites, of which half of the amount was generated in the last two to three years.

The evolution of smallsats has considerably reduced the cost of space mission for end users, such as academic and commercial, which do not require high-end satellite capabilities. This cost reduction is due to the alterations in the construction process, which is essentially an amalgamation of traditional components with technological innovations.

The space industry is undergoing a transformational evolution, thus making space industry accessible and affordable for small businesses and everyday individuals as the potential participants. The benefits of using smallsats over the conventional ones are also responsible for the emergence of multiple space industry segments.

The smallsats market has witnessed a high growth rate owing to the advancements in satellite miniaturization, increasing capability of electronic technology, ascending demand for small satellite constellations, and an increase in the deployment of smallsats for commercial end users.

Recent innovations in satellite equipment and services enable the small satellite technology to reach a wider segment of consumers in the industry. However, developing safe, low-cost, and small payload satellite to launch beyond LEO, clean-up and removal of space debris, act as the major challenges for the market.

Companies are developing emerging technologies such as 3D printed electronic components, on-board internet system, and electronic propulsion system, among others, which are expected to increase the competition in the near future as well as facilitate the utilization of smallsats as the primary satellite for space missions.

Furthermore, the satellite market is replete with technological developments in satellite subsystems, such as propulsion system, on-board computer, payloads, power system, and structure, among others, to facilitate a significant reduction in size and mass of satellites.

Increasing market penetration of smallsats into disaster management — an emerging small satellite application, nations developing their own Global Navigation Satellite System (GNSS), advancements in small satellite structure, and rise in the requirement of low cost launching sites for small launch vehicles are the major factors which are expected to create lucrative opportunities for the market in the next five years.

Currently, the satellite industry is witnessing a rapid growth in the number of constellations consisting of hundreds of smallsats that will be used for applications such as Earth observation (EO) and telecommunications.

With a drastic rise in the use of smallsats, various end users, including academic, commercial, government, defense, and non-profit organization, are investing in the market to generate greater revenues. Furthermore, government is the biggest end-user of the market, utilizing and availing benefits of smallsats.

According to Ayushi Bajpai, analyst at BIS Research, "*From growth prospect, Asia-Pacific is expected to witness a higher growth rate of 32.9% in the market, owing to heavy investment by the companies in the emerging nations of this region, such as China and India. Furthermore, the demand for smallsats in the region is mainly driven by the dynamic approaches of the key players in the region towards risk management, such as natural catastrophes, cyber risk, natural resource management, and crop management*."

For additional information regarding this report, please access ***bisresearch.com/industry-report/global-small-satellites-market-2021.html***

Intelsat brings Galaxy-30 satellite contract to Orbital ATK for build

Orbital ATK has been awarded a contract by Intelsat to build the Galaxy 30 communications satellite — the satellite will be based on Orbital ATK's highly successful GEOStar-2™ satellite platform.

Galaxy 30 will be designed, built and tested at Orbital ATK's state-of-the-art satellite manufacturing facility in Dulles, Virginia, and will primarily serve video markets in North America. The satellite is scheduled to launch in early 2020.

Galaxy 30 will be the 41st commercial spacecraft built by Orbital ATK for customers around the world.

With the company's flight-proven GEOStar-2 spacecraft platform, Orbital ATK is the world's leading supplier of 1.5 - 5.5 kilowatt commercial geosynchronous (GEO) communications satellites used to provide DTH TV broadcasting, cable program distribution, business data network capacity, regional mobile communications and similar services.

The company has also manufactured three spacecraft on the new GEOStar-3 satellite platform, which provides as much as 8.0 kilowatt of payload power and can accommodate virtually all types of commercial communications payloads.

According to Amer Khouri, VP of the Commercial Satellite Business at Orbital ATK, the company is proud to continue their legacy of producing high quality satellites for valuable customer, Intelsat. This long-lasting relationship with Intelsat demonstrates Orbital ATK's ability to provide satellites that meet and exceed the expectations of customers.

Ken Lee, Intelsat's SVP Space Systems, noted that Galaxy 30 will be the 11th satellite Orbital ATK has built for Intelsat, and represents the first satellite in the Galaxy fleet replacement program. Galaxy 30 demonstrates Intelsat's commitment to the Galaxy cable distribution neighborhood, which has an unmatched penetration of headbands in the U.S. and will support traditional broadcast applications, such as UHD distribution, while at the same time being capable of supporting new network solutions for applications such as OTT video and other distribution requirements.

Lee added that in addition to the satellite's C-band payload, Galaxy 30 includes Ku- and Ka-band payloads to support broadband applications. The GEOStar-2 design has the capabilities that will allow the company to advance our network architecture while still providing incomparable economics for our customers.

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Space Launch Services market estimated by ASDReports to reach $27.18 billion

A new research report, now available from ASDReports, is entitled "*Space Launch Services Market by Service Type (Pre-Launch, Post-Launch), Payload (Satellite, Human Spacecraft, Cargo, Testing Probes, Stratollite), End User, Orbit, Launch Vehicle Size, Launch Platform, and Region - Global Forecast to 2025.*"

The space launch services market is estimated to be USD 8.88 billion in 2017 and is projected to reach USD 27.18 billion by 2025, at a CAGR of 15.01 percent during the forecast period.

The increase in demand for small satellites (smallsats), rise in space exploration activities, and technological advancements to develop low-cost launch vehicles are key factors driving the growth of the space launch services market.

Based on service type, the pre-launch segment is expected to lead the space launch services market from 2017 to 2025.

The growth of the pre-launch services segment can be attributed to an increase in the number of launch service providers and reduction in the price of launch and integration services that include flight hardware support and mission management.

In addition, technological advances in space systems have led to expanding the capabilities of payloads, thereby contributing to the growth of the pre-launch services segment of this market.

Based on payload, the satellite segment of the space launch services market is expected to grow at the highest CAGR from 2017 to 2025.

The increased demand for Earth observation (EO) and communication satellites has led to the growth of the satellite segment.

These satellites are intended for monitoring the Earth's surface to obtain valuable information for mapping, mineral exploration, land-use planning, and resource management, among other activities.

Based on launch vehicle size, the small lift launch vehicles segment is projected to lead the space launch services market from 2017 to 2025.

The increasing deployment of small satellites for commercial and military applications and rising investments for the development of small launch vehicles are factors contributing to the growth of the small lift launch vehicles segment of the space launch services market.

North America is estimated to lead the space launch services market in 2017. The increasing demand for launch services for satellites, human spacecraft, and space probes is projected to drive the growth of the space launch services market in North America.

In addition, increased investments in space probe missions are further contributing to the growth of the space launch services market in this region.

Antrix Corporation (India), Arianespace (France), Boeing (US), China Great Wall Industry Corporation (China), EUROCKOT (Germany), ILS International (US), Lockheed Martin (US), Mitsubishi Heavy Industries (Japan), Orbital ATK (US), Space Exploration Technologies (US), Space International Services (Russia), Spaceflight (US), Starsem (France) and United Launch Alliance (US) are key players operating in the space launch services market.

Download information regarding this informative report at ***www.asdreports.com/market-research-report-436017/space-launch-services-market-global-forecast?utm_source=ASDNews&utm_medium=affiliate&utm_campaign=ASDNews_PRS&utm_content=title_tekstlink***

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Israeli SmallSats will be the first to fly in formation later this year

A group of three smallsats developed by scientists from Haifa's Technion-Israel Institute of Technology will be the first autonomous spacecraft in the world to be flown in formation.

The project, developed with the support of the Adelis-Samson Foundation and the Israeli Space Agency (ISA) in the Science and Technology Ministry, will be launched on the Indian launcher PSLV at the end of 2018 by the Dutch company Innovative Solutions In Space, which specializes in launching nanosatellites.

The project has been developed by a team of researchers headed by Professor Pini Gurfil, head of the Asher Institute for Space Research and a member of the aerospace engineering faculty at the Technion. The project is designed to prove that a combination of satellites can hold together in a controlled formation for a year some 600 kilometers above Earth. A successful small model of the smallsats also exist at the Technion.

"*Israeli technology is breaking boundaries and proving its innovation again and again*," commented Science and Technology Minister Ofir Akuni. "*We are proud to be part of this flagship project, which is a significant contribution to the advancement of space in Israel and to the training of students in the field.*"

The satellites will be used to receive signals from Earth and calculate the location of the source of the broadcast for rescue, detection, remote sensing and environmental monitoring. Each of the smallsats is 10 cm. x 20 cm. x 30 cm. — about the size of a shoebox — and weighs about eight kg. They will be equipped with measuring devices, antennas, computer and control systems and navigation devices.

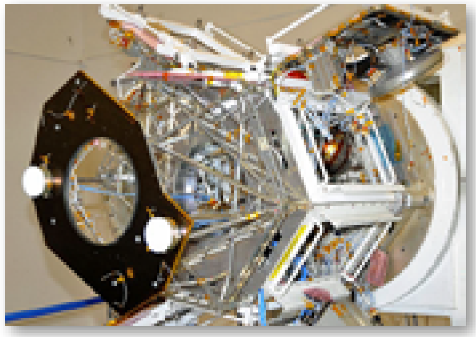

Photo of Israel's VENuS smallsat, courtesy of ISA/Science.

The software and algorithms that will control the flight were developed in a laboratory for distributed space systems at the Technion.

"*Miniaturization in the field of satellites, together with advanced Israeli technology, allows us to take Israel an important step forward with mini-satellites*," said Gurfil. "*The degree of innovation of nanosatellites can be compared to switching from a PC to a mobile phone, which offers far more capabilities than its predecessors.*"

"*The field of nanosciences has been increasing significantly in recent years and the number of launches doubles every year*," added ISA director Avi Blasberger. "*The development and launch costs of such satellites, capable of filling a variety of uses, are significantly lower than those of conventional satellites... In the near future, networks are expected to include thousands of nano-satellites that will cover the Earth and enable high-speed Internet communications at a significantly lower cost than today.*"

The unique features of the satellites are all locally produced. Rafael's krypton gas-based propulsion system will be the first of its kind in the world to fly a tiny satellite.

The digital receiver was developed by Elta and the guidance control system was developed at the Israel Aircraft Industries' Mabat plant in cooperation with the Technion researchers.

In addition to the propulsion system, the satellites will accumulate energy through solar panels that will be spread out alongside each satellite and serve as wings that will be able to control the flight of the nano-satellites' structures without the use of fuel through air resistance in the atmosphere.

Each of the satellites will have a digital signal receiver, one of the most complex receivers ever designed in a nanoscale. The satellite information-processing system and the algorithms that will maintain the formation will be the first of their kind in the world and support the autonomous operation of several satellites together.

The communication and navigation systems will include two GPS receivers, through which the three nano-satellites will communicate with one another and with the ground station — a significant challenge that has been solved in the current project. A dedicated frequency will be used to transfer information to the Earth in broadband.

"*If we can prove in an experiment in space that the flight of satellites in formation is possible*," Gurfil concluded, "*it will be a significant boost to the development of small satellites and technologies related to minimizing electronic components, efficient space processing and space propulsion systems.*"

Article sourced from ***The Jerusalem Post,*** *authored by Judy Siegel-Itzkovich.*

CETel commits to SES Networks

CETel has committed to a five year relationship with SES Networks to achieve new exploration and production sites in Africa via SES Networks' MEO O3b satellite constellation — CETel is a German service provider of global, managed end-to-end communications solutions.

CETel will leverage the O3b fleet's low latency and high throughput capabilities for big data applications required by the exploration and production industry. With round trip latencies below 150 milliseconds, MEO-enabled networks are on par with standard fiber connections and are more reliable and faster to deploy than other infrastructure.

The inking of this MEO deal with SES Networks empowers CETel to serve new applications where lower-latency connectivity matters, and to complement the comprehensive and versatile business applications it currently serves today.

Guido Neumann, Managing Director of CETel, said that CETel is delighted to be one of the first European service providers to use SES Networks' MEO fleet to add fiber-like connectivity to their existing service and product portfolio. This is yet another example of a successful collaboration between SES Networks and CETel in the delivery of managed end-to-end communications solutions.

CETel sees MEO connectivity as an ideal extension that complements the connectivity delivered by established GEO satellites. The fleets have their own unique capabilities and are suited for different applications that will help meet the growing demands of content and data delivery.

Simon Gatty Saunt, Head of EMEA Fixed Data Sales at SES Networks, added that, depending on their customers' needs, CETel will be able to deliver the ideal solution in a cost-effective manner.

ce-tel.com/

ses.com/

Blue Origin's New Shepard completes Mission 7 with 12 payloads

Blue Origin's Crew Capsule 2.0 landed after the company's first successful commercial payload flight. Photo is courtesy of Blue Origin.

In December of last year, Blue Origin's New Shepard flew again for the seventh time — known as Mission 7 (M7), the flight featured the company's next-generation booster and the first flight of Crew Capsule 2.0.

While the primary objective was to progress testing this new system for human spaceflight, the company also achieved an exciting milestone with suborbital research in space by sending 12 commercial, research and education payloads under full FAA license for the first time.

Payloads flying on New Shepard were engaged in important science and research onboard the 11 minute flight to space and back.

During this flight, Blue Origin customers get approximately three minutes in a high-quality microgravity environment, at an apogee around 100 kilometers, making New Shepard ideal for microgravity physics, gravitational biology, technology demonstrations, and educational programs.

The combination of high altitude and low-gravity exposure provides an environment for a wide range of payloads ranging from basic and applied microgravity sciences to Earth and space science.

Each of these domains has the opportunity to engage users ranging from universities to corporations.

The rapid timelines and low costs of flight are also increasingly attracting educators and students of all ages.

Here are a few highlights of investigations that were a part of the New Shepard M7 flight:

- ***Zero-Gravity Glow Experiment (ZGGE),*** *Purdue University & Cumberland Elementary School (West Lafayette, Indiana) in partnership with Arete STEM. The Zero-Gravity Glow Experiment, or ZGGE for short, was inspired by a second grade classroom's question: "Can fireflies light up in space?" The payload operates by mixing the appropriate chemicals during the weightless coast period of the vehicle's mission and observing the response with a miniature video camera.*
- ***DCS Montessori Middle School*** *(Castle Pines, Colorado), in Partnership with DreamUP. This payload was a collaboration across nearly 500 K-8 students and consisted of two parts. The first included an Arduino Nano microcontroller with a sensor package, designed and programed by the students to learn more about the environment inside the Crew Capsule. The second part contained a school-wide art project that all DCS Montessori students participated in. Upon landing, the data from the experiment will be analyzed and the art will be returned to the students and shared with the community.*
- ***Cell Research Experiment in Microgravity (CRExIM)****, Embry-Riddle University-Daytona Beach, University of Texas Health Science Center at San Antonio & Medical University of South Carolina (Daytona Beach, Florida) in partnership with Arete STEM. The CRExIM (Cell Research Experiment In Microgravity) NanoLab was a multidisciplinary effort between students and faculty in Embry-Riddle's Spaceflight Operations degree program and Aerospace and Mechanical Engineering departments, who partnered with other teams from the University of Texas Health Science Center at San Antonio and the Medical University of South Carolina. The experiment studied how microgravity impacts the cellular processes of T-cells, which develop from stem cells in the bone marrow and are key to immune system function.*

Blue Origin's New Shepard Mission 7 successful booster landing.
Photo is courtesy of Blue Origin.

- ***Expression of Genes in Tumor Growth, Embry-Riddle University-Daytona Beach**, Grand Canyon University & Thermo Fisher Scientific (Daytona Beach, Florida) in partnership with Arete STEM. This payload focused on studying the effect of microgravity exposure on the expression of genes that play a role in tumor growth. Two modified flasks were seeded with osteosarcoma cells. Syringes containing RNAlater for cell fixation were attached to each flask and their contents were deployed just before the onset of microgravity (in the case of the experimental control flask) and just after its completion (in the case of the experimental test flask). Now that the mission is complete, the samples will be analyzed via reverse transcription-polymerase chain reaction (RT-PCR) to determine how the expression of the genes has changed.*

- ***JANUS Research Platform**, Johns Hopkins University-Applied Physics Laboratory (Baltimore, Maryland). The JANUS integration and monitoring platform, about the size of a car battery, provides researchers with a look at suborbital flight conditions. While this flight deployed JANUS in the shirtsleeve environment of the New Shepard cabin, future iterations will also look at the environment outside the vehicle.*

- ***Evolved Medical Microgravity Suction Device**, Orbital Medicine (Richmond, Virginia) with Purdue University (West Lafayette, Indiana), with funding from NASA's Flight Opportunities Program. The Evolved Medical Microgravity Suction Device could assist in treatment of a collapsed lung where air and blood enter the pleural cavity. The payload — which included the device along with a hemothorax simulator — was constructed in collaboration with the Purdue University School of Aeronautics and Astronautics. The device is able to collect blood in microgravity, and still allows for the suction to continuously inflate the lung and allow it to heal. The payload marked Blue Origin's first flight under NASA's Flight Opportunities program.*

Blue Origin's frequent flight schedule will enable the launch of experiments multiple times to iterate on findings, improve statistics, or rapidly collect data. As human flights begin, customers will also be able to fly with their payloads for hands-on experimentation.

www.blueorigin.com/

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The top teleport operators of 2017 named by World Teleport Association

The World Teleport Association (WTA) has now published the organization's annual rankings for the Top Teleport Operators of 2017 — the annual rankings of companies by revenue and revenue growth are compiled by surveying teleport operators around the world as well as referencing the published results of publicly-held companies.

Executive Director Robert Bell reported that the teleport industry becomes more complex every year in terms of ownership, acquisition and competitive dynamics. Satellite operators are investing in and partnering closely with teleports, while acquisitions drive the growth of some of the new 'majors' in the business.

Bell added that competitive pressure is rising within the sector but teleports are also increasingly competing and partnering with data centers, cloud service providers and telcos. The Top Operators of 2018 list reflects all of these changing conditions.

In May 2018, WTA will publish its annual *Inside the Top Operators* report that will provide a more detailed analysis of survey results.

The Independent Top Twenty

The Independent Top Twenty ranks teleport operators based on revenue from all sources. The list focuses on the independent operators at the core of the business, excluding companies whose primary business is ownership and operation of a satellite fleet or terrestrial network. In order from largest to smallest, the Independent Top Twenty of 2017 are:

1. *Global Eagle (USA)*
2. *Telespazio S.p.A. (Italy)*
3. *Globecast (France)*
4. *Encompass Digital Media (USA)*
5. *Arqiva (UK)*
6. *Speedcast (China)*
7. *Globecomm (USA)*
8. *elstra Corporation (Australia)*
9. *du (UAE)*
10. *Etisalat (UAE)*
11. *PlanetCast Media Services (India)*
12. *Media Broadcast Satellite (Germany)*
13. *Global Data Systems (USA)*
14. *Axesat (Columbia)*
15. *Signalhorn Trusted Networks (Germany)*
16. *Jordan Media City (Jordan)*
17. *STN (Slovenia)*
18. *Elara Comunicaciones SA (Mexico)*
19. *US Electrodynamics (USA)*
20. *CETel (Germany)*

The Global Top Twenty

The Global Top Twenty ranks companies based on revenues from all customized communications sources and includes operators of teleports and satellite fleets. In order from largest to smallest, the Global Top Twenty of 2017 are:

1. *SES (Luxembourg)*
2. *Intelsat S.A. (Luxembourg)*
3. *Eutelsat (France)*
4. *Telesat (Canada)*
5. *EchoStar Satellite Services (USA)*
6. *Global Eagle (USA) **
7. *Telespazio S.p.A. (Italy)*
8. *Globecast (France) **
9. *SingTel Satellite (Singapore)*
10. *Thaicom Public Company Ltd. (Thailand)*
11. *Encompass Digital Media (USA) **
12. *Hispasat (Spain)*
13. *Arqiva (UK) **
14. *Optus (Australia)*
15. *Speedcast (Australia) **
16. *Russian Satellite Communications Company (Russia)*
17. *Globecomm (USA) **
18. *AsiaSat (China)*
19. *MEASAT (Malaysia)*
20. *Telenor Satellite (Norway)*

* Independent: does not operate satellite capacity

The "Fast Twenty"

The Fast Twenty ranks all teleport-operating companies based on year-over-year revenue growth in their most recent fiscal years. Santander Teleport, a small company in Spain, was the fastest of the fast with a 37 percent year-over-year growth rate. Ranked by revenue growth, the Fast Twenty of 2017 are:

1. *Santander Teleport (Spain)*
2. *Etisalat (UAE)*
3. *Speedcast (Australia) **
4. *US Electrodynamics (USA)*
5. *Russian Satellite Communications Company (Russia)*
6. *PlanetCast Media Services (India) **
7. *Gazprom Space Systems (Russia)*
8. *MEASAT (Malaysia)*
9. *du (UAE) **
10. *Globecast (France) **
11. *Hispasat (Spain)*
12. *Satellite Mediaport Services (UK)*
13. *Elara Comunicaciones SA (Mexico) **
14. *SES (Luxembourg)*
15. *Encompass Digital Media (USA)*
16. *CETel (Germany)*
17. *Milano Teleport S.p.A. (Italy) **
18. *Telstra Corporation (Australia) **
19. *Singtel Satellite (Singapore)*
20. *Optus (Australia)*

* Independent: does not operate satellite capacity

Since 1985, the World Teleport Association has focused on improving the business of satellite communications from the ground up. At the core of its membership are the world's most innovative operators of teleports, from independents to multinationals, niche service providers to global carriers. WTA is dedicated to advocating for the interests of teleport operators in the global telecommunications market and promoting excellence in teleport business practice, technology and operations.

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GateHouse Telecom offers insights into the 2018 SATCOM industry

GateHouse Telecom A/S has published the five trends the firm sees as the focus of the satellite communications industry in 2018 — with connectivity at the forefront — additional rends span cyber security, the connected aircraft, the increasing use of commercial SmallSats and easier terminal development processes enabled by core modules and off-air test tools.

Connectivity
The demand for connectivity wherever and whenever is omnipresent and driven by both end-consumers, industries and governments.

This will drive the SATCOM industry to innovate and integrate further with other communications mediums such as GSM, Wi-Fi, or by other means to deliver the connectivity in demand.

Creating connectivity anywhere and anytime will call for optimization of present day communications solutions and applications to conform with the needs of tomorrow.

Cyber Security
In light of the ever more connected world, cyber security is of paramount importance as ‘always-on’ entails a prevalent vulnerability. According to research firm Gartner, cyber security spending on connected products and services exceeded more than $80 billion in 2016 and as the IoT revolution accelerates, expenditure is expected to increase to $1 trillion over the next five years.

“*With our off-air test tools, enterprises can apply vulnerability scanning and penetration test tools to eliminate the risk of their products being exposed to cybercrime during live test campaigns*,” said Thomas S. Jensen, Director, GateHouse Telecom.

The Connected Aircraft
The aviation industry will come under increasing pressure from passengers as well as competitors to supply connectivity in the sky in 2018.

“*As we move further into the era of ‘Connectivity’, the year 2018 and beyond is likely to see the aviation industry incorporating systems on board that enable real time tracking as well as normalizing in-flight wi-fi for passengers*,” said Thomas Jensen, Director, GateHouse Telecom.

“*The advantages of the connected aircraft are plenty. The always connected aircraft will enable a more efficient packing of the airspace, maintenance optimizations and for ground controls to more effectively handle the many daily changes in take-off and landing schedules. New applications and solutions will have to be developed and optimised to deliver stable and seamless connectivity*,” added Jensen.

Terminal Development with Core Modules
SATCOM terminal development has historically been a very time-consuming, complicated and expensive process.

With the introduction of core modules, this barrier has been greatly reduced — making the road from idea to finished application or product much shorter.

The benefits are obvious with better conditions for innovation and less risk in relation to the development process. The core module or COTS approach is vital for complying with the ever growing demand for increased connectivity.

SmallSats
The use of satellite generated data is greatly improving driven by both commercial and public interests. Hence, in 2018, the satellite communications industry will see greater numbers of small satellites put into orbit for Earth observation (EO), scientific research, communications and to explore new space technologies.

Where once the use of smallsats was the domain of academia, the vast majority of new launches will be commercial applications. Off-the-shelf solutions and off-air test tools will help early delivery of these new satellites and applications.

gatehouse.dk/telecom/

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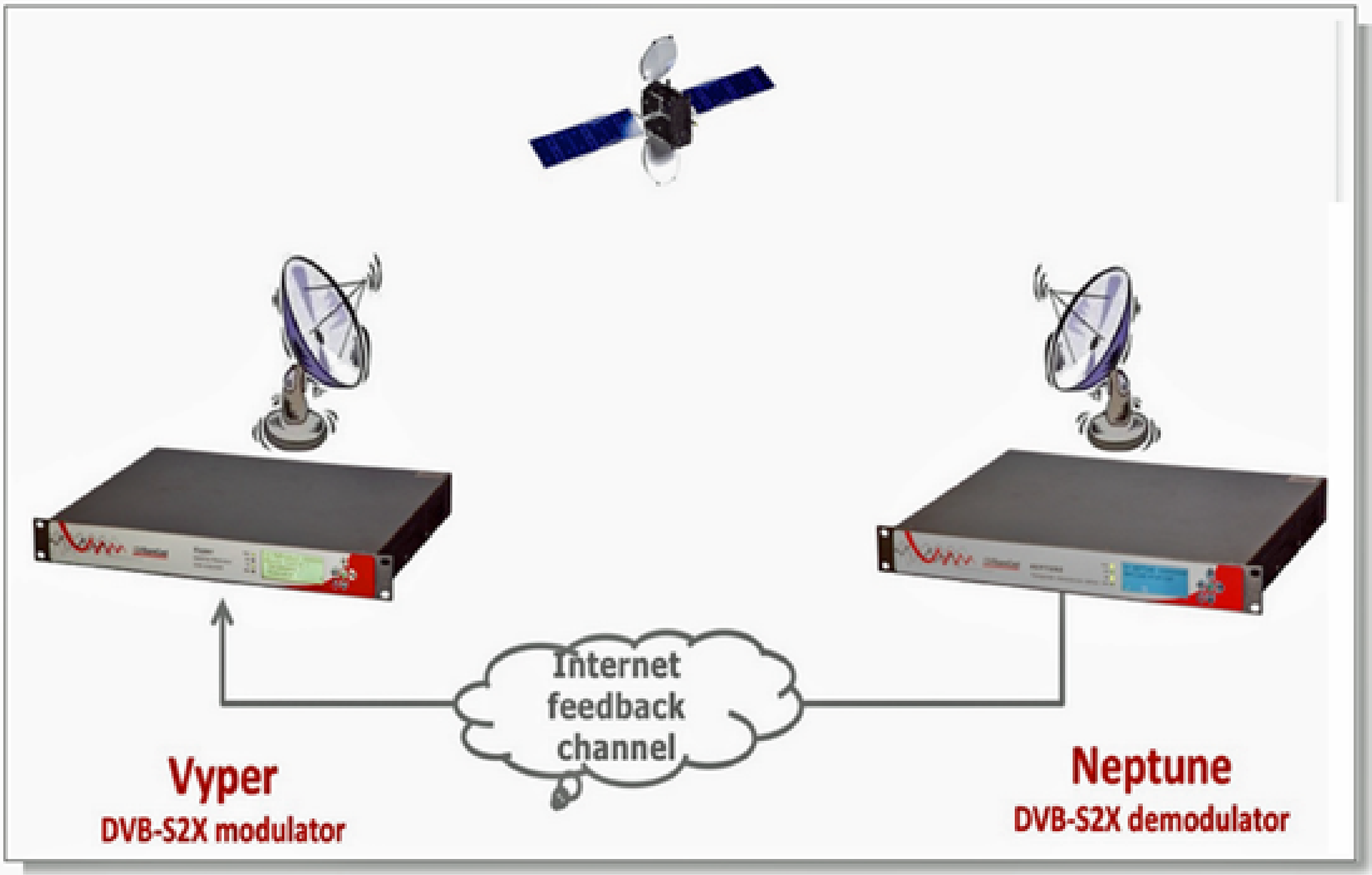
TeamCast becomes disruptive with satellite links



TeamCast describes their latest achievement as a totally disruptive solution for optimizing satellite links.

TeamCast provides digital modulation technologies for Digital Terrestrial Television (DTT), Wireless Transmission and Satellite Applications.

The solution uses a feedback channel through a regular low bitrate internet connection to optimize the link budget and increases the available payload capacity while keeping costs low.

The feedback information elaborated by the downlink Neptune receiver is used by the uplink Vyper modulator to pre-correct the linear and non-linear impairments of the on-board transponder chain.

The optimization is automatic and transparent for the user and can be used while the link actually carries user data, without any need to put the transmission on hold. No specific knowledge of the transponder characteristic is necessary; no specific skills are required for the operator.

The link budget automatically increases while the link is used. That means the link margin is getting better providing the possibility either to secure the link against unexpected adverse conditions or increase the useful bandwidth by adjusting the modulation parameters.

Christophe Trolet, head of the Satellite Business Unit at TeamCast said that their fully automatic solution offers increased transmission performance to operators, without requiring specific equipment or knowledge.

He added that they are proud to offer this new and powerful tool to operators, without adding operational complexity. Everything is included in the Vyper modulator and the Neptune receiver, both meeting DVB-S2/S2X requirements for the highest operational flexibility and the payload capacity for a given transponder.

teamcast.com/

InfoBeam

ISRO's PSLV-C40 flight drives 31 satellites to orbit

India's Polar Satellite Launch Vehicle (PSLV-C40), in its 42nd mission, successfully launched the 710 kg. Cartosat-2 series Earth Observation (EO) satellite and 30 co-passenger satellites — totaling 613 kg. at lift-off.

PSLV-C40 was launched from the First Launch Pad (FLP) of Satish Dhawan Space Center (SDSC) SHAR, Sriharikota.

Around 17 minutes after the lift-off, the rocket injected its main payload — the Cartosat-2 Series — weighing 710 kg., the seventh satellite in the series — into the Polar Sun synchronous orbit at an altitude of about 510 km.

Within a span of seven minutes, the rocket ejected 29 smallsats as it maneuvered its way up the altitude to 519 km.

"It is an excellent mission. Cartosat's performance has been so far satisfactory," said retiring ISRO chairman AS Kiran Kumar.

After the ejection of the 30th satellite, the fourth stage Earth storable liquid engine was restarted for the first time 30 minutes later and was shut off within five seconds.

For the next nearly 45 minutes of coasting period, the rocket would move from 505km to 359km altitude before the engine was restarted again for the second time for another five seconds.

The PSLV-C40 launch from the Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota, India.

The co-passenger satellites comprise one micro-satellite and one nano-satellite from India as well as 3 microsatellites and 25 nanosatellites from six countries, namely, Canada, Finland, France, Republic of Korea, UK and USA. The total weight of all the 31 satellites carried onboard PSLV-C40 is about 1,323 kg.

The 28 International customer satellites were launched as part of the commercial arrangements between Antrix Corporation Limited (Antrix), a Government of India company under Department of Space (DOS), the commercial arm of ISRO and the International customers.

This successful outcome of this return-to-flight launch of the Polar Satellite Launch Vehicle (PSLV) revealed the importance of the PSLV for the smallsat sector in general and for the Dutch cubesat company ISIS — Innovative Solutions In Space (ISISpace), in particular.

Out of the 31 satellites, 23 were integrated on the rocket (and subsequently successfully deployed into orbit) using the ISISpace's QuadPack cubesat deployers and relied on the ISISpace sequencing electronics for the timely deployment.

With the success of this campaign, ISIS has reached a total of 256 satellites sent to space and 197 QuadPack doors successfully opened.

The cubesat manifest using QuadPacks came together from several launch services providers and aggregators. These included ISISpace's own ISILaunch service.

In addition, many of the cubesats carried components, subsystems or complete spacecraft buses provided by ISISpace to enable the exciting space missions that have now started their operational lifetime and will undoubtedly provide interesting and meaningful results in the near future.

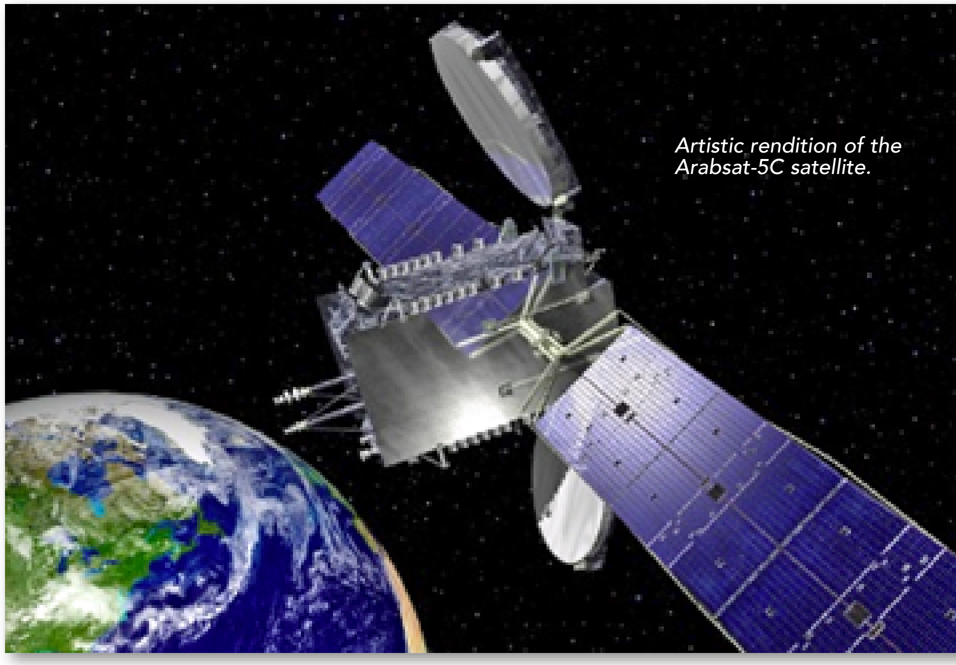
www.isro.gov.in/

www.isispace.nl

InfoBeam

CETel and Arabsat offer continuity services security and more

Arabsat and CETel's long-time relationship enabled them to develop a product for companies to safeguard their existing networks for redundancy, back-up and security needs.



Artistic rendition of the Arabsat-5C satellite.

They realized that Big Data and permanent connectivity requirements made service availability the basis of every operation and that no organization wants to rely on a single string when it comes to connectivity and communications.

Additionally, historical voice and data applications, communications for Machine to Machine (M2M), Internet of Things (IoT) or Critical Applications is becoming more crucial for the customer's network infrastructure; and the complexity of global communications networks makes the service critical.

Offering Business Continuity Services that include back-up requirements for each customer and are also cost-efficient are the major issues.

Customers select from a variety of service levels, depending on their individual back-up needs. Often, the service includes periods of free-usage.

The service is initially offered on, but not limited to, the ARABSAT-5C satellite, located at 20 degrees East.

Unlike traditional back-up links, this new product provides services at predetermined levels that are greatly reduced compared to the usual service investment.

Guido Neumann, Managing Director at CETel said that they are thrilled to include such an important service into their product and services portfolio. The requests for the provision of reliable and cost effective back-up services are permanently growing.

He added that this innovative service enables their customers to enhance their network and connectivity performance, also supporting them to further expand and secure their core businesses. He added that teaming up with Arabsat they are able to offer such a service. In their long-standing and fruitful partnership with Arabsat they have found the perfect fit for this growing and essential demand.

Khalid Balkheyour, President and CEO at Arabsat, said that CETel has been their long entrusted and distinguished partner. Arabsat and CETel have always strived to provide high-quality satellite based solutions to their customers.

He noted that with the ever growing requirements of permanent connectivity, the Business Continuity Solution will increase their customers' confidence in the services provided by CETel.

www.arabsat.com

www.ce-tel.com/

CETel's Ruppichteroth, Germany, teleport.

On a Personal Note...

The Changing Face of Space

By Professor Sir Martin Sweeting, OBE, FRS, FREng — Executive Chairman, SSTL

Artistic rendition of NovaSAR on orbit. NovaSAR is an example of the cooperation between UK companies and the UK government to achieve innovation in space technology.

The role that space has in our lives is now taken for granted: we have become reliant on it every day – whether it be for weather forecasting, satellite TV, banking, communications or navigating in our cars. It is now part of our national infrastructure underpinning our economy, security and well-being.

Space in the UK has been rather a well-kept secret; we have a thriving space industry and a strong academic community and both punch above their weight internationally. We have heard that space contributes over £14 billion turnover, £5 billion in exports and nearly 40,000 jobs to the UK's national economy and is second only to the oil & gas industry in the value per head of its skilled workers.

As demonstrated by the ESA Rosetta comet lander and the mission of Tim Peake to the ISS, space has the ability to fire the imagination of the young and not-so-young alike to take an interest in technology, its uses and our place in the universe.

The last decade has seen a rekindling of the space spirit in the UK — across industry, business and academia — stimulated by the initiative of Lord Drayson some 10 years ago that formed the United Kingdom Space Agency (UKSA) and was then picked up by and driven forward by Lord Willetts.

Most importantly, through the Space Innovation and Growth Strategy, the government has realized that space is one of the '*eight great technologies*' underpinning UK society and has substantially increased its investment and support for national space activities. This has been through an investment

The Carbonite-2, a high resolution, full color video satellite. Image is courtesy of SSTL.

in a range of national projects and key facilities as well as through increased contributions to ESA.

In 2017, the UK position had risen from ninth to fourth after France, Germany and Italy, although we are still twelfth in per capita contribution. The UK is a key intellectual contributor to ESA through science missions, Copernicus and Galileo.

Space provides unique opportunities for collaboration between nations on climate, the environment, food and water security, science and exploration beyond Earthly limits. International partnerships are highly beneficial commercially and intellectually for the UK space community — this is going to be especially important in a post-Brexit world.

Of course, from its high vantage point, space is also 'dual-use' in providing security and military leverage — indeed, it has become increasingly difficult to envisage military engagements without the use of space assets… which, by the way, generates strength and vulnerability due to over-reliance.

The first four decades of the space era were dominated by a few super-powers who alone possessed the knowledge and budgets to undertake the enormous technical and programmatic challenges posed. This small club became used to having the advantages of space all to themselves and the exploitation of space was driven primarily by military and national priorities, whereas commercial applications grew slowly — mainly in communications.

The last two decades have seen this model overturned. Some 65 countries have now taken their first steps into space, often through small satellite projects using COTS techniques largely pioneered in the UK. These modern small satellites (smallsats) have evolved steadily in their capabilities and, most importantly, their utility.

Indeed, in the last few years, smallsats now provide lower cost and more responsive solutions to meet many well-trodden applications, while also stimulating completely new business models based on constellations and rapid re-visit — fundamentally changing the economics of space... for both the civil and the security/defense sectors.

Two variants of the SSTL-42 platform. Photo is courtesy of SSTL.

Robotic additive (and subtractive) manufacturing techniques now make possible product geometries that were previously physically impossible by human hands and in a fraction of the time — and 'digital factory' manufacturing provides freedom of location and dramatically increases speed of the cycle of design evolution and product innovation.

Stimulated by the entrepreneurial hotbed in California, innovative 'New Space' businesses are sprouting — around 400 such companies have attracted ~ $10 billion in investments from an excited investment community who appear to have recovered from, or forgotten, the earlier painful experiences of the 1990's constellations.

Constellations of 100s, even 1,000s, of smallsats are being proposed for new network structures to provide ubiquitous access to high speed digital communications and unparalleled persistence of global Earth observation (EO). NewSpace is not restricted to start-ups, and, it is noted that established space players are proposing 'mega-constellations' while they try to adapt to this new space business environment.

Space has become 'democratized' and accessible to almost anyone — to universities and business start-ups, not just space agencies and large organizations. This has changed the face of space.

The underlying technologies that have enabled this 'revolution' have come from the enormous investments made by the industrial and domestic consumer sectors in developments that have created mass markets for their products... reducing the unit production costs by orders of magnitude, while simultaneously achieving high yield and reliability through a parallel 'revolution' in manufacturing and production techniques.

Smallsats have been quite effective in taking advantage of 'COTS' microelectronics to create small, low-cost, yet capable and reliable satellites. However, up to the start of this decade, the evolution of smallsats was being driven primarily by advances in microelectronics, while the structural designs tended to be based on more conventional techniques.

Over the last five years, the pace of microelectronics development has continued to accelerate — continuing the trend observed in the 1960's by Gordon Moore. However, there has been a parallel development in new materials that, when combined with robotics, have given rise to new satellite/spacecraft manufacturing techniques that enhance smallsat capabilities as well as further reduce cost and timescale.

There are currently some 160 constellations proposed worldwide that, all together, would comprise more than 25,000 satellites — 90 percent of which aim to provide some form of digital communications, with the remaining 10 percent (still several thousand!) focusing on various EO services.

At the same time, the growth of the various terrestrial communications infrastructures (such as 5G) and advances in data handling, management and knowledge extraction — often referred to as 'Big Data' — now begin to blur the boundaries between space and terrestrial systems and soon an integrated 'space-wide-web' with an opportunity to align space with 5G will be experienced.

The quantities of satellites being proposed will drive changes in their production techniques in order to lower cost and increase delivery tempo. However, the availability and cost of launch remains a bottleneck.

Again, there are 60+ new launcher initiatives, but this is a notoriously risky business area and small rockets tend to have a higher specific cost ($/kg) than large ones. Currently some of the mid-size launchers (*e.g.*, DNEPR, PSLV) offer the greatest economy and flexibility — but there are few readily available. An order-of-magnitude reduction in launch cost is needed to drive a new approach to satellite production and business service models.

Of course, not all of these proposals will survive investor expectations. Some will weather the gauntlet and the new 'mega' constellations and launch operators will pose additional challenges — regular, affordable launch on a tempo and price hitherto not achieved; space traffic management and debris control; the efficient handling of communication of vast amounts of data; cyber resilience and security; safe autonomous orbital operations —– and not forgetting communications spectrum and legal or policy issues.

However, like the extraordinary number and diversity of 'SmartPhone Apps' that have been created by a completely new business community, most of which we would not have dreamed of even being possible a decade ago, the probability is that the new smallsats and constellations will stimulate applications that we currently do not envisage. These will require a different and more agile regulatory environment that is already a challenge for governments.

Space is becoming dominated by the private sector and the new services being proposed today require new policies and regulatory processes for businesses to be successful. In the UK, secondary legislation alongside the Space Industry Bill needs to be acted upon and put into place quickly and must be sufficiently flexible to be able to account for changes in business needs.

The threshold of reconfigurable 'software defined satellites' is already here and, looking a little further ahead, robotic assembly in orbit will soon allow for the construction of larger structures 'lego-like' in orbit. For example, building space telescopes with apertures too big to launch on a single rocket would be built in such a manner.

The current design of satellite structures is largely dictated by the size of the rocket fairing and the harsh physical environment experienced in just the first 20 minutes of ascent through the atmosphere to orbit before embarking on an otherwise physically benign multi-year mission: '3-D printing' in orbit offers the potential simply (but not yet!) to launch bags of sand and metal and then upload instructions to manufacture (or modify) a gossamer satellite in orbit.

The greatest impediment to the rapid development of the smallsat sector is the cost and availability of launch to orbit. The proposals for spaceports and launches from the UK provide another opportunity for the nation's communities to build an innovative business and enhance the sovereign capability.

While there is a most welcome movement to produce more cost-effective launchers — both small and large — a 90 percent reduction in launch cost is needed to change the game — no such solution is currently present on the near horizon, although the Sabre Initiative will hopefully move in that direction.

Nevertheless, looking a little further ahead, the discovery of substantial quantities of water on Moon and Mars means that there are in situ resources that eventually will enable sustained human habitation away from Earth.

With the experience gained through the ISS in long-duration human spaceflight, the advances in robotics and AI, and the rapid commercialization of launch services will, undoubtedly, in my view, enable sustained presence on these heavenly bodies — it is only a matter of time, hopefully measured now in a few decades.

This will open up a whole new chapter in not just space exploration, but in space business as well — providing the infrastructure and services to support these new outposts.

The UK is well-placed to play a leading role in these new technologies and to be an attractive place for innovative and imaginative space businesses through a strong partnership between industry, academia, business and government.

www.sstl.co.uk

In the mid-1970s, space was considered to be such a different environment to Earth that anything sent into the atmosphere needed to be specially designed and tested for the harsh conditions of space. Naturally, this made building satellites incredibly expensive and time-intensive.

In the late 1970s, a group of highly-skilled aerospace researchers working at the University of Surrey, including a young Martin Sweeting, decided to experiment by creating a satellite using commercial off-the-shelf (COTS) components. The results were surprising.

That first satellite, UoSat-1, was launched in 1981 with the help of NASA and the mission was a great success, outliving its planned three year life by more than five years. Most importantly, the team showed that relatively small and inexpensive satellites could be built rapidly to perform successful and sophisticated missions.

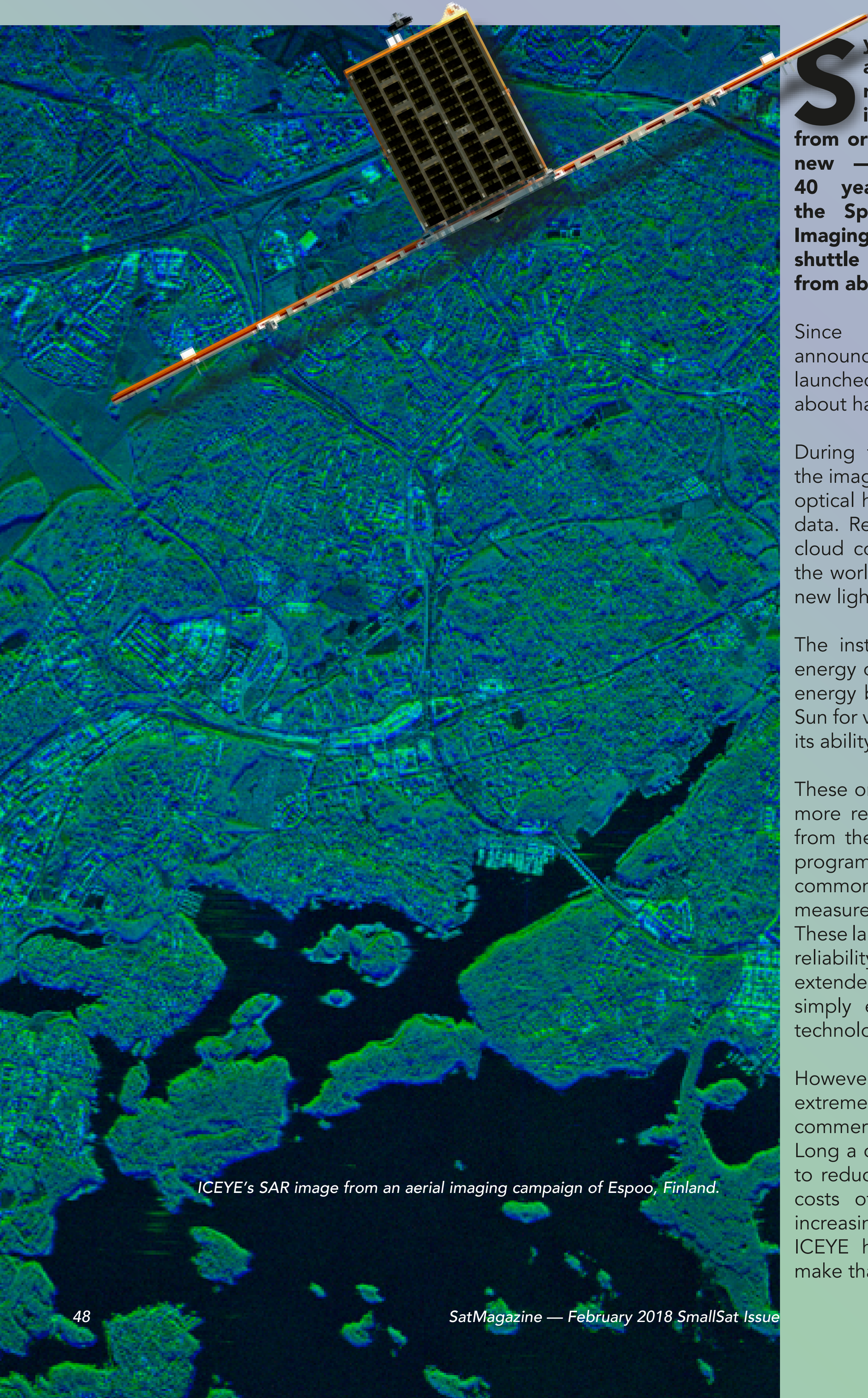
In 1985 the University of Surrey formed Surrey Satellite Technology Ltd as a spin-out company to transfer the results of its research into a commercial enterprise. The growth of the company has accelerated, and their innovative approach to the design, build, test and operation of spacecraft has propelled SSTL to the forefront of the small satellite industry — today the company is the supplier to 40 percent of the world's smallsat exports market.

In 2009, Airbus bought a 99 percent shareholding in the company from the University of Surrey, allowing SSTL to fulfill its growth potential. Surrey Satellites is now an independent company within the Airbus Defence and Space group.

An ICEYE Focus

Synthetic-aperture radar in under 100 kg. satellites

By Pekka Laurilla, Chief Financial Officer and Co-Founder, ICEYE



ICEYE's SAR image from an aerial imaging campaign of Espoo, Finland.

Synthetic-aperture radar (SAR) imaging from orbit is not new — almost 40 years ago, the Spaceborne Imaging Radar (SIR) flew on two shuttle missions to image Earth from above.

Since then, roughly 15 publicly announced SAR satellite missions have launched. Out of those satellite missions, about half are operational today.

During their lifespan, they've enabled the imaging of Earth in conditions where optical has not been able to deliver the data. Regardless of the time of day or cloud cover, SAR imaging has allowed the world to see both sea and land in a new light.

The instrument actively sends its own energy down to Earth and receives that energy back, rather than relying on the Sun for visibility, and it is more flexible in its ability to see the surface at all times.

These original missions — and even the more recent ones, such as Sentinel-1B from the European Union's Copernicus program — have one key element in common... most have had a launch mass measured in the thousands of kilograms. These larger sized missions increased the reliability of the onboard instruments, extended the lifespan of missions, or simply enabled testing of these new technologies altogether.

However, larger satellites are also extremely prohibitive when it comes to commercial and government operations. Long a dream of the satellite industry is to reduce the development and launch costs of SAR satellites to meet the increasing global need for SAR data and ICEYE has been working fervently to make that become a reality.

ICEYE-X1 being prepared for bake-out.

SAR — Starting from smaller-than-possible

ICEYE's initial steps started in a smallsat program at Aalto University in Finland back in 2012. Prior to this program, there weren't any national capabilities for complete satellite missions but, rather, only capabilities for participation in larger missions with individual instruments. ICEYE officially started operations in 2015 as a spin-off from that program, with a focus on synthetic-aperture radar sensor technology.

The goal directly from the start for ICEYE was to launch the smallest SAR satellite possible to meet ongoing development needs for the future. One of the key use cases that raised keen interest was to monitor Arctic sea ice for commercial and research purposes.

Naturally, there was a healthy sense of skepticism in the industry on developing a SAR satellite under the traditional mass of one or two tons. At the time, the instruments simply required satellites above that launch mass. As no other organization had ever produced a SAR satellite under 100 kg., such seemed to be an impossible feat at that time.

With this skepticism acknowledged, the initial ICEYE team explored different cubesat possibilities. They had to initially understand the synthetic-aperture radar instrument itself and the limitations and possibilities of the technology.

While the team was well-versed in nanosatellite technology, creating a SAR instrument to fit a smallsat was problematic then and remains so to this day. However, one item remained certain — it was entirely possible to create a sensor far smaller than what was currently being used on satellites around the world for an instrument of this type.

A large portion of the fast development cycle ICEYE has used has revolved around using airborne platforms to test the company's synthetic-aperture radar instruments. Original designs and implementations were not built for a satellite as is, but rather for aerial imaging to trial sensor capabilities and to rapidly develop the overall systems further. These tests quickly validated the final size range for the first proof-of-concept satellite ICEYE-X1, below 100 kg., but above cubesat range —- firmly in the microsatellite category.

Creating a synthetic-aperture radar sensor from scratch in such a way had the added benefit for ICEYE to enable creating a completely platform agnostic instrument. As a result, today ICEYE offers satellite and aerial SAR imaging for governmental and commercial entities.

ICEYE aerial radar imaging in progress — through clouds and darkness.

Benefits of smaller SAR satellites

Up until now, SAR instruments were being launched on satellites the size of a school bus. One of the main benefits of using smaller satellites than those large spacecraft is that they are more conducive to commercial operations, especially in regard to cost efficiency. ICEYE's satellites are a 100 times less expensive for the development and manufacturing cycles than traditional SAR satellites.

When adding in the cost of launch, simply being able to launch 20 or more satellites for the cost of one satellite enables new opportunities for radar imaging. While optical satellite constellations are already in use, a synthetic-aperture radar constellation remains unachieved.

That is what ICEYE is aiming at and is well on its way to become the first to deliver a constellation of SAR satellites that will bring the added benefit of distributing the SAR instrument reliability onto multiple satellites rather than just a single satellite.

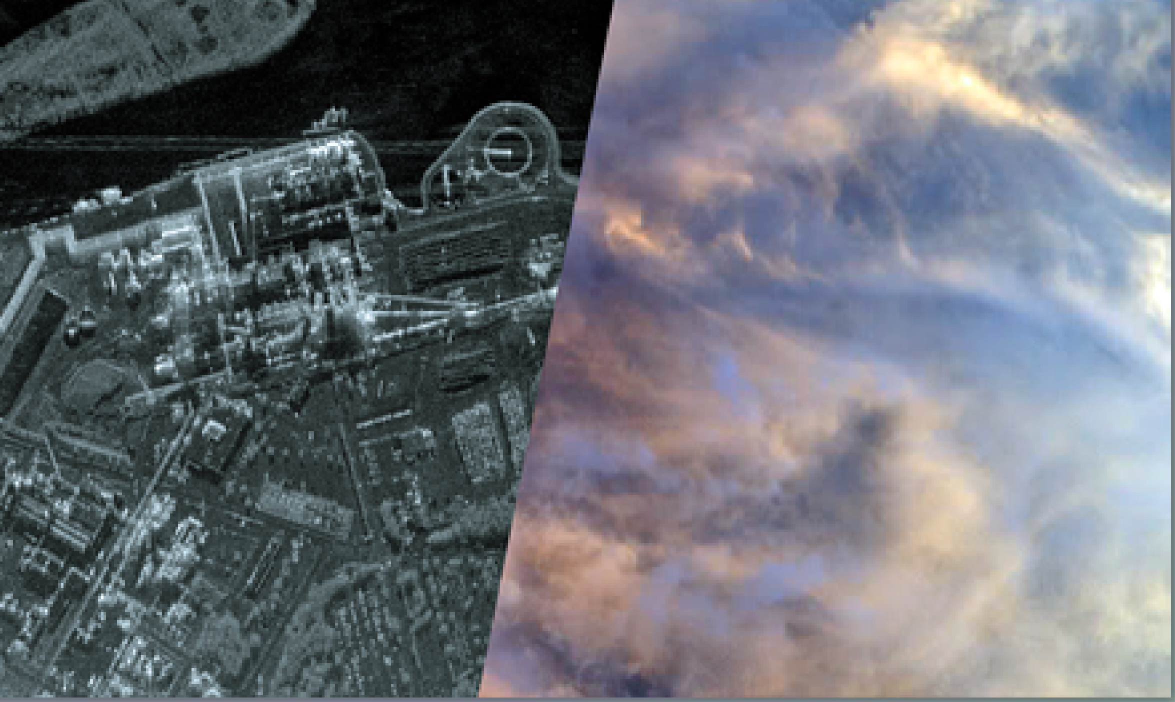
There are two key concerns regarding SAR instrument development for smaller than traditional platforms. The first is that there is a natural limitation on how small your instrument can physically be constructed before losing too much resolution in the final data that can be gathered. The second is that this task is extremely difficult to execute.

ICEYE-X1 mission

ICEYE has come a long way in developing SAR technologies since the concept was initiated in 2012. At the start of January 2018, ICEYE launched ICEYE-X1, the company's first proof-of-concept satellite mission equipped with a SAR instrument.

This mission will achieve several major milestones for ICEYE, locally and globally, including being the world's first SAR satellite under 100 kg. to be deployed in space as well as the first Finnish commercial satellite ever launched.

The goal of the ICEYE-X1 mission is to validate the on orbit performance of the satellite's sensor and to start pilot operations with select customers. The Earth Observation (EO) data gathered in this SAR imaging can be used to help monitor Arctic sea ice movements, marine oil spills, prevent illegal fishing and even help first responders in emergency situations. The use cases for radar imaging are vast, as ICEYE continues to scale out its operations to a multitude of industries, for both commercial and governmental purposes.



SAR peers through the clouds...

During 2018, ICEYE plans to have more commercial SAR satellites on orbit than any other organization on Earth.

During 2019 and 2020, ICEYE is aiming to distribute a constellation of 18 or more SAR satellites to orbit, each satellite offering more capabilities than the satellite preceding it. With this high number of sensors on orbit, ICEYE can guarantee revisit times any time of day, or in any weather condition. These capabilities completely enable new, reliable and timely solutions to be built on top of SAR data, capabilities that were previously unattainable.

ICEYE-X2 and ICEYE-X3 for 2018

ICEYE's plans for 2018 doesn't stop at one single mission. ICEYE will be launching two or more additional proof-of-concept missions in 2018.

There are three major goals for these additional missions.

- *First, the missions are intended to help the ICEYE team further develop and demonstrate the capabilities of the company's SAR technology.*

- *Second, these missions are used to further test and develop exactly how ICEYE's SAR constellation will be used to deliver data to customers for different use cases.*

- *Third, the missions are a part of a risk mitigation strategy where several different launch providers are verified for future capabilities, including for integration and timelines.*

After ICEYE's missions

ICEYE's innovative smallsat approach allows for a distribution of a large amount of sensor units through a variety of orbital planes and local time nodes. This efficiency vastly increases the availability of acquisition times and locations and enables launching multiple SAR satellites at costs that previously had to be allocated for just a single mission. Previously, traditional fixed orbital planes and a limited number of sensors created a cap on what would be feasible for global SAR data acquisition.

While optical data currently has a lead on how often an overpass occurs, cloud cover and a distinct inability to see in the dark leaves roughly 75 percent of imaging opportunities unused. Paramount is that SAR satellite constellations become established to increase the global reliability to a level that meets the requirements of commercial and governmental entities.

www.iceye.com/

Pekka Laurila is the Chief Financial Officer and Co-Founder of ICEYE. As CFO, Laurila has been instrumental in establishing company-wide financial procedures and raising funds for ICEYE, which has now received more than $15 million in recent capital infusions. As a Nordic native from Finland watching the Arctic ice caps melt, Laurila joined forces with Rafal Modrzewski to create synthetic-aperture radar (SAR) smallsats in hopes of ensuring the sustainability of global warming research.

Prior to co-founding ICEYE, Laurila played an instrumental role in Finland's Aalto University Nanosatellite Program, where he studied as a student of the Engineering and Geoinformation Systems program. Using this engineering and entrepreneurial experience, Laurila helped to co-found a spin-out company of Aalto University, which would later become ICEYE.

An Earth-i Focus

Satellites to predict the future...

By Richard Hollingham

Example of sub-1 meter imagery from the DMC3 constellation used by Earth-i. Image ©21AT ©Earth-i Ltd.

On May 18, 1969, just over four hours into their mission to the Moon — the dress rehearsal for the first lunar landing — the crew of Apollo 10 pointed their video camera through the command module window toward the Earth.

The live images of the planet they sent back were transmitted across the world, revealing banks of white clouds over blue-green oceans lapping at ocher continents. These first color TV pictures from space not only transformed our view of the Earth, but were an impressive demonstration of the potential of video technology.

Today, images from space are taken for granted. With daily uses ranging from weather forecasting and mapping, to detailed resource and security analytics, the commercial global Earth Observation (EO) market is expected to grow to some $8.5 billion over the next decade (Euroconsult). However, capturing video from space remains a technological challenge. You only need to compute the math to see why this is so...

Satellites travel around the Earth at seven kilometers per second. This equates to passing seven kilometers a second across the ground — a staggering 25,200 kilometers per hour. Attempting to take pictures of anything at that speed involves a satellite constantly adjusting its angle of rotation to remain pointed at the same area.

Earth-i is engaged in defying the math, and plans on launching a new constellation of satellites designed to capture high definition images and — for the first time — commercial video from space from 500 kilometers above the planet — and in ultra-high definition (UHD). Earth-i shared their plans for the

The Earth-i VividX2 satellite in the clean room. Photo is courtesy of SSTL.

future of EO with the author of this article, science and space journalist Richard Hollingham.

"*It is difficult, it is challenging,*" said Earth-i founder and CEO, Richard Blain. "*I think sometimes we have to pinch ourselves a bit that we are doing something ground-breaking.*"


Richard Blain, the CEO of Earth-i.

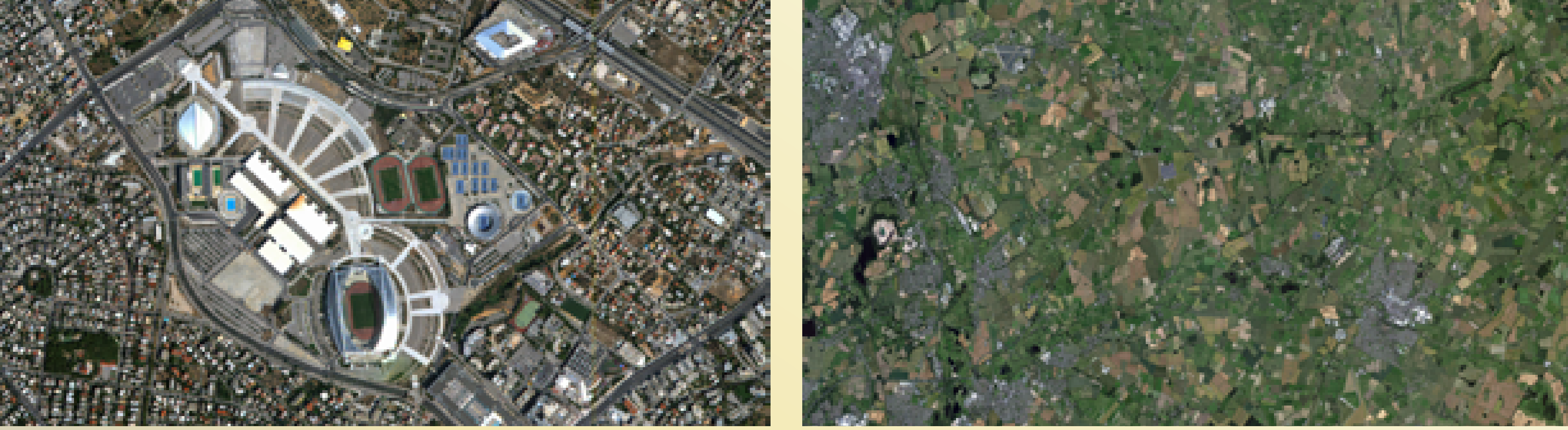
Earth-i's plan goes like this: In January of 2018, the UK company will launch a technology demonstrator satellite, VividX2. This will be followed by a five-satellite constellation around 2019. Two further groups of five satellites will be launched by 2022. Further batches of five will be deployed after that, depending on customer demand.

"*Earth-i takes the view that to fulfill the needs of our clients, it's vitally important we have our own source of data,*" said Blain. "*By having our own assured supply of Earth Observation data which, let's face it, is very difficult to get, we can provide levels of assurance in terms of answers to our clients that are valuable to them.*"

The Earth-i satellites are being built by small satellite (smallsat) specialist, Surrey Satellite Technology Limited (SSTL). Their manufacturing base is just across the road from Earth-i in an extensive landscaped research park on the outskirts of Guildford, around 50 kilometers (30 miles) south of London.

Earth-i's established EO business already uses data from several satellites, including the SSTL-built DMC3 constellation, to provide services to a wide-range of clients across the globe. But the new spacecraft — VividX2 and the Vivid-i Constellation to follow — represent a step-change in capabilities.

Only around the size of a small domestic appliance, each satellite is fitted with a single HD camera able to



Example of sub-1 meter imagery from the DMC3 constellation used by Earth-i. Left: Athens, Greece. Right: Nottingham, UK. Image ©21AT ©Earth-i Ltd.

simultaneously capture high-definition (HD) images — with better than one meter resolution — and up to two minutes of full-color, high-frame-rate video.

Satellites in the constellation are designed to have many of the capabilities and resolution of large (usually) government-funded satellites. "*Ten years ago, a satellite like VividX2 would be quite a large power-hungry spacecraft, weighing several hundred kilos and have several limitations in terms of what it could do*," said SSTL Commercial Director, Luis Gomez. "*We're now doing this in a package weighing less than 100 kilos, which is able to capture and transmit huge amounts of data*."

Multiple satellites will provide clients with an assured and reliable stream of information based on multiple revisits of the same location over the course of a day. Combined with video capability, not yet possible with cubesats, it should give the system few competitors. And, as the constellation grows, its capabilities will only get better. As one satellite passes over the horizon, the next can target the same location.

"*The big change for us is the ability to keep on going back every day to any location on Earth and capturing any image or a video clip of that location*," said General Manager, Adrian Norris. "*With the initial constellation of five satellites, that gives us the opportunity to see any point on Earth every day, to let our customers monitor their assets on a regular basis to see change detection, day by day, of any site*."

"*We look at the high temporal resolution of multiple revisits per day and we look at ultra-high temporal resolution where we've got video taking 25-30 frames per second*," said Blain. "*In terms of revisits, with video we're effectively revisiting every fraction of a second and creating therefore a whole new type of information from space that isn't available today. That will drive an amazing array of new and interesting applications*."

With ground infrastructure and a specialist center under construction to control and support the satellites, Earth-i aims to be able to task the spacecraft within minutes of client requests and deliver images or video to customers within half an hour of them being captured. The company anticipates no shortage of demand for the new products and services it will be able to offer. While it's easy to get excited about the technology, it's these end products that most customers care about.

"*The Earth-i constellation is a huge game changer for the industry*," said the company's technical advisor, Paul Brooks. "*The remote sensing market is worth billions of dollars a year and the key is to provide not just images but the information to end-users of what they want. We're extracting information and extracting value for our customers to make their businesses better*."

As well as offering multiple revisits over target areas, unlike drones, a constellation can provide a global perspective. Brooks calls this "*planetary big data*" and cites the example of tracking resources such as copper, important for the commodities market.

"*Copper is mined in many mines spread across the globe, so what you need to do is provide information on what all those copper mines are doing at any one time across the world*," he said. "*You need to have a global picture, an assured picture, and that you'll get the information in a timely manner*."

With images supplemented by data from other imaging, radar and atmospheric-monitoring satellites, applications might also include monitoring crop health, water supplies, a refugee camp or border security. The data could be used to develop maps or make decisions about allocating resources. Adding video to the mix adds a whole new level of potential data analysis and insights. It could be used to track the movement of vehicles or, because of its high resolution, derives highly detailed 3-D models.

"*For example, we might pull out moving features from the video for a 3-D model or extract transport information from ports across the world*," said Product Development Director, Owen Hawkins. "*We can build all of those together into deeper layers of analytics*."

Earth-i is adopting machine learning and computer vision systems to automate the tasks and overcome what Hawkins calls "*a data deluge*." But, as no-one has done video from

Example of sub-1 meter imagery from the DMC3 constellation used by Earth-i. Queensland, Australia. Image ©21AT ©Earth-i Ltd.

space on this scale before, there is a lot to do to make the most of the potential capabilities of the new satellites. "*We need to do some cutting-edge work to answer the unique needs of the satellites we're putting into space.*"

"*To innovate in the space industry, we really need to look to other industries to see what they're doing with these new technologies,*" said Hawkins. "*In medical imaging, for example, the way that they do computer vision is streets ahead of what you see in the space industry, quite fantastic.*

"*So, we're picking the bright stars, leading lights of these industries to come and help us to bring that knowledge into the space industry,*" he added. "*In addition to being able to repurpose things that other people have done, because of the way the satellites operate, we're aware we also have hard technology challenges to process the video.*"

Chief Technology Officer, John Linwood, argues that Earth-i isn't only in the space business but the future business. "*The really exciting thing about insights is predicting things that will happen, and that opens us up to a whole raft of industries,*" he said. "*Whether it's the insurance industry, commodity traders or the power industry, we can do trend analysis and look at what we call patterns of life to predict traffic growth, power demand or even commodity production into the future. We want to help people make smarter decisions.*"

Earth-i CEO, Richard Blain, hates using the word "*ambitious*" to describe the company's aspirations. But given the growth of Earth-i, he concedes that it's sometimes necessary.

"*We founded Earth-i with a very clear vision and a very clear plan…and whilst it is hugely ambitious, we do have an exceptionally competent and talented team,*" he said. "*We have to think about everything from satellite sensors and launch solutions, to collation of data and the derivation of insights,*" said Blain. "*But the most important piece at the front end is engaging with clients to enlighten them to the benefits that can be derived from this new source of data from space.*"

Richard Blain, John Linwood and Adrian Norris will be attending the ***Smallsat Symposium*** from February 5 to 8, 2018, at the Computer Museum in Silicon Valley, California. To arrange a meeting, please tweet **@Earthi_**

Richard Hollingham is a science journalist, writer and broadcaster. A science presenter and producer for BBC radio, he is also space correspondent for BBC Future. Richard is the editor of space:uk magazine.

Richard has broadcast live for most BBC radio outlets, BBC TV news and is a frequent contributor to From Our Own Correspondent. He has reported on science and the environment from more than 40 countries. These include reports from the Chernobyl nuclear power plant, Baikonur Cosmodrome, Russia (several times), Libya, Antarctica (twice), Vietnam, and from an ice floe in the Arctic. A former Senior Producer for the BBC's flagship news program, Today, he was also its first science producer.

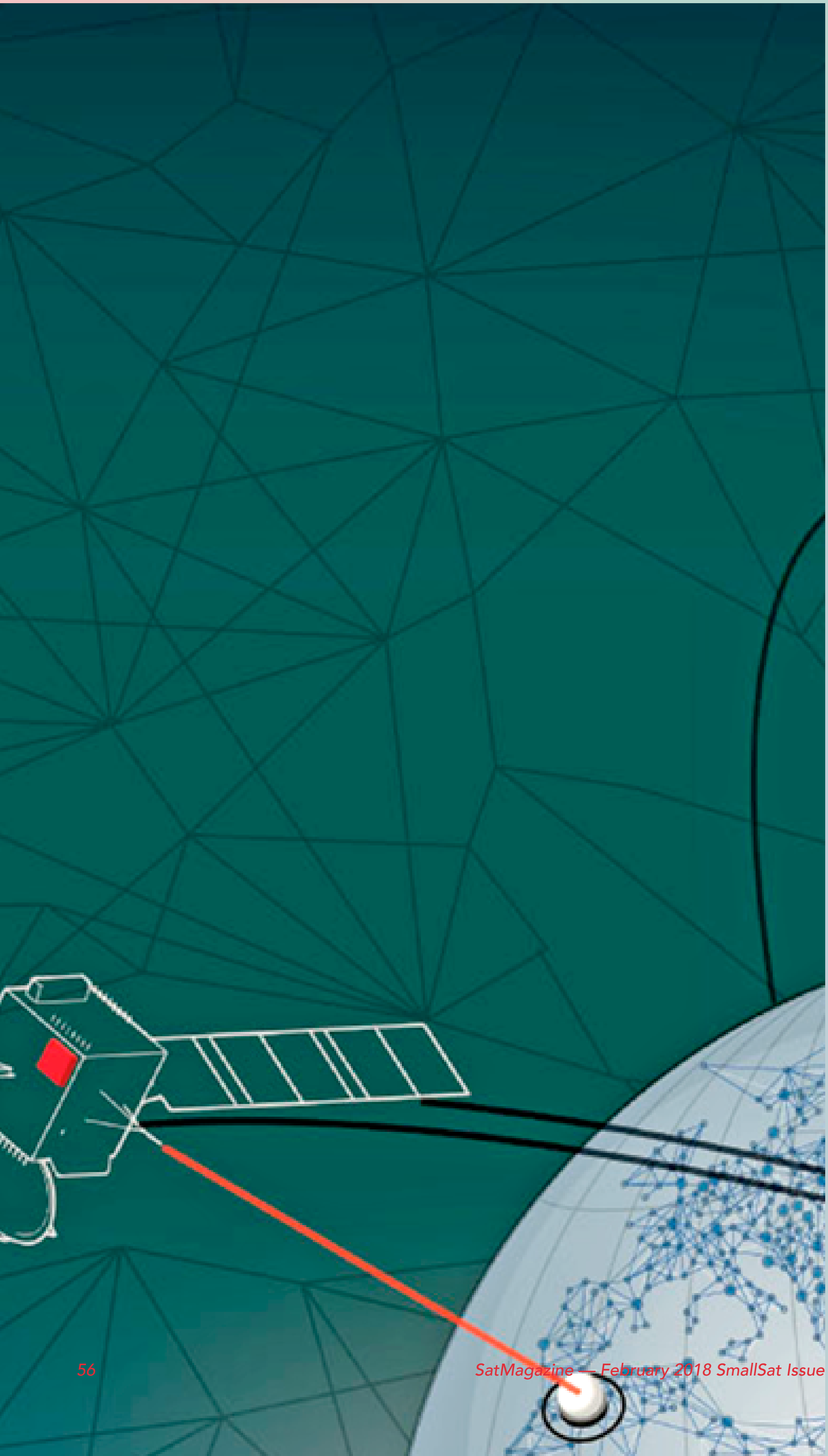
Richard is a producer/presenter for the award-winning Space Boffins Podcast. He also anchors live TV broadcasts for the European Space Agency and has written for New Scientist, Discover and most national UK newspapers.

earthi.space/

A BridgeSat Focus

Design and application of space-based optical communications

By David Mitlyng, Product Management, BridgeSat Inc.



For operators that need to securely and efficiently move large amounts of data from space to ground, optical communications offer a viable solution.

Previous articles have discussed the history of optical communications (***www.satmagazine.com/story.php?number=2026136812***), as well as the benefits for smallsats and secure communications (***www.satmagazine.com/story.php?number=1701251348)*** ***(http://www.milsatmagazine.com/story.php?number=723110643***).

Generally, commercial satellite operators understand RF systems much better than optical communications — this addresses the basics by comparing the two designs.

Data Rates of Optical versus RF Communications

The first step in evaluating the communications architecture for a satellite system is the trade between availability of spectrum and necessary data rates required for the specific mission. A summary of the typical options is shown in the table (*Figure 1*) on the following page.

Of course, the data rates shown in this table only tell part of the story.

First of all, the flight hardware, encoding and modulation scheme, ground stations, and link budgets need to support the assumed data rates. For RF systems, these options are well understood, so let's focus on the optical communications system.

Design of Laser Communications Terminals

There are a number of qualified space hardware suppliers that are offering optical comms hardware, known as laser communications terminals (LCTs), in the data rates shown in *Figure 1*, next page. In addition to data rates, these manufacturers offer different levels of

	Typical Data Rate	Availability
S-Band	Up to 50 Mbps	Typically available in the amateur band
X-Band	Up to 500 Mbps	Requires ITU filing
Ka-Band	Up to 3 Gbps	Very difficult to obtain
W/V/E-Band	Up to 10 Gbps	Expensive and limited space hardware, with no commercial ground station support
Optical	Up to 100 Gbps	Available, with low cost hardware and evolving global network

Figure 1.

qualification, sizes, power consumption, encoding/modulation, delivery schedule and price. However, all these LCTs use similar design elements:

- *Modem or RF-to-digital converter*
  *Before the data is encoded and modulated on the laser, it first needs to be converted into the digital domain from either a RF signal or from a mass memory storage device on the satellite. Once converted to digital, most LCT designs utilize an encoding scheme that will help overcome the noise and losses that primarily come from atmospheric effects. These schemes could include some combination of forward error correction (FEC), interleaving, and/or an automatic repeat request (ARQ). Encoding can lower the bit error rate (BER) substantially, but at the expense of additional overhead that effectively reduces the data rate. While there are a number of RF broadcast standards available (most notably Digital Video Broadcasting (DVB) S2), an optical communications standard is being developed by the Consultative Committee for Space Data Systems (CCSDS) optical working group (**cwe.ccsds.org/fm/Lists/Charters/DispForm.aspx?ID=79**).*

- *Transmitter and Receiver, or Transceiver*
  Once the data is assembled with or without encoding, a seed laser, which is typically a stable low power laser diode, is modulated. The most simple modulation schemes are on-off keying (OOK), which changes the signal amplitude, or differential phase-shift keying (DPSK), which measures the change in the phase state. OOK and DPSK only offer one bit per symbol, but work with simple direct detection receivers. The more advanced modulation schemes that are common in the RF world, such as phase shift keying (PSK) or quadrature amplitude modulation (QAM), require coherent receivers that can more accurately measure amplitude and modulation changes.

- *Amplifier*
  Most LCTs use fiber amplifiers, which are optical glass fibers doped with rare earth ions such as erbium, neodymium, ytterbium, praseodymium, or thulium. This active dopant is pumped with light from a seed laser in the transmitter, which propagates through the fiber core and amplifies the signal. Most designs today use Erbium-doped fiber amplifiers (EDFAs) that have relatively low efficiencies (around ten to twenty percent), but can output up to ten or more watts of laser output power.

- *Optical Head Assembly (OHA)*
  The most advanced technology for LCTs resides in the optical head assemblies, which contains the optics necessary to convert the laser signal into a beam that is transmitted and received. Some designs split the transmit and receive paths, but most use a more mass efficient co-boresighted design that requires filters and beamsplitters to segregate the two signals. The simplest OHA designs use an open-loop pointing system based on the spacecraft pointing knowledge, and therefore do not require active pointing and position sensing equipment. To achieve tighter beams with higher data rates, a closed-loop lock of a receiver beacon is required. The more sophisticated designs utilize steering mechanisms and passive isolators to compensate for satellite pointing errors and spacecraft micro-vibrations based on the feedback from the beacon

- *Controller, Power, and Command/Telemetry Interface electronics*
  To round off the list, these electronics are usually packaged as separate cards that are designed to interface with the LCT and the spacecraft.

Optical Communications Link Budgets

The data rate is found from the optical communications design and the associated link budget, which is similar to the traditional RF link budget.

The key differences between the two types of budgets is in the evaluation of the transmit and receive gain, and the transient atmospheric losses associated with scintillation and clouds. Otherwise, the terms in an optical comms link budget should look familiar: the amount of power collected by the receiver is proportional to the square of the transmit and receive telescope diameters, and inversely proportional to the square of the range and the optical wavelength:

The key parameters in the optical link budget:

- *Laser Output Power*
  Typically ranges from low milliwatts to single digit watts of output power, based on today's best fiber amplifiers. Data rates (or, more accurately, the link margin) increase proportionally with laser output power, but so does DC power consumption on the satellite.

- *Laser Transmit Beam Divergence Angle*
  This is set by the design of the transmit optics in the LCT, and defined by the transmit waist diameter. Narrower beams provide better link margins, but at the expense of more complicated pointing and tracking mechanisms.

- *Pointing Loss*
  This is located by considering the pointing accuracy of the beam against the beam divergence angle. All laser beams output power in a roughly normal (gaussian) distribution, so a small pointing error with a wide beam divergence angle would have lower peak power losses than the alternate. However, tight pointing angles require ever more sophisticated sensing/tracking and pointing mechanisms. Simple open-loop pointing systems can achieve around 1/10 of a degree of pointing accuracy based on the spacecraft, requiring half a degree laser beamwidth. Current state-of-the-art closed-loop designs have beamwidths that are less than 100 micro-radians, with pointing in the tens of microradians, yielding far better data rates (consider that data rate improves as a square of beam width).

- *Free-Space Optics (FSO) Loss*
  This a simple calculation based on the wavelength (typically 1550 nm) and range (typically 1500 km slant range for LEO satellites).

- *Atmospheric and Scintillation Loss*
  This most difficult term to properly assess, even though there are a large number of papers written on the subject (https://ntrs.nasa.gov/search.jsp?R=19890017910). There are localized atmospheric effects that mean that atmospheric losses fluctuate in time, as well as based on the elevation angle and altitude of the ground station.

- *Receiver Optics*
  Ground stations receive telescope apertures typically range between 40 to 60 cm diameter, though they can be larger. As the size increases, the cost of large lenses increase almost exponentially, and the complexity of the telescope motor increases — however, the power collected is proportional to the square of the diameter.

- *Receiver Loss*
  While the receiver optics induce some loss, the receiver design can actually have positive gain if it removes scintillation effects through adaptive optics or multiple apertures. Optical signals can be distorted due to local scintillation effects in the atmosphere, which is similar to the visual star twinkling effect. The ground station can correct out these aberrations, providing better links during the transient effects. However, these modifications add expense and complexity to the ground station.

- *Receiver Sensitivity*
  This the minimum signal level needed to distinguish the signal from the noise from the received laser beam. Most receivers are avalanche photodiodes (APD) that are tuned to provide an electrical signal for the maximum data rate modulation of the optical signal. There are more sophisticated heterodyne receivers that use a local oscillator (LO) source to more accurately detect the phase and amplitude of the optical signal. These designs, while more expensive and complicated, support coherent signals that deliver multiple bits per symbol, with the resulting increase in data rates.

Mission Analysis
Once the data rate is established, the operator needs to prepare a mission analysis to assess data downlink capacity. BridgeSat prepares a detailed mission-specific analysis, using LCT capability, link budget, data rate, satellite orbit, and BridgeSat's optical comm ground network as inputs.

Complicating this analysis is the statistical variation in cloud cover at the ground station locations. To evaluate this, a detailed statistical model has been created using seasonal cloud variation.

For example, a satellite in a LEO sun-synchronous orbit at 500 km using a 10 Gbps optical comms system and BridgeSat's initial ground station sites, can expect more than 2 TB of data downlink per day.

BridgeSat is locating ten optical ground stations at low cloud sites, many in areas near the poles to ensure coverage for polar orbits. This gives the operator confidence that their valuable data will be downlinked quickly and efficiently.

Conclusions
Optical communications offer a strong solution for commercial satellite operators that need to securely and efficiently move large amounts of data off their satellites.

With a basic understanding of the design and applications of optical communications, these operators can make the best system trade for their next satellite architecture.

http://www.bridgesatinc.com/

A KSAT Perspective

The SmallSat industry in 2018

By Katherine Monson, Director of Business Development, Kongsberg Satellite Services (KSAT)

The last ten years have fuelled a dynamic wave of launch approaches, including Rocket Lab which will launch spacecraft from Spire and Planet early this year.
Credit: Rocket Lab Video Capture

The smallsat revolution has now, arguably, been underway for a decade.

The changes that enabled this commercial space revolution were 1) the increased technological capability to do more with less weight and mass; 2) the decreased cost of space hardware and infrastructure; and 3) the willingness to start and fund companies targeted to solve problems in a commercial marketplace, outside of the traditional telecommunications and defense applications.

The last ten years have seen dozens of companies emerge under a similar banner of affordable access to space data — heralding new ways of using the unique vantage point of space to capture and transmit data home to Earth. The rise of these burgeoning companies has, in turn, led to a solidification of growth in the service sector — as the problems of launch, ground communications, space hardware development, and spacecraft manufacturing have been tackled by existing and new companies eager to meet these needs.

Ten years into this revolution, spacecraft owners and operators now have many options from which to source and procure sub-systems and support — many of which were not available when the companies first began operating.

Companies that in the past had no option but to purchase larger turnkey satellites, or recruit teams of manufacturing technicians to build spacecraft with cheaper commercial off-the-shelf component specifications, can now turn to Tyvak, Clyde Space, Blue Canyon Technologies, and Loft Orbital, to mention a few, to build their spacecraft or even fly their payloads directly.

KSAT's Svalbard Station.

Strict standards of reliability on the proven and tested ground network provide certainty for space systems that inherently may encounter risk from the challenging operational environment of space. Credit: Kongsberg Satellite Services

While launch continues to be a cost-restrictive barrier for many business cases, the last ten years have fueled a dynamic wave of new and innovative launch approaches that aim to break down that barrier. Established launch providers such as ISRO, ULA, and Orbital ATK have partnered with new companies, Nanoracks and Spaceflight, to normalize a ride share approach to launch, driving costs down to a level that opened up the possibility for many more business cases to close.

The emergence of new giants such as SpaceX, which rose after a series of delays and difficulties in 2016 to complete 18 launches in 2017, has opened up even more access to space. The success of these companies has laid the foundation for even more innovative development from companies such as Virgin Orbit, who will test their jet-based launch system in 2018, and newcomer Rocket Lab who after high-altitude winds pushed their second test launch out from December, will launch spacecraft from Spire and Planet early this year.

Ground-based infrastructure has also seen its fair share of development and innovation. Supporting more than 10,000 passes from smallsats monthly, KSAT has continued to drive cost reduction through standardization around the KSATLite form factor.

Focusing on S-,X-, and Ka-band frequencies, the KSATLite network enables flexibility for spacecraft operators to schedule passes from any of the twenty ground stations around the world, leveraging the dynamic capabilities of software-defined radios to seamlessly move data from spacecraft to servers.

Enabled through decades of expertise, KSAT further minimizes risk for satellite owners, ensuring on-time delivery of data to local or cloud-hosted databases. Strict standards of reliability on the proven and tested ground network provide certainty for space systems that inherently may encounter risk from the challenging operational environment of the spacecraft. With continued developments in communications technology, the pipelines from space to Earth continue to grow, while cost savings due to economies of scale and operational efficiencies combine to enable more data-intensive missions.

In 2018, the smallsat industry is truly over the proof of concept phase. The question is no longer can it be done — because dozens of small satellite companies have, without a doubt, proven that it is indeed technologically possible to host a whole array of smallsat payloads and missions on a smaller form factor. Now the question turns to profitability. Can the industry stand on its own two feet?

Supporting more than 10,000 passes from smallsats monthly, the KSATLite network enables flexibility for spacecraft operators to schedule passes from any of the twenty ground stations around the world. Credit: Kongsberg Satellite Services

With more than $4.5 billion of venture capital[1] driving the growth of the smallsat revolution, the push is now for the industry to focus on revenues and returning value. While access to space has become orders of magnitude more affordable, owning and operating a space-based data collection company is still extremely capital-intensive. With that high barrier of entry, comes a high bar for revenue generation over which each company must jump.

The scope of the problems that smallsats can be tasked to solve are huge — weather data to improve responses to climate change; radar imaging to track movements of illegal or hostile maritime activity; photographs to measure deforestation, monitor humanitarian crises, and assist farmers navigate changing agricultural landscapes. Many technologists have the tendency of grouping these companies based on the platform — these are NewSpace companies, this is a smallsat industry.

In reality, these companies have as much in common as the internet companies of the nineties' dot-com boom. Each company will live or die based on how well they can solve the problem for their end-customer — be that customer in government, oil and gas, finance, or agriculture. As many dot-com era companies learned the hard way, the proof is in the product.

While many in the space industry entered this line of work due to a passion for the process — the challenging parameters of getting hardware into space and the data back down — the end-customers largely do not care that their data comes from space. Setting aside the challenges and passion for working on a space-based platform, the product must speak for itself. Hence, the crux of these companies are not rooted in intriguing new technologies, but rather in end-user requirements.

The individual success of any smallsat company ultimately is derived from the firm's ability to maintain profitability by meeting customer needs. Working backward down the value chain — the success of any service provider in this industry (be it launch, manufacturing, regulatory, communications) is to then increase the success of the satellite owner and operator by improving the capability delivered, ideally while decreasing the per unit cost.

None of these principles are unique to smallsats or the aerospace industry. Companies who cannot maintain profitability, who do not earn their right to exist in the marketplace, are shuttered up, sold off, or auctioned at a bargain rate.

In the midst of the technological innovations that surround the developments with smallsats over the last ten years — it is easy to stray away from these foundational realities.

Due to huge successes over the last decade, the industry is past the proof of concept and the focus must now be on product and the pursuit of profitability. For space craft owners and operators, that means redirecting capital and engineering efforts toward maximizing gains through product market fit, and operational efficiencies.

Avoiding the temptation to do it all, smallsat companies should resist re-inventing the wheel if that wheel can be purchased for cents on the dollar in the marketplace. In particular, new companies must think critically about how to keep ahead of competition and realistically assess whether a vertically-integrated approach allows or inhibits a faster, cheaper, and better product to emerge.

In the excitement of a fast-paced industry, it requires discipline to hold the line that engineering time spent in areas away from revenue-generating activities is a cost center. Whereas engineering time spent on projects that improve the product offering, lead to differentiation in the market place and ultimately the creation or capture of market share.

As the industry matures and smallsat companies are able to rely more on service providers to provide quality sub-system components and support, the service providers in turn must hold this responsibility with great importance. While the last ten years have seen tremendous growth, the smallsat industry remains a closely interdependent ecosystem. If smallsat companies are not successful in gaining profitability, so, too, are the business cases for launch, manufacturing, and ground systems that were built on the small satellite market at risk.

What does this mean? Spacecraft owners and operators must share feedback with their service providers. They must be clear in outlining their system requirements and their expectations, and work iteratively to find the solution that best meets their product needs. They must focus on differentiating their product value in the marketplace.

Service providers must leverage their expertise to solve problems that their customers may not even realize can be solved. They must push to make more capability available at more affordable rates by harnessing economies of scale, innovation, and technological advances. They must work to support their customers' growth and success.

KSAT has moved to support this development. Standardization of systems requirements, minimizing modifications, and leveraging the flexibility of software-based radio platforms are all key to reducing engineering costs previously incurred through custom architectures.

Clear definition and prescription of available spacecraft to ground interfaces eases the burden on the satellite owner and operator, allowing them to focus on the key task of building, operating, and maintaining the instrument. Simultaneously, constant assessment of new technologies for operational readiness generates increased capability, while growth in the industry enables cost efficiencies.

The fast-paced growth of the last ten years has opened the industry for fresh minds to join and tackle these tough business and technology problems. Together, smallsat companies and the service providers that support them will determine the fate of the industry for the next ten years.

There is tough work ahead, for each company must earn its right to exist in the marketplace — creating value for their customer in a way that is better, faster, or a cheaper way than can be accomplished alone.

To do this, focus on the product and the customer.

ksat.no/

Reference

[1]*According to the 2017 Bryce "Start-Up Space" report*

Katherine Monson is a Director of Business Development for KSAT where she works with smallsat, legacy space and launch companies to retrieve their data from space. Prior to joining KSAT, Katherine was an early member of the Spire Global team, where she ran the Ground Station department. Katherine is based in the Silicon Valley, California, and can be reached at Katherine.Monson@ksat.no.

Innovation: Rock Seven

SmallSat size and software matter

By Nick Farrell, Director, Rock Seven

Rock Seven's RockAIR.

In the article *'The Diverse World of Remote Monitoring… A Rock Seven Perspective'* **featured in the January 2017 issue of** *SatMagazine***, the company's comment was** *"…in this area of connectivity innovation, small is most definitely the best.*"

The comment related to the advent of compact and low cost SATCOM systems, such as RockBLOCK and mini-computers such as Arduino™, Raspberry PI™ and Intel Edison, which are enabling the development of data-centric monitoring systems on a budget.

These products are essentially democratizing the Internet of Things (IoT), allowing almost anyone to create their own secure and connected solutions without the need to generate massive start-up capital or indeed navigate the hit and miss world of crowd-funding.

The beauty of this new wave of technology is that the power of connectivity for remote applications can be harnessed by any organization, regardless of their core business.

In the Rock Seven January article, a number of applications were covered, from sensors that support the health of under-privileged communities in Africa to climate research in the Arctic and Antarctic. Even the monitoring of divers in hyperbaric lifeboats.

The one element that all of the applications have in common is that IoT was being deployed to "do good." That's not to say connected fridges don't illicit happiness when users can order more milk when they are running low, or there's no enjoyment when the ability to click a 'stick on' button and instantly order more cat food is saving time.

However, helping people survive in tough conditions, making the world a cleaner and safer place and potentially saving lives, these are perhaps more socially responsible applications for IoT technology.

For many of the more socially responsible applications, though, budget is even more critical than with commercial organizations, as grants or donations are often the primary source of income for technology projects. Which is why going small is more often the best approach.

While RockBLOCK has always been a compact and low-cost device, the technology has already moved on since the company's feature article in January. Rock Seven has reached the point where the latest version of RockBLOCK is now nearly half the size of the product being discussed at the start of the year. This makes it possible for users to develop even more compact products and solutions, helping them to reduce development and implementation costs.

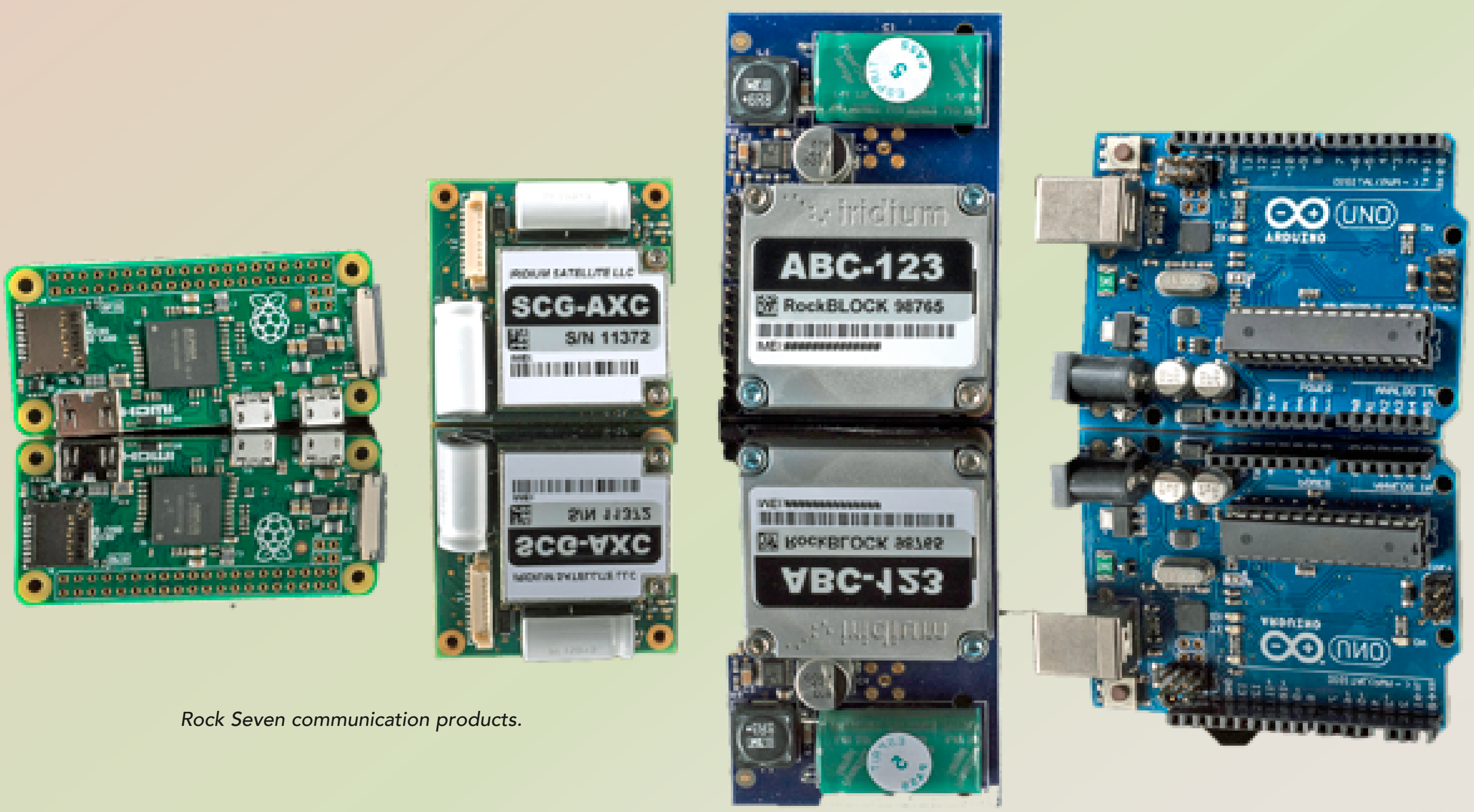
Using the latest Iridium modem technology, Rock Seven engineers have managed to shrink the already compact RockBLOCK form factor down to just 45x45x15 mm, including the unit's powerful antenna.

Compared to the standard RockBLOCK MK II dimensions of 76x51.5x19.0 mm, the new RockBLOCK 9603 is even easier to integrate on space limited remote sensing and instrument platforms, while offering identical performance in terms of data throughput and link reliability anywhere in the world (including the Arctic and Antarctic).

Weight has also been reduced, from 76 to just 36 grams, including the antenna. RockBLOCK 9603 is uniquely delivered as a complete system with electronics, antenna and power conditioning in a single compact module, ready for users to integrate in minutes.

The new RockBLOCK still interfaces seamlessly with all mainstream computing platforms, from Windows, Mac and Linux through to miniature the computing hardware mentioned earlier in this article. Initial investment is also at a level that allows for cost-effective mass manufacturing of remote sensing systems viable for, in example, NGOs and charities working in third world countries.

RockBLOCK 9603 is a cost-effective way to turn any system into a fully connected IoT device, even with limited space available. Considering that much of RockBLOCK's core user-base is developing distributed multi-sensor station networks for scientific research or commodity products, many of which are classed as disposable due to harsh environmental conditions, the low capital outlay for RockBLOCK is essential.



Rock Seven communication products.

Running costs are low, as well. RockBLOCK 9603 can send messages of 340 bytes and receive messages of 270 bytes using Iridium Short Burst Data (SBD), with flexible packages making the cost per message extremely affordable. There is no requirement for an annual contract for line rental, which includes access to the RockBLOCK management system for managing all devices in a network.

The pay-as-you-go model gives ultimate flexibility and cost saving for development — however, other tariffs are available for users with large numbers of devices and who are willing to ensure airtime commitment of 12 months or more. The latter approach could significantly cut costs for organizations supporting developing communities in third world countries.

With space at a premium on many of the core RockBLOCK applications, due in part to the environmental and financial restrictions system designers and integrators face, RockBLOCK 9603 enables engineers to introduce global M2M communication with even less impact on the required form factor of their sensing platforms and products. Likewise, the overall cost, from capital expenditure through to satellite airtime is enabling users to do more with less, especially when integrating RockBLOCK in tens or hundreds of identical systems.

The Internet of ThingSpeak

Reducing the size of RockBLOCK is not the only innovation, though. In May, Rock Seven launched compatibility with the ThingSpeak Open IoT (Internet of Things) platform for all RockBLOCK variants. Enabling users to aggregate, visualize and analyze live data streams in the cloud, the combination of RockBLOCK and ThingSpeak will enable significant time and cost efficiencies for scientists and organizations deploying remote research and monitoring stations anywhere in the world.

With RockBLOCK providing a low-cost satellite data link, and ThingSpeak's ability to negate the need for an organization to buy and manage its own servers, databases and associated infrastructure, the entire scientific process — from data collection in the field and transmission through to analysis and communication of results — can be significantly streamlined and automated. Data is transmitted directly to ThingSpeak servers via RockBLOCK, where users can access it using a sophisticated toolset that enables effective management and dissemination of the data.

With the ability to execute MATLAB® code in ThingSpeak, data can be quickly analyzed and processed as soon upon arrival in the cloud. Storing data in the cloud provides easy access to data and using ThingSpeak's online analytical tools, it can be easily explored and visualized, enabling faster discovery of relationships, patterns, and trends in data.

Within ThingSpeak, data can be converted, combined and new data calculated and then visualized in plots, charts, and gauges. ThingSpeak also schedules calculations to run at certain times and enables data to be combined from multiple channels to build a more sophisticated analysis.

ThingSpeak and RockBLOCK create a low-cost yet powerful solution to collect data from remote locations, analyze that data using industry standard technology and finally act on that data through the use of automatic alerts or social media postings. While RockBLOCK takes care of the connectivity side of remote monitoring, integration with ThingSpeak enables users to deliver data directly to the cloud and manage it quickly and securely.

Aviation IoT

Going full circle, another hardware innovation at Rock Seven, is in the form of a new Iridium solution aimed at providing tracking and IoT connectivity for aircraft and vehicles. RockAIR delivers regular GPS location reports from anywhere in the world over the Iridium satellite network or GSM, helping to improve flight safety by accurately tracking the location of a light aircraft at user defined intervals.

While tracking systems for light aircraft already exist, the company has introduced a wealth of new features that are designed to bring extra functionality and safety through the RockAIR system.

For starters, RockAIR is the only dashboard mounted tracking system to offer dual mode functionality over SATCOM and cellular networks. The solution provides lower-cost GSM based tracking when in cellular range, and reliable failover to an Iridium satellite when outside of built-up areas; whether the aircraft is working over a city, or is in the middle of the Sahara, GPS coordinates will be automatically transmitted

using whichever network is available and most cost effective. This also provides an extra layer of safety and security not available in existing systems.

Enhancing safety even further, RockAIR is the only carry-on tracking system for light aircraft to feature an integrated back-up battery. The battery will automatically take over should the 9-30v DC or Micro USB power be interrupted. While this feature is vital for emergencies, a level of security against theft or unauthorized use of an aircraft is also provided.

RockAIR is CE, IC, FCC and DO160 certified, and at 119x100x25 mm / 210 g, the unit is easy to carry on board an aircraft and attach to the included dashboard quick release clip. The unit features its own built-in antennae but can also work with external antennae, allowing complete flexibility of the installation location.

In action, RockAIR can automatically transmit a GPS position as often as every 15 seconds, or as infrequently as once every 24 hours, all easily configured by the user. The unit also allows tracking profiles to be setup to enable faster rates if the integrated alert button has been pressed, if external power is applied, or if cellular data is being used rather than satellite. RockAIR also features a 'Watch Me' feature, accessible via the keypad, which informs the provider that more active monitoring is required for a period of time.

While delivering precise tracking is RockAIR's primary application, the company has integrated incredibly useful extra functionality that takes advantage of the always on connection the system keeps to the Iridium satellite and GSM networks. Users can send and receive low-cost, short emails and text messages using the free (iOS/Android) companion app over Bluetooth, ensuring that regardless of location, they can stay in touch.

In addition to all of the flight following and alert capabilities, being able to use the RockAIR's Bluetooth API provides a useful platform for connection to other in-flight apps for weather, NOTAMs (Notice to Airmen) live updates and other operational applications and messaging.

In parallel to the product's tracking and communication functionality, RockAIR is also a true IoT device and features an RS-232 port, which can be used for M2M data, thereby enabling users to connect sensors and computing platforms to the internet. A Bluetooth API makes it easier for light aircraft owners or technology developers to create their own apps that make use of the highly reliable connectivity RockAIR provides.

With RockAIR, the primary objective is to ensure high availability of tracking services, making the dual mode operation, back-up battery and alerting feature vital to improving safety. The extra messaging and IoT/M2M functionality complete the package, ensuring that RockAIR users can make the most of the connectivity provided by RockAIR however they want to.

While RockAIR is designed primarily for aviation users, they have also received interest in the system from government and private organizations operating land vehicle fleets. The beauty of the system is that all of its features will work as well on the ground as they do in the air, so the system will find a home in everything from fixed wing and rotary light aircraft to battle tanks, commercial vehicles and 4x4s.

www.rock7mobile.com/

*The **www.rock7.com/wind** infosite provides real-time weather data from the Calshot Spit Light Float.*

The float is managed by ABP Southampton and is fitted with instrumentation from Hydrosphere and Gill. Telemetry data is transmitted via Iridium satellite technology provided by Rock Seven.

An Orbital Micro Systems Focus

SmallSats: The champions of LEO commercialization

By William Hosack, Chief Executive Officer, Orbital Micro Systems

For many decades, NASA and other government-based space organizations, have led, driven, nurtured, and helped to create, a robust and fertile ecosystem leading to the commercialization of space-based technologies.

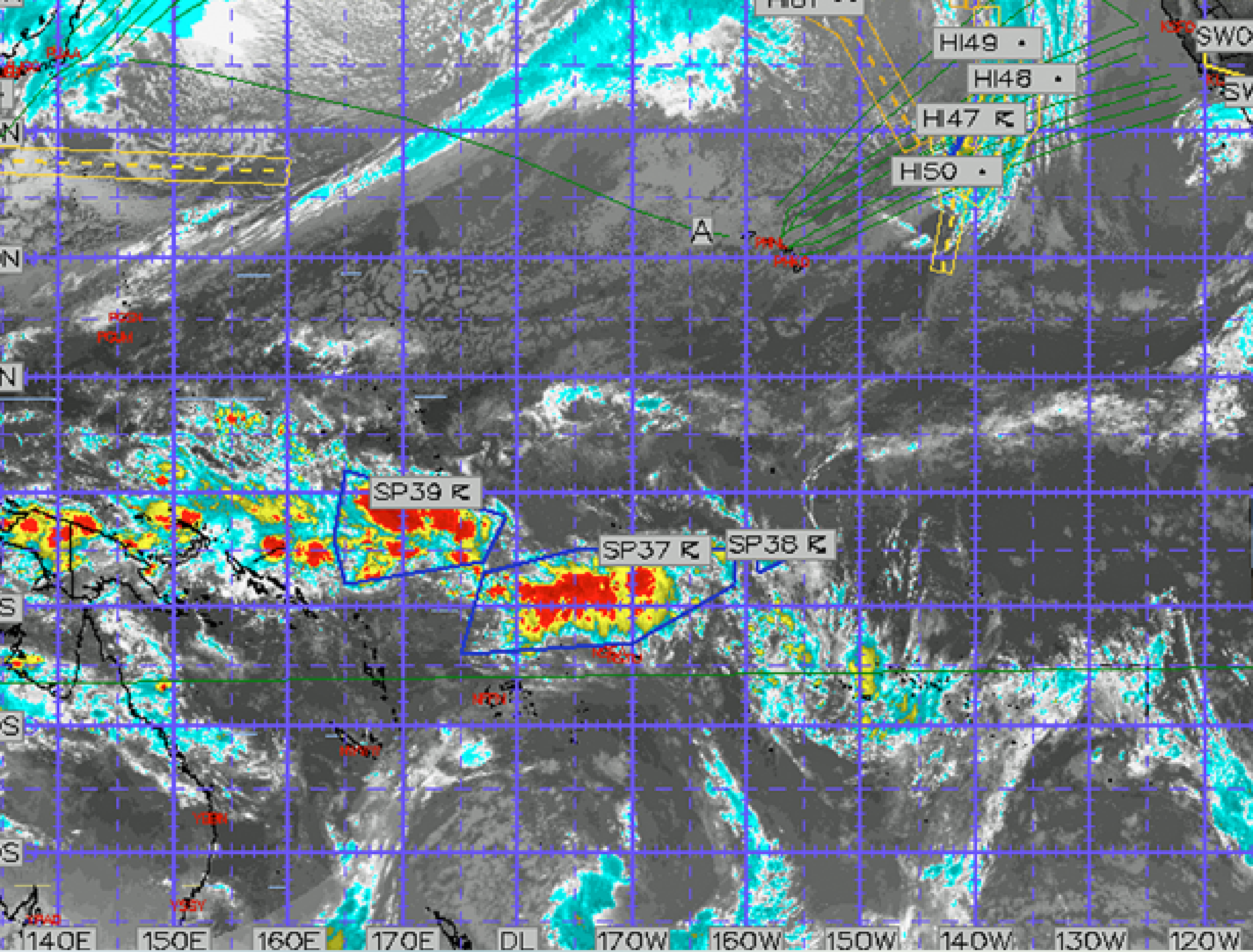
Much of these activities were driven by security interests, as well as the desire to maintain competitive standing in technology. Through public-private partnerships, and massive budgetary outlays, these government organizations have established a foundation that has become a launchpad for innovation and the commercialization of Low Earth Orbit (LEO).

Facilitating increased innovation in LEO is the rapid expansion of small satellite (smallsat) technology and launch opportunities. Smallsats, and in particular, cubesats, have changed the game in LEO.

Large facilities and systems occupying LEO include the International Space Station (ISS), the A-Train constellation and the Joint Polar Satellite System (JPSS) satellites. These massive — physically and functionally — platforms took years to develop, and huge sums to launch and maintain. They are loaded with capabilities and sensors, and are built with redundancy designed for zero failure tolerance.

Government-based missions such as these tend to incorporate broad objectives to push the edge of technology, but because they serve many needs, they also include many compromises. The resulting general-purpose missions touch on many new markets and potential business applications that can benefit from the research outputs of these missions.

The results of these activities are coming to light with the rapid expansion of private LEO-based satellite constellations with



carefully focused capabilities that create new commercial markets, or expand the capabilities of free public services. The new objective is to address the competitive and economic needs of specific industries. And the vehicle of choice for these business operators is the cubesat.

Why Cubesats and Why Now?

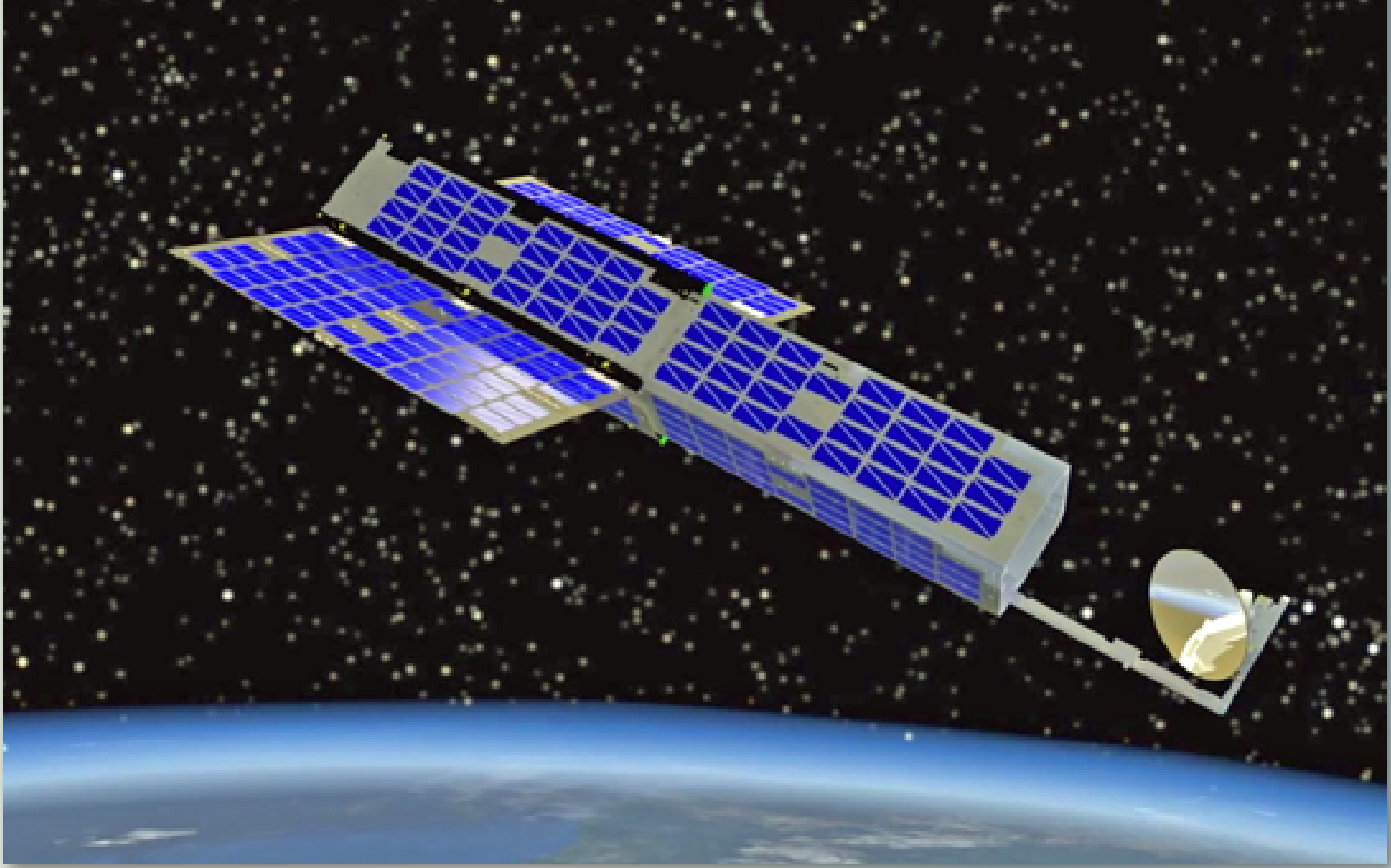
Cubesats are typically referenced in increments of 1U (10cm x 10cm x 10cm) and range from 1U to 24U. The capability to put cubesats into orbit has been around for some time, but in recent years, factors have converged to make commercial utilization more attractive. From 2000 through 2014, some 230 cubesats were launched. In 2017 alone, cubesat launches exceeded that amount.

While not inexpensive, the cost to build and launch a cubesat-based system can range from a few hundred-thousand dollars to a few million dollars — a small investment when compared with the multiple billions of dollars spent on government missions.

Currently, several innovative companies such as Orbital Micro Systems (OMS), as well as Spire, Planet and DigitalGlobe, have announced, or have launched, constellations of smallsats to provide high-resolution observations of the Earth. Key commercial markets for these services include insurance, food production, aviation and maritime transportation, and government.

Through normal competitive market forces, the costs associated with building and launching a cubesat have been reduced. Economies of scale, competitive pressures from bus providers, availability of dedicated, as well as piggy-back, rides to space, and advances in miniaturization, receiver sensitivity, computing capacity on-board and in dynamic cloud-based terrestrial systems, and continuous development of low-power, high-function electronics, all factor into the equation for growth.

Leveraging these capabilities and advantages, nimble and innovative companies are staking out territories for



commercial ventures. Among the most active markets are different types of Earth observation (EO), including high-resolution imagery, maritime tracking, and weather data collection. While large government missions also provide some level of capability in each of these areas, with their multi-purpose objectives, the information and data does not always fulfill the needs of the marketplace.

Cubesat operators have the advantage of creating purpose-built single- or dual-function devices that can be placed in constellations to provide near-constant global observation. For example, DigitalGlobe touts a global revisit rate of approximately one day for high-resolution digital images; Orbital Micro Systems plans for high-resolution weather data observations with 15 minute global revisits; Planet provides images of the Earth's landmass every day; and Spire offers highly accurate ship tracking throughout long ocean voyages.

Impacts of Weather Observation

One market with tremendous potential for economic success, as well as societal impact, is the expansion of weather data observation.

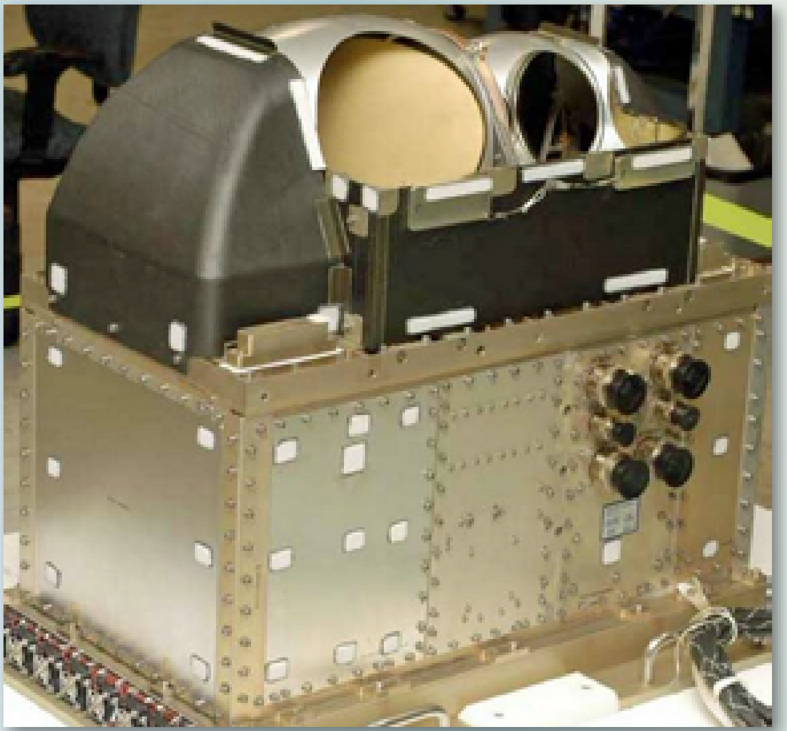
A seemingly unending stream of weather-related disasters have dominated the headlines in 2017, highlighting a consistently concerning global weather picture, and the need for better forecasting in every region. A key factor hindering the ability to understand and predict weather is limited by the low number of observation and sensing systems in LEO.

In some regions, such as North America and Europe, and parts of Asia, there is substantial investment in space systems, resulting in adequate weather observation density — on the order of three- to six-hour revisits.

Unfortunately, outside these zones, observation intervals are much longer, and in some cases non-existent. Weather data is as important in other world regions, but the resources aren't available on a global basis, and unfortunately, many areas of the globe, including less developed regions, receive little satellite weather coverage. It can be said that the government satellites, such as GOES and JPSS, already provide the required data and EO necessary. However, while these highly effective systems do provide adequate data, the small number of available samples from just a few satellites leave substantial holes in what is actually going on.

For headline-grabbing storms such as Hurricane Irma in 2017, the three- and six-hour interval weather data updates fed the hurricane track models, but short-term shifts in direction led to a missed landfall estimate — sparing Miami, and striking a less-prepared Tampa. Had a storm of this magnitude existed in a different part of the world, the models would have been even less accurate.

In general, more frequent data improves model accuracy and performance, providing ample warnings to communities at risk, and hopefully mitigating human and economic catastrophes. Just considering the case of extreme weather events, there is a strong business-case for high-revisit weather observation services.



Advanced Technology Microwave Sounder on JPSS. Cost: $140 million, 70x40x60 cm, 75 kg. 130 W power.

Looking beyond extreme weather events, the daily nowcasting and forecasting of LEO-based weather observations has a direct impact on agriculture, extending to food supplies and markets.

For example, nine of the ten largest rice producers in the world are in Asia. A staple food, and a large economic component for many of these countries, ensuring high yields and avoiding weather-related crop losses are important issues. Governments have actually toppled as a result of price spikes in rice. However, this region, has limited access to reliable weather data from space-based systems.

Lacking sufficient weather data, forecasting of weather patterns and events in Asia is difficult. The result is farming advances seen in other world regions have not been implemented. Many decisions are based on historical, custom and day-to-day weather observations.

Plantings are staggered to spread risk from bad weather washing out a new crop, harvests are sometimes lost when not completed prior to storms, and unexpected droughts or floods cause catastrophic losses. While weather cannot be controlled or managed, most farmers would agree that better forecasting and understanding of impending weather conditions, such as wind speeds, precipitation density, and temperature variations, would be a substantial improvement over the current practices used for farming.

The ability to cover the globe with state-of-the art weather observation technology, at a fraction of the cost of large government satellites, will have a dramatic effect on agriculture in currently neglected and economically disadvantaged regions. Cubesat technology not only enables this, but conducted in concert with commercial entities offering stronger and more affordable solutions, will enable these regions to benefit. There are equally compelling business cases in other vertical markets, as well — for every opportunity, there is a quickly expanding number of payload companies looking to compete.

OMS MiniRad cubesat radiometer. Cost: $100k, 10x10x15 cm, 2 kg., 5 W power.

Government's Continuing Role in LEO

Just as governments continue to lead other important sectors of science, such as medicine and public health, it is important to consider the development of LEO in a similar model.

In medicine, governments fund and encourage the research and development of new cures and treatments. However, when it comes to commercialization, they assume a regulatory role and let the marketplace take over.

For LEO, there is a similar inflection point. Government focus should continue to invest and support cutting edge technologies, national security, research and developments that will pay greatest returns for society, while ceding the commercialization to entrepreneurs and innovators in the private sector.

The convergence of multiple factors is defining an inflection point that makes the transition of LEO use from the domain of governments and science to an active and highly competitive landscape for commercial development and innovation.

Innovation will be driven through the greater access to LEO via cubesats and a healthy competitive playing field.

With this framework, all citizens will derive the most value from new technology and investment and markets will get much-needed solutions to address very specific business and market requirements.

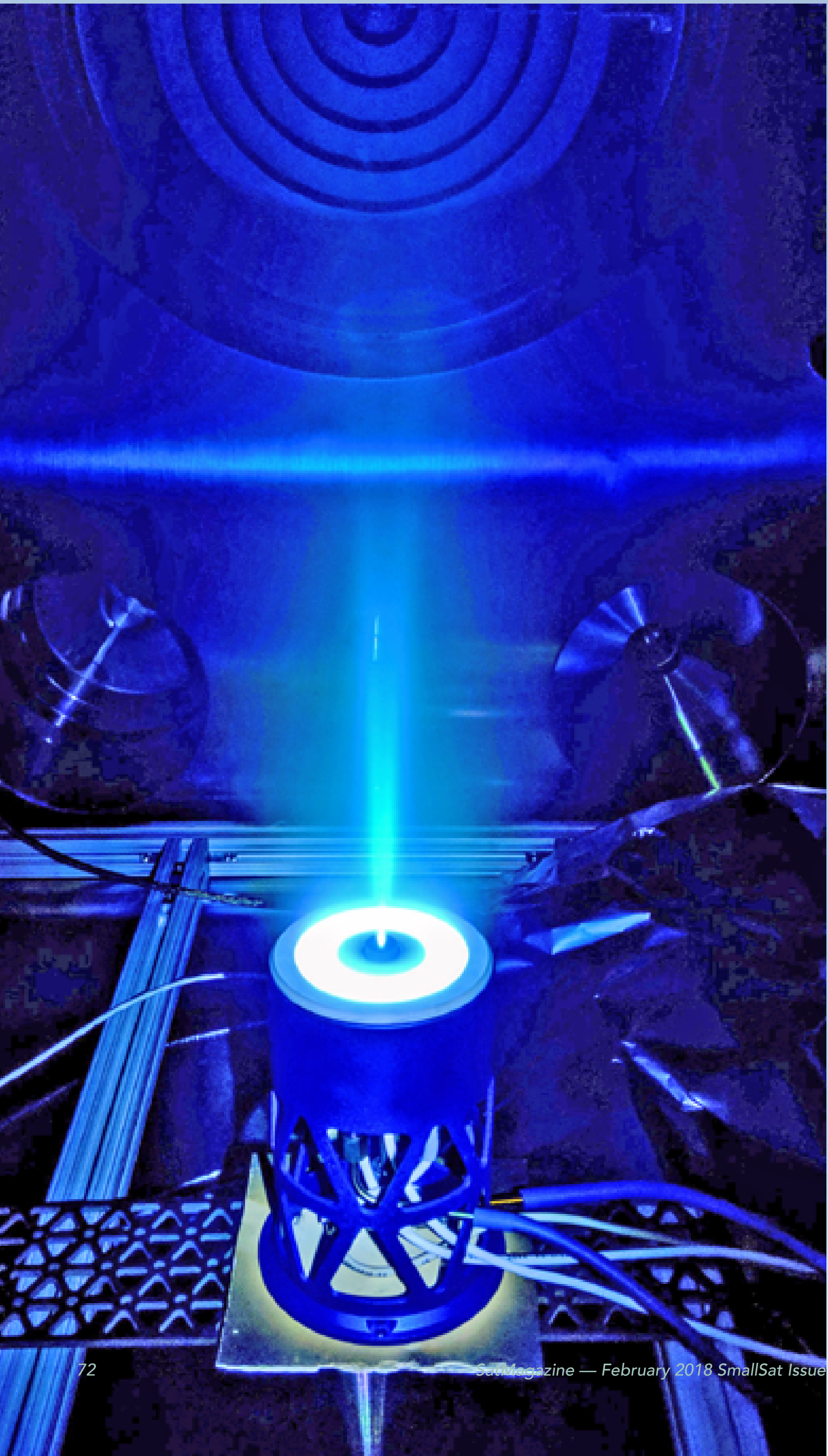
www.orbitalmicro.com

William Hosack serves as chief executive officer for Orbital Micro Systems. His extensive aerospace background includes, twenty-eight years of supply, production, and senior management experience, executive management consulting, expertise in strategic business development in Asia, and as a compliance expert for export and ITAR in Southeast Asia. William studied Aeronautical and Space Management Operations at Embry-Riddle Aeronautical University. He is also an IFR Certified private pilot.

An Apollo Fusion Perspective

The trade space will change in 2018 due to new propulsion systems

By Ben Longmier, President and Co-Founder, Apollo Fusion



Some 7,000 satellites have flown on orbit during the 60 years since Sputnik was launched.

Recently, several companies have filed FCC applications with their goal being the launch of more than 30,000 new satellites during the next five years.

By leveraging miniaturization, commercial off-the-shelf technology, and mass-manufacturing techniques, companies are changing the economics of satellite missions to enable ambitious projects that previously were not possible. One of the key components of this new generation of constellations is the satellite propulsion system.

New developments with Hall thrusters are introducing major improvements which significantly reduce volume and mass while providing the performance for demanding missions.

These innovations are creating a significant number of commercial opportunities for imaging, synthetic aperture radar, and telecommunications satellites, and everyone wants to be first to the market.

2018 is the first year new propulsion systems will change the trade space. The teams designing the new class of constellations face many challenges. Engineers and scientists must design a satellite that meets tough performance requirements. The goal is a satellite that is priced low enough to make the constellation profitable and that can be launched in larger numbers, at a faster rate than ever before possible.

Once the satellites are launched, the operators must move these satellites to their correct orbit, constantly monitoring and adjusting the positions of all satellites in the constellation to avoid collisions with the ever increasing number of satellites and debris in orbit. Until now, the satellite propulsion systems placed major constraints on the sizes of the satellites themselves.

Historically, propulsion systems have been bulky, expensive, and manufactured "by hand." Traditional chemical propulsion systems could occupy as much as 50 percent of the satellite's volume and mass in order to boost the satellite into the proper orbit. In the last several decades, the much more efficient electric propulsion systems (ion propulsion and Hall Effect Thruster systems) have helped reduce the mass and volume fractions to 30 percent of the satellite mass and volume.

In the last couple of years, several new companies (including Apollo Fusion) have been developing even more compact electric propulsion systems — these would occupy a mere 10 percent of the mass and 5 percent of the volume of a satellite by taking advantage of better thruster efficiencies, smaller electronics as well as novel propellants.

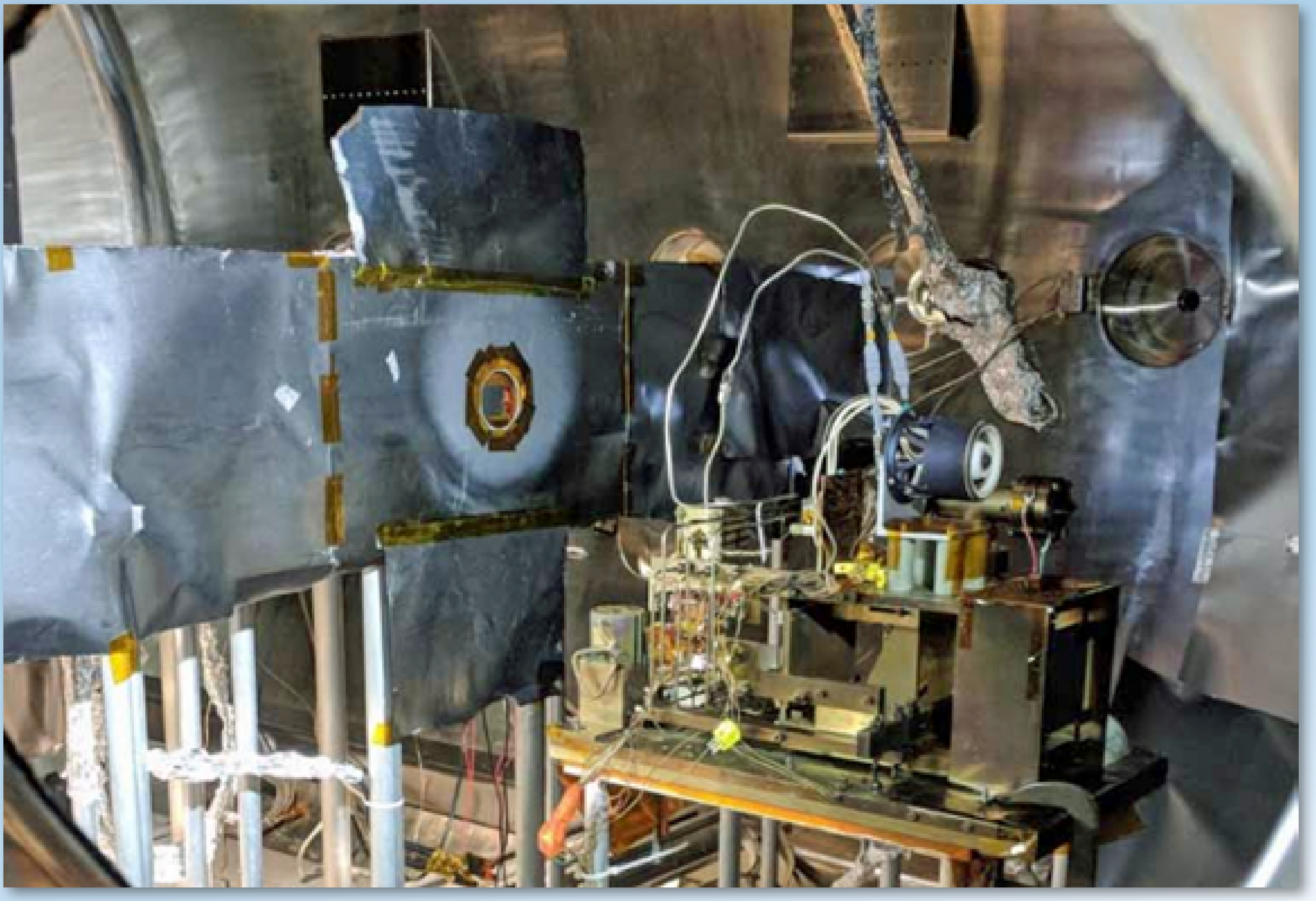
When every kg. of mass launched into space costs as much as the price of gold ($15,000/kg.), every gram counts!

The extra mass and volume savings of a satellite achieved by switching to a higher performance propulsion system results in less expensive satellite price tags, or more space for revenue-generating payload — or both.

With smaller and more powerful propulsion systems, teams are now considering the advantages of flying in the lowest possible orbit.

Telecommunications and Earth imaging companies are deploying vast constellations. Some will use propulsion systems to efficiently maintain altitude in orbits lower than ever before experienced.

These lower altitudes mean faster data rates for telecommunications missions and increased resolution for Earth imaging. For these new missions, improved propulsion systems can boost the key drivers of revenue growth — imaging resolution and mission duration.



Apollo recently tested their ACE thruster in an independent lab at The Aerospace Corporation where thrust, Isp, and efficiency measurements closely matched Apollo's own lab tests. These results confirmed that ACE has 3x better impulse per kg and 3x better impulse per liter than competing thrusters.

Vibration tests at Quanta Laboratories were designed to exceed the loads experienced by satellites on eight popular launch vehicles. With random and sine loads up to 13 G's, ACE withstood the harsh conditions and passed all tests without damage.

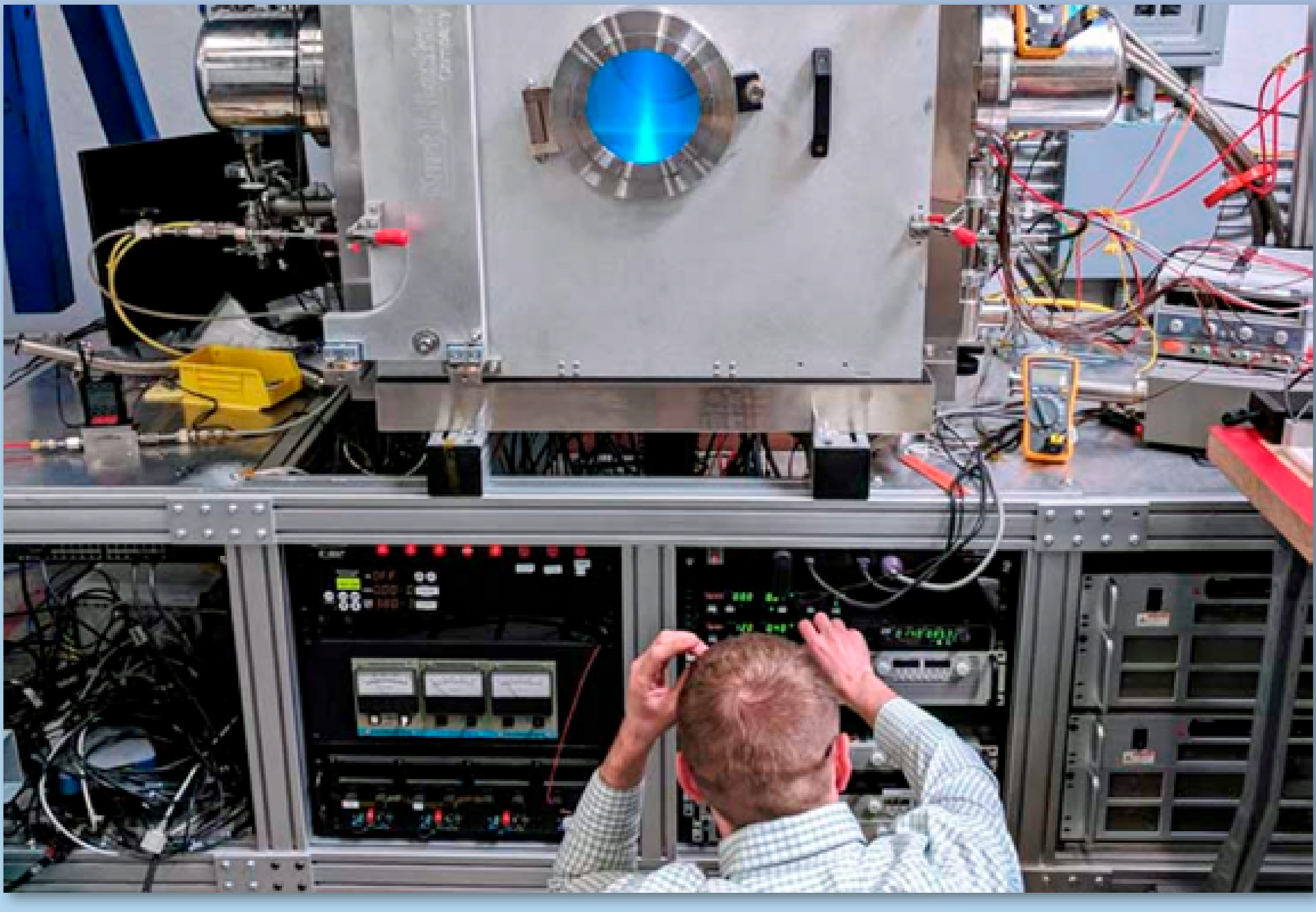
Manuevering from LEO to GEO orbit.

For telecommunications satellites, LEO altitudes can reduce the distance between satellite and customer by half. By positioning the satellite 20 times closer to the customer than a GEO satellite, data rates can be as much as 400 times higher, resulting in reduced latency and greater revenue potential.

Earth imaging satellites like to fly as low as possible, increasing their image resolution. However, at such low altitudes (300 to 350 km) satellites are at risk of being pulled into the Earth's atmosphere and burning up within weeks after their launch.

Previously, engineers designing Earth imaging satellites had two options: increase the optical aperture size to increase image resolution at higher altitudes or fly lower and use chemical propulsion to maintain altitude for years. Both of those options are expensive. Increasing aperture size is one of the more expensive hardware upgrades an observation satellite manufacturer can make.

Chemical propulsion systems are also expensive and there's also the additional cost of a losing a satellite once



Using Apollo Fusion's four test chambers, the team completed a series of lifetime tests using three different types of propellant over hundreds of hours of operation including hundreds of start/stop cycles.
Results indicate reliable performance and an operational lifetime expected to exceed 4,000 hours.

the chemical propellant runs out after only a year on orbit — long before the satellite is considered obsolete.

Engineers may now select to use high performance Hall thrusters to maintain an imaging satellite's altitude at 300 to 350 km. for approximately five to seven years. This allows Earth imaging satellites to double their resolution at one-fifth the cost of increasing the aperture size.

In 2018, attaining GEO will become far less expensive and faster to implement an orbit.

Other satellites with GEO missions have, until now, been locked into expensive GTO launch options with less frequent and less flexible launch schedules.

For these GEO satellites, compact, high thrust electric propulsion systems can significantly reduce launch costs (by at least $5 million for some satellites) and accelerate schedules by enabling mission planners to select a LEO launch and to use electric propulsion to move satellites from LEO to GEO. Many constellations are expected to take advantage of this capability to reduce their launch costs.

With these innovations, satellite manufacturers can now do things that were previously never possible.

2018 promises to be the year that economical satellites make their orbital debut, enabled by higher performance propulsion systems, smaller COTS electronics and reduced launch costs.

apollofusion.com

Ben Longmier holds advanced degrees in Physics, Nuclear Engineering, and Plasma Physics, is a former professor at the University of Michigan, and was the founder and CEO of an aerospace company which was acquired by Apple.

Executive Spotlight

Meir Moalem, CEO and Managing Director, Sky and Space Global

A jet fighter pilot, Lt. Col (Ret.) of the Israeli Air Force (IAF), Meir has more than 20 years of experience in management, R&D and operation of state-of-the-art projects in Space Systems and Unmanned Aerial Systems.

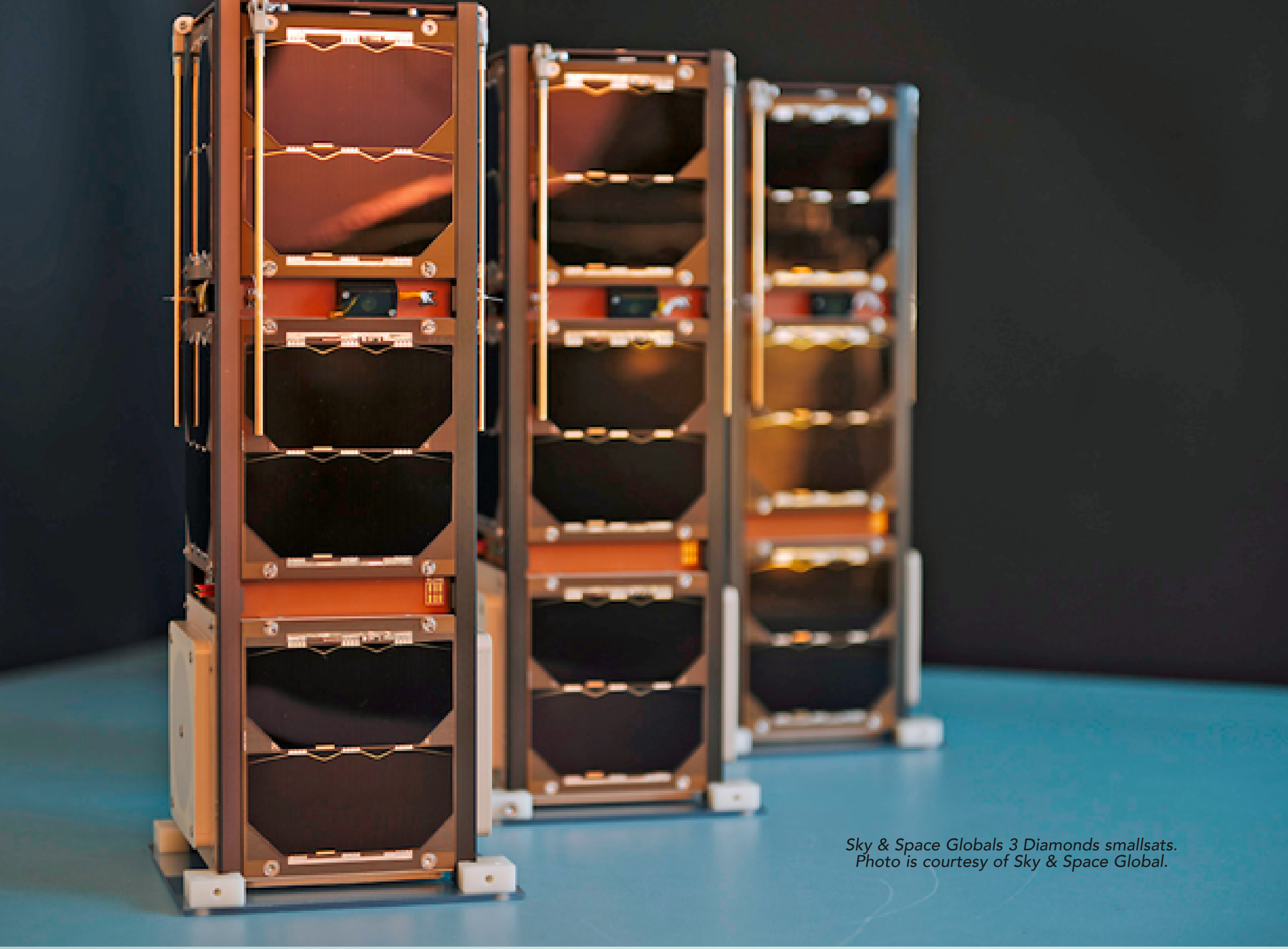
He was the project manager for Israel's first astronaut flight and has been managing Israel's satellite projects (such as Ofeq, Tecsar and more) for several years.

Moalem has now established his own company, Sky and Space Global, and he recently managed the launch of the company's first set of smallsats.

He has a B.Sc. in Physics and Computer Sciences (with honors) and an M.A. from the Diplomacy and National Security executive program (with honors). Currently, he is working on his PhD in national security and space programs. Meir has also received the Israel National Defence award in 2009.

Who are Sky and Space Global and what is your mission?

Meir Moalem (MM)
Sky and Space Global is a UK-based start-up, registered in the UK in November of 2015. It is the first company to use smallsats to build a proprietary communications network in the equatorial belt, which will deliver affordable communications services for businesses operating in this region, and for people living in emerging markets.



Sky & Space Globals 3 Diamonds smallsats.
Photo is courtesy of Sky & Space Global.

This technology will allow telecom operators, enterprises and communication service providers to deliver affordable connectivity services to remote locations that do not have access to reliable and affordable connectivity services. The company's ultimate mission is to provide affordable communications services to anyone, anywhere, anytime.

How many satellites have been launched?

MM
On Friday, June 23, 2017, Sky and Space Global launched the firm's first three nano-satellites, the 3 Diamonds. This launch is part of the company's mission to launch a constellation of 200 nanosatellites by 2020, providing full coverage of the equatorial areas of Earth, including South America, Central Africa, and Southeast Asia. These smallsats are controlled by a proprietary network management software platform that will enable the constellation to automatically manage, monitor, and control orbital maneuvering.

The 3 Diamonds have been going through rigorous In Orbit Testing (IOT) and, so far, have performed as expected, while also demonstrating a few first-time-ever: first time of demonstrating Inter Satellite Links by nanosatellites; first time of demonstrating orbit maintenance and relative distance control by use of differential drag and satellites maneuvers; and soon demonstrating the first time ever voice calls are supported via nanosatellites.

What sets Sky and Space Global apart from its competitors?

MM
Sky and Space Global strongly believes that affordable connectivity is a basic human right in today's world and is committed to providing affordable access to essential voice and data services to remote locations in developing economies across the world.

Nano-satellites have thus far been used in the Earth observation (EO) domain as part of commercial business models, mostly controlled by smallsat operators. However, no company other than Sky and Space Global is working on utilizing the nanosatellite narrow-band connectivity in the mainstream communications domain, especially in the civilian sector. This is what makes Sky & Space Global unique.

Sky and Space Global is also building a proprietary network management software platform that will enable the satellite constellation to function autonomously, conducting both health management and essential transmission activities. This will remove the need for a widespread network of ground stations for round-the-clock telemetry and replace it with an interconnected capability covering all the nano-satellites in the constellation. The ability of this system to manage satellites autonomously makes the Sky & Space Global constellation truly unique in the industry.

Has Sky and Space Global entered into any partnerships?

MM
Sky and Space Global has entered into a number of partnerships and commercial agreements to help realize its aim of providing affordable communications services to anyone, anywhere, anytime.

Recent partnerships include, but are not limited to:

- ***WeFarm Ltd.***
  In May of 2017, SAS signed a Memorandum of Understand (MOU) with WeFarm Ltd., the world's largest knowledge and data network for small-scale farmers. The MOU was to explore the integration of the SAS nano-satellite communication platform into WeFarm's process of on-boarding users, who are small-scale farmers living in remote and isolated locations.

- ***Globalsat***
  In March 2017, Globalsat Group and Space Global announced a MOU (Memorandum of Understanding). Under the agreement, Globalsat Group will take part in early trials of the Sky and Space Global satellite system. The non-binding deal also involves working towards establishing a commercial agreement for providing services to end-users across Globalsat Groups' multi country footprint.

- ***U.S. Department of Defence***
  In February 2017, Sky and Space Global signed a Cooperation Agreement for Sharing Space Situational Awareness Services with the Department of Defence (DoD) of the United States of America. This marks the first contract of its kind for the company and the DoD and recognizes the mutual objectives of both parties to ensure safe and peaceful space flight operations.

- ***SocialEco***
  Sky and Space Global signed a Memorandum of Understanding (MoU) with SocialEco, a London based IT company that produces a $1 smartphone, also with the vision to bring affordable, universal connectivity. The MoU stipulates that SocialEco and Sky and Space Global will initially explore potential markets, products and commercial opportunities to bring together SocialEco's $1 smartphone and Sky and Space Global's network coverage.

- ***Beeptool***
  Earlier this year Sky and Space Global entered into an agreement with the mobile messaging and payments app Beeptool Llc. Under the terms of the deal, BeepTool will collaborate with Sky and Space Global on a pilot program that will integrate the BeepTool app with the company's telecommunications software systems to provide affordable communication and payment services to certain regions in Africa.

What does the future hold for Sky and Space Global? Do you have any future plans or projects?

MM
Sky and Space Global plans to deploy 200 smallsats by the close of this decade. By 2020, the company is planning to have a full equatorial constellation and provide 24/7 services of voice, data, instant messaging and M2M/IoT, enabling the firm to be positioned for scaling up the system, depending on the market opportunities.

The company believes that constellations of smallsats will soon be able to provide more and more space related services to every human being, and at affordable prices. By focusing on delivering satellite connectivity services, rather than on the satellites (although the company's satellite constellation will be upgraded constantly), Sky and Space Global will be able to maintain its position in the market and will keep providing competitive services and, more importantly, affordable connectivity to the people who needed the most.

What are the key market opportunities that your technology is addressing?

MM
As this world is becoming increasingly interconnected, the demand for affordable connectivity is growing dramatically. This growth is partially driven by the increasing adoption of mobile technology in emerging markets and by the growing demand for data.

Despite the rapid adoption of communication technology across the world, there are still almost four billion people living without affordable mobile coverage in emerging markets. This creates a huge demand for connectivity services in remote locations.

The mobile market is a key player in enabling companies to reach new customers and offer new services and the mobile industry can also create a lot of new jobs in these markets. However, for the full potential of mobile communications to be realized, the citizens of these countries need cost-effective access to mobile networks, to affordable devices and data services.

Smallsats have the potential to provide affordable connectivity to anyone, anywhere, anytime in the world and offer a great alternative to traditional satellite communications, which are quite costly.

The ability to provide mobile coverage in remote locations is vital for building a healthy information infrastructure in developing countries where poor connectivity is a barrier to education, healthcare, business growth and economic prosperity.

This is why Sky & Space Global's mission is not only becoming a leader in building innovate satellite technology, but also as a company that helps to drive digital inclusion across the world. It's about providing affordable connectivity to everyone and creating more opportunities for people across the world.

What have been the major recent trends and challenges in your sector of the telecommunications market and how has your business adapted to these?

MM

Currently, the telecoms and utility industries are under a lot of pressure to innovate with data and connectivity services, all the while cutting costs. In the telecoms space in particular, the consumer-driven data consumption, fueled by live video streaming and the rise of content-heavy VR/AR apps, has put unprecedented pressures on networks. This has created a greater need to expand capacity, while also reducing costs.

Simultaneously, developed markets are becoming increasingly saturated with communications service providers and offer limited opportunity for incremental growth. This is why many global telecoms companies are looking to expand into emerging markets. However, the lack of coverage in remote locations, combined with the lack of affordable connectivity solutions, is making this an extremely challenging process.

Sky and Space Global's unique technology and business model allow the company to build a low CAPEX space infrastructure, based on smallsats which are less expensive to produce and launch.

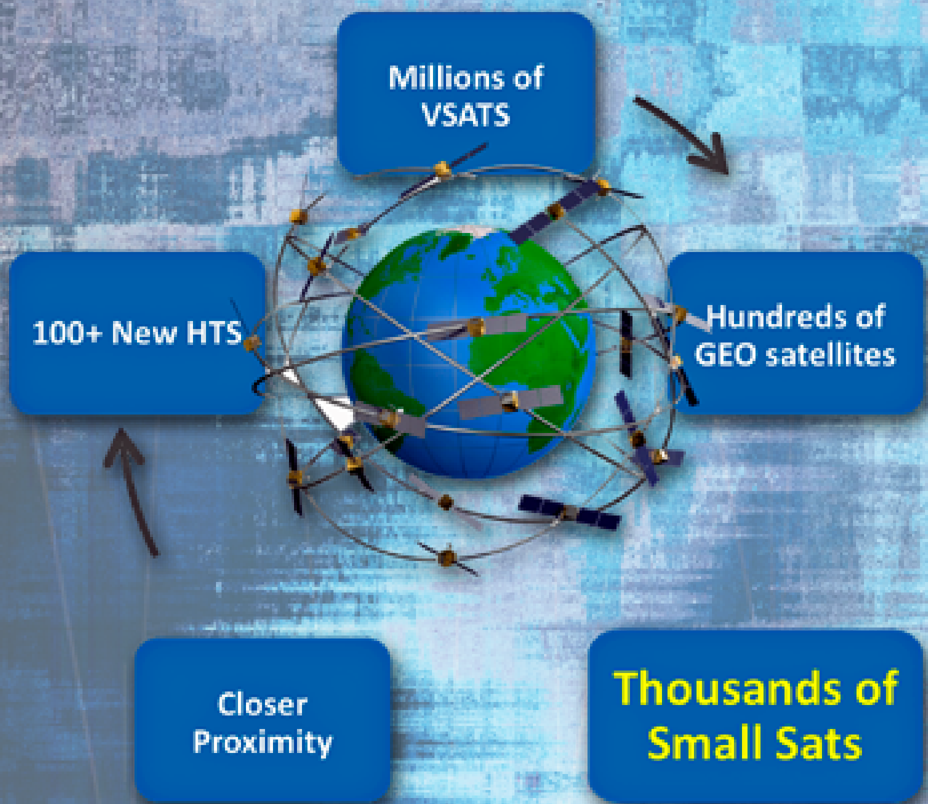
The company also has low operational costs as the nanosatellites will be managed by an autonomous network management software program. This allows Sky and Space Global to offer services of narrowband satellite communications at much more affordable prices than traditional satellite connectivity services. Therefore, the total capital and operational costs of Sky and Space Global is a fraction of the cost of competing services and is disrupting the market.

www.skyandspace.global/

A Kratos Perspective

The Growing Specter of LEO/GEO Interference

By Bob Potter, Vice President, Signals and Ground System Technology, Kratos



Thousands of smallsats will add to a growing RF interference issue...

Small satellites (smallsats) are creating new and disruptive opportunities in today's space industry — applications that were once the purview of traditional satellites in geosynchronous equatorial orbit (GEO) are finding that, in a growing number of cases, those applications (Earth observation [EO], imaging, etc.) are being performed by small satellites in Low Earth Orbit (LEO).

Big satellite programs can take decades to procure, build, launch and operate at price tags in excess of a billion dollars. In contrast, the benefits of smallsats can be significant — lower costs to acquire and launch, plus a higher refresh cycle that supports rapid technology insertion as programs and technology evolve.

Additionally LEO satellites offer reduced communication time lag (latency), require less energy to place into LEO orbit and less powerful amplifiers for successful transmission. As such, they are used for an increasing number of existing applications and are poised to add communication applications in the future.

However, unlike GEO satellites, LEO satellites are in non-geostationary (NGSO) orbits and thus require a constellation of smallsats to provide continuous coverage.

Significant Growth Anticipated... Along with LEO/GEO Interference

According to Statistics MRC, the global smallsat market is expected to grow from \$2.28 billion in 2016 to reach \$7.66 billion by 2023, with a CAGR of 18.8 percent.

Rising demand for high-resolution imaging services, lower costs and continuing technological advances are some of the factors driving the market.

However, the deployment of LEO constellations is apt to significantly escalate interference issues with GEO networks.

As proposed constellations are launched and the number of LEO satellites increases dramatically, so, too, does the risk of LEO/GEO satellite interference. This is caused when a LEO satellite crosses the path between a GEO Earth station and a GEO satellite.

This problem was first recognized during an earlier wave of proposed LEO constellations some 20 years ago. At that time, the International Telecommunications Union (ITU) stated that NGSO craft bore the responsibility for avoiding interference with GEO satellites.

Per the ITU, the responsibility was with the NGSOs to undertake measures, including power management, pursuant to Equivalent Power Flux Density (EPFD) limits, repointing beams so as not to interfere with the beam footprint of a GEO beam and changing frequency bands to avoid interfering with GEO transmissions.

Fast forward 20 years. Among the advances in GEO satellite technology is a significant increase in the sensitivity of GEO satellites, enabling satellite operators to utilize smaller antennas, *i.e.*, 2 meter vs. 6 meter. On the LEO side, as LEO satellites are closer to Earth, they also use smaller antennas.

While the smaller antennas have much upside, smaller footprint and reduced costs, they also have their downside. Smaller antennas have higher side-lobe gain, increasing the possibility of interference of operational power requirements. In the larger GEO antennas, side lobe gain might be 60 dB down. However, in small antenna, this will be much less so, making them more susceptible to interference

As a result GEO satellites previously protected from interference by LEO, EPFD limits are now more susceptible to LEO satellite interference, even though they operate within the EPFD limits established by the ITU.

At a 2016 conference, Daryl Hunter of ViaSat expressed additional concern that the deployment of smallsat constellations would makes the identification of LEO satellites that are violating ITU rules much more difficult — whether accidentally or intentionally occurring.

Frequency Sharing
To optimize the frequency spectrum, GEO and LEO satellite operators may sometimes share the same Ku-/Ka-band frequency band once the LEO operators, in their licensing application, demonstrate how they plan to minimize this potential conflict.

In this instance, LEO satellites crossing the equator will have to change bands to avoid interfering with the GEO satellite, whose frequency rights take precedence. Once passed the equatorial belt, they can resume frequency sharing with the GEO satellite.

Should LEO satellites achieve the numbers forecast for them, frequency sharing between LEO satellites and existing GEO satellites could become the norm rather than the exception.

Beam Pointing
In the northern hemisphere, GEO antennas point to their satellite in a mostly southerly direction, while LEO antennas will point in a northerly direction so as not to interfere with the GEO signals.

As LEO satellites cross the equator, their payload is switched off so as to not interfere, or be interfered with, the GEO antenna beam footprint. Once clear of the footprint, the LEO satellite is switched back on.

Power Management
As discussed earlier, power management on the part of the LEO operator is another means to avoid LEO/GEO interference. The potential issue is that as satellites become more sensitive due to beam shaping, the ground GEO antennas are getting smaller, which means lower Equivalent Isotropically Radiated Power (EIRP) to the satellite, and also less gain on the receive side.

The consequence is that side lobe gain of the antenna becomes relatively higher compared to larger antennas and so more susceptible to interference from legal third party transmissions such as frequency sharing terrestrial systems as well as LEO communication systems.

The question is: will EPFD limits for LEO satellites need to be reduced... and, will that power reduction have any negative effect on their ability to adequately perform their mission?

Kratos and the SmallSat Market

In addition to adapting its traditional satellite products to the smallsat industry as described above, Kratos is committed to the advancement of the industry with quantum®, a fully functional C2 to RF suite of solutions specifically designed to meet the cost, size and ease-of-use requirements of small satellites.

quantum's hardware agnostic software solutions leverage virtualization technology, reducing risk and eliminating integration labor. quantum's offering includes C2, signal processing, front end processing, and mission data processing capabilities for high demand applications and is uniquely engineered to support individual spacecraft missions, spacecraft, test, and spacecraft fleet operations.

The bottom line is that while there are approaches to minimizing LEO/GEO interference (power management, beam management and frequency sharing) these are going to become more difficult to manage as space is flooded with hundreds, if not thousands, of smallsats in multiple constellations.

To that end, Kratos is working with a number of LEO operators to enhance, and make more effective, the monitoring and management of EPFD limits, beam pointing and frequency sharing.

Working with LEO operators, Kratos is leveraging the carrier monitoring capabilities of Monics®, the company's industry-leading carrier monitoring and interference detection solution, the M&C capabilities of Compass® and the data analytic capabilities of Skyminer.

A packaged solution for LEO operators is being developed by Kratos to monitor the performance of a company's complete satellite network, drilling down to ground systems, satellite performance, beam pointing and power usage to minimize interference with GEO satellites.

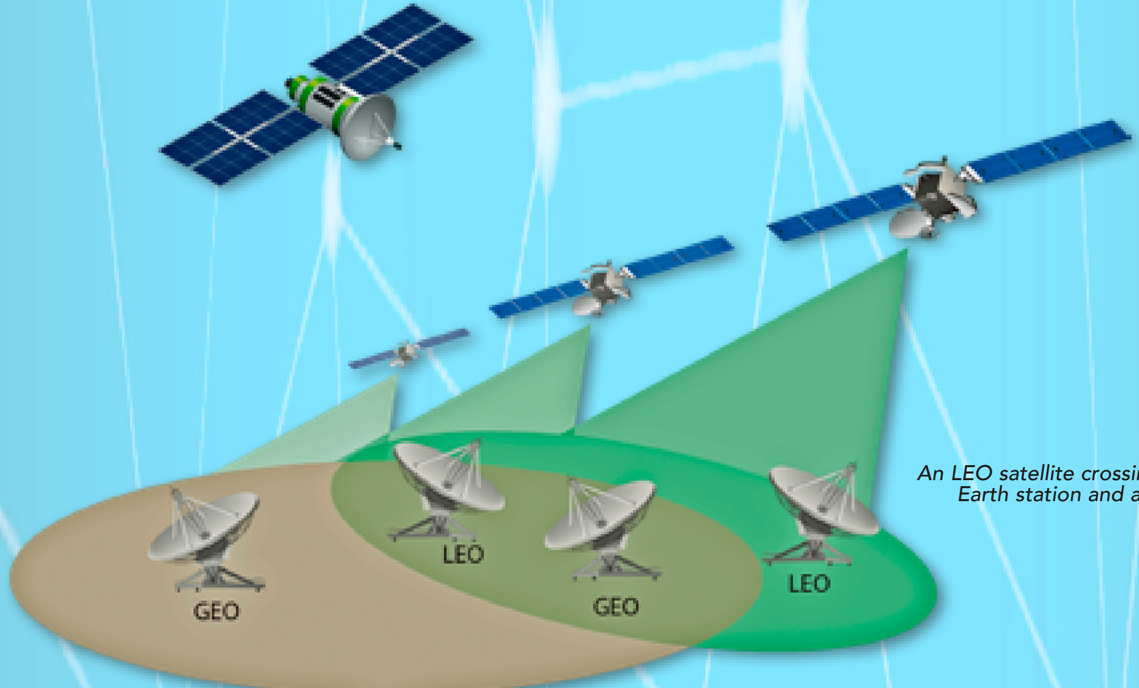
Monitoring Makes Good Neighbors

Kratos' approach to minimizing LEO/GEO interference is to enable the new smallsat constellations to act as "good neighbors" to their more established GEO counterparts.

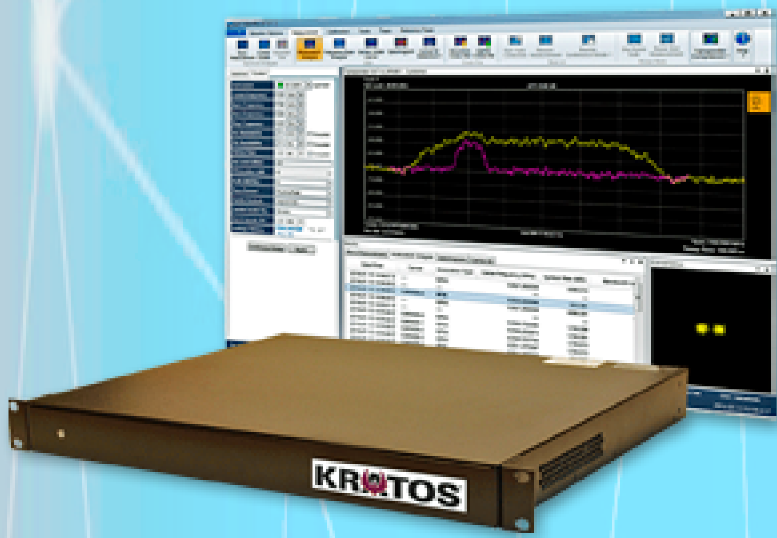
As envisioned by Kratos, in conjunction with LEO satellite operators, Monics will monitor the total performance of the LEO satellite to include beam patterns and pointing as well as measuring the RF energy to monitor compliance with ITU EPFD requirements.

For those LEO satellites sharing Ka-/Ku-band frequency with GEO satellites, Monics will monitor spectrum usage to ensure that there is no spectrum degradation to the primary user — the GEO satellite. Monics' algorithms and measurements are fast enough to adjust to any Doppler effects (shifts) that might occur during the satellite pass. Additionally, interference characterization, will determine local (terrestrial) interference affecting the LEO gateway.

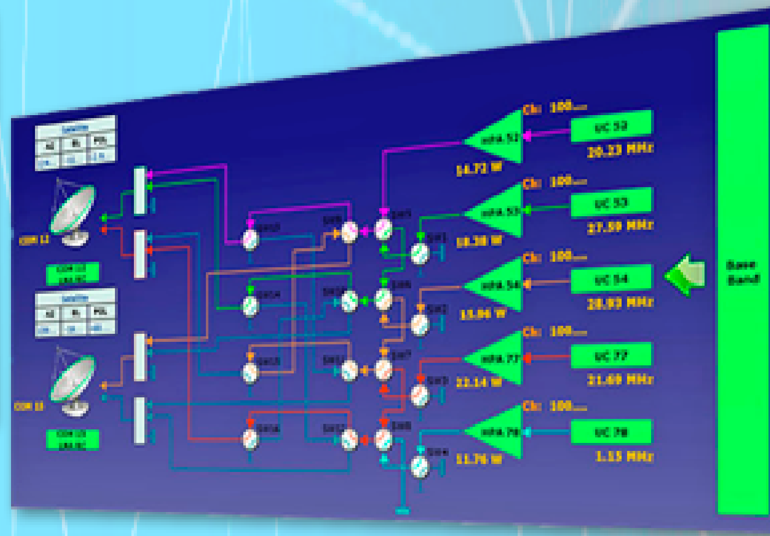
With Monics, all carrier spectrum monitoring is available through one logically organized client, increasing operational efficiency and reducing time needed to manage and protect the RF spectrum.



An LEO satellite crossing between a GEO Earth station and a GEO satellite.



Kratos' Monics with digital signal processors (DSP).



Kratos' Compass® screenshot.

Gateway M&C

While Monics monitors satellite performance, Compass monitors the LEO operators' ground operations. Compass will provide LEO operators with complete visibility to monitor and control equipment from a single management console; enable them to change displays, add devices and perform configuration changes with an easy-to-use interface.

Analysis/Corrective Action

Monics' satellite monitoring data will integrate with Compass' gateway M&C data to provide the LEO operator with service level assurance. The RF measurement becomes part of the data network management tool-set thereby assuring data throughput in Bits/Hz rather than dBW and MHz.

Dashboards provide instant system overview and situational awareness of the network, while advanced analytics from Skyminer provide prediction of outages due to external factors such as weather, along with trend analysis and cross correlation to determine localized interference issues. Skyminer offers unlimited aggregation capabilities and predictive analytics that provide the LEO operator the ability to compensate/correct potential performance anomalies (power usage, beam patterns, frequency sharing, etc.)

These proven capabilities — satellite monitoring, ground equipment M&C and analysis — will be integrated into a packaged solution for LEO operators.

Should even two of the proposed mega LEO constellations become a reality, they will affect all GEO satellites; thus LEO and GEO operators will need to actively cooperate to ensure that the best both have to offer are made available to all.

The majority of GEO satellite operators worldwide employ carrier monitoring and interference detection products such as Monics, which can provide early warning of potential LEO interference so that cooperative preventive/corrective action can be taken.

Today, a number of GEO satellite operators are either invested in LEO operators or are actively working with them. The cooperation between the two camps is driven by their common need–to coexist and neutralize interference.

www.kratosdefense.com

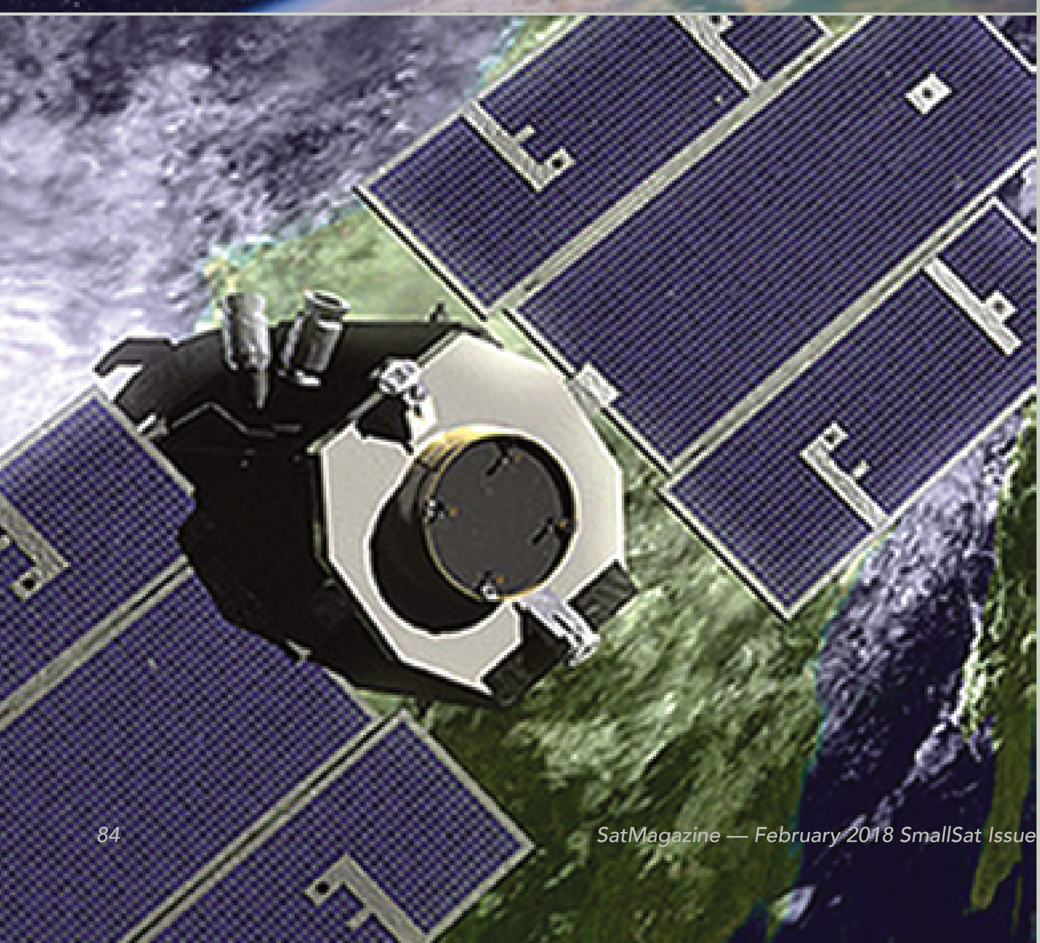
Editor's note:
An interesting article in Intelsat General Corporation's *SatCom Frontier* infosite, entitled "*Talking Space Technology with Kratos' Stuart Daughtridge*" discusses Continuous Wave (CW) Interference, the new Kratos modems that can address these issues, how interference monitoring can change for HTS as well as other interesting topics. To read this informative article, please visit ***www.intelsatgeneral.com/blog/talking-space-technology-with-kratoss-stuart-daughtridge/***

A Ball Aerospace Focus

SmallSats — single answers or tools for greater solutions? Yes!

By Debra Facktor,Vice President and General Manager of Strategic Operations and of the Commercial Aerospace strategic business unit for Ball Aerospace

The U.S. Air Force STP-SIV series of satellites is based on the Ball Configurable Platform (BCP) 100.



The small satellite (smallsat) market continues to grow — in interest, investment, capability and potential impact.

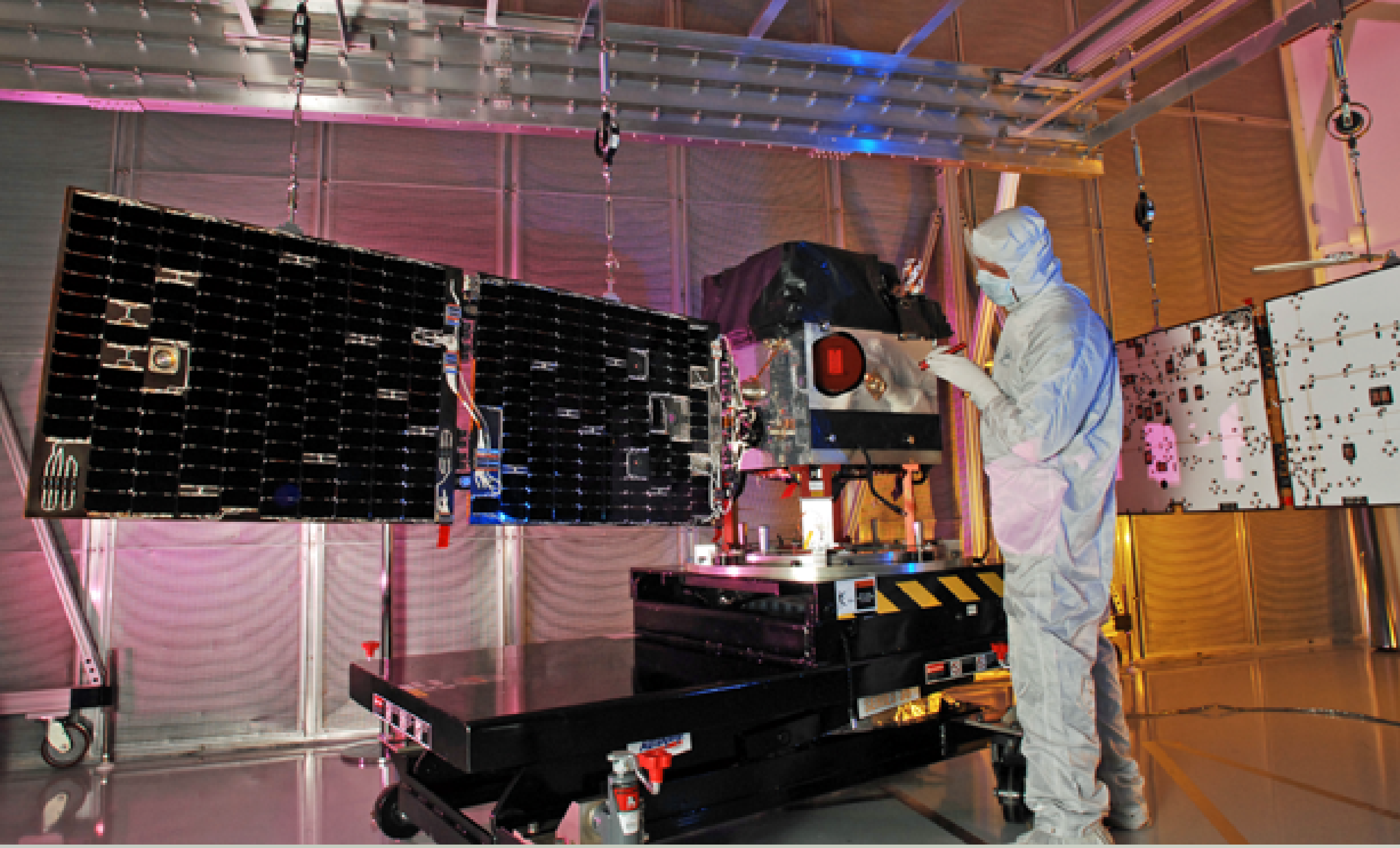
There is an opportunity for new uses including Earth imaging, space science, weather and climate, biology research, growing security threats and communications.

Commercial and government customers are increasingly considering how smaller platforms, coupled with more affordable access to space, shrinking budgets and improvements in technology miniaturization, can contribute to new solutions and markets.

Smallsats are maturing into systems capable of producing potentially valuable data. As this smaller technology becomes widely available, customers and providers must face a challenge relevant to all new products and capabilities—figuring out how it will fit into existing structures.

This process begins with identifying how smallsats affect the broader satellite market, specifically the existing capabilities and services that will be changed by the growth in smallsat technologies.

In addition, smallsats are emerging as a complement to larger, more exquisite architectures across the defense, science and commercial markets. They are proving useful in areas like technology demonstration missions and rapid access to space, and should be viewed as a supplement, rather than a replacement for programs of record.



A Ball engineer inspects the U.S. Air Force's STP-SIV small sat, which is built on Ball's BCP-100 spacecraft, developed for fast and affordable access to space. Photo is courtesy of Ball Aerospace

Defense

Augmenting large, government-owned systems with smallsat-enabled solutions and commercial business models is a benefit small sats can offer in the defense sector.

Government customers are increasingly interested in data from a diverse set of sources including everything from small satellites to airborne instruments and even stratospheric balloons. Companies that can integrate data from emerging technologies such as smallsats with data from existing architectures, can find a niche and enhance solutions for government customers.

For example, together with Spire Global, Ball Aerospace is using commercial data from smallsats to improve maritime domain awareness in the Arctic, which provides the National Geospatial-Intelligence Agency (NGA) with information on real-time shipping traffic and other activities in this strategic ocean basin.

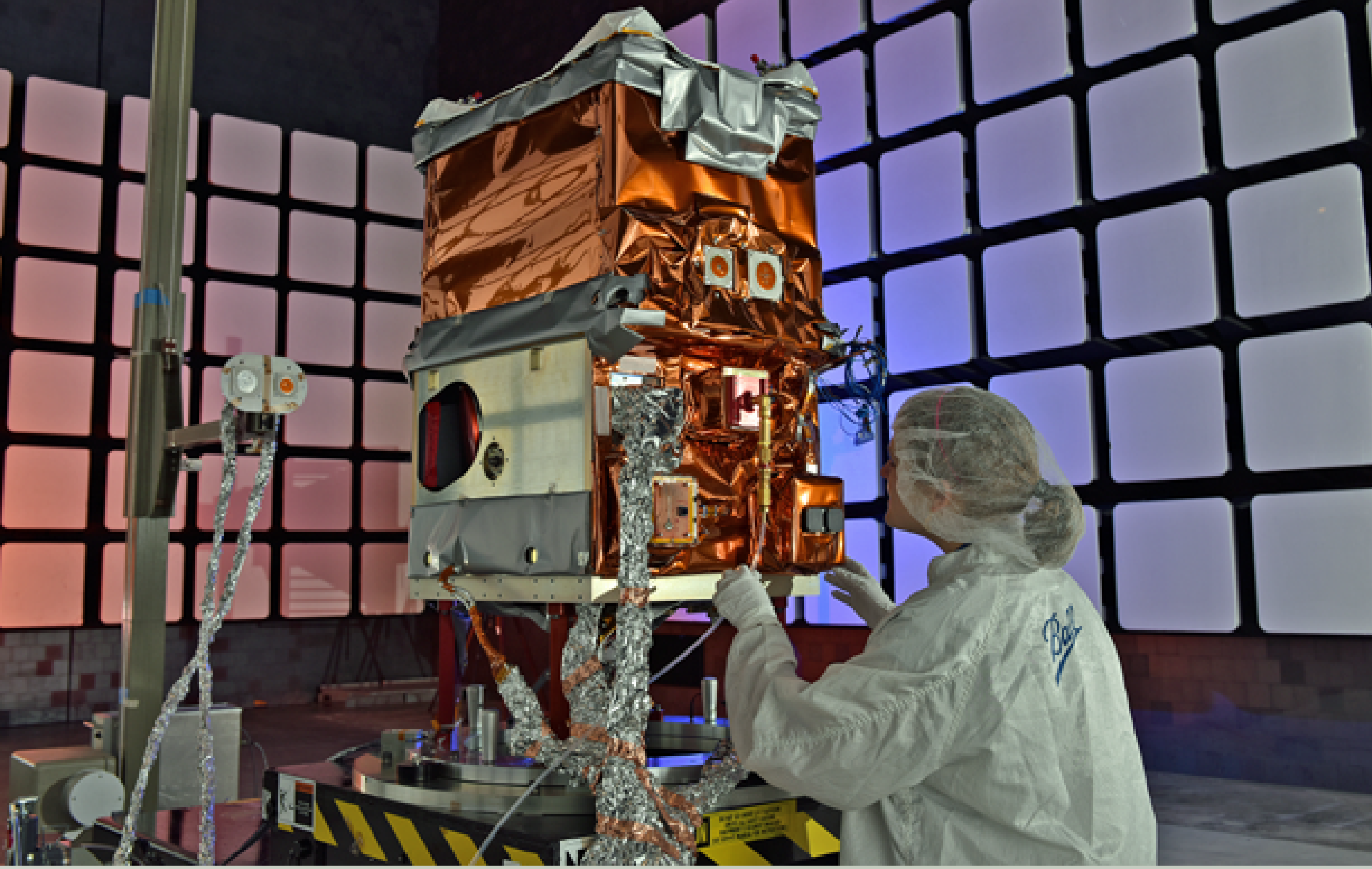
By combining data from programs of record like Landsat and Sentinel with new data from Spire cubesats, Ball is creating a data product that does not exist today, and making that data accessible and useful to its customer. This work for NGA demonstrates a successful case of connecting-the-dots across customers and industry partners to improve the NGA's existing data product.

The resiliency and rapid response afforded by smaller spacecraft is also a priority for defense customers. The U.S. Air Force Space Test Program's Standard Interface Vehicle (STP-SIV) project has developed a common spacecraft bus with a standard payload interface that improves the nation's ability to quickly and affordably launch satellites into space.

The STP-SIV series of satellites is based on the Ball Configurable Platform (BCP) 100, which is ideal for a variety of science, technology development, risk reduction and operational missions. Ball built two STP-SIV spacecraft buses with common payload interfaces, the second of which was built in only 47 days. The STP-SIV spacecraft, both STPSat-2 with three payloads, and STPSat-3 with six payloads, continue to fly and demonstrate flexibility and significant cost effectiveness after seven and four years, respectively, of on orbit operations.

Science

Smallsats are also making inroads for scientific applications. The platforms are lower cost, can be fielded more quickly and used to demonstrate technologies. Reduced development and launch costs means more money is available to conduct scientific observations. Government customers like NASA are exploring small satellites both from technology demonstration and mission architecture standpoints.



A Ball technician prepares the GPIM spacecraft in the Electromagnetic Interference (EMI) testing chamber. GPIM will validate a new high-performance spacecraft propellant, a safer and more fuel-efficient alternative to hydrazine.
Photo is courtesy of Ball Aerospace

One example of technology demonstration is NASA's In-Space Validation of Earth Science Technologies (InVEST) program. Ball Aerospace is designing and building the Compact Infrared Radiometer in Space (CIRiS) instrument for integration on a cubesat platform.

CIRiS will validate the ability of miniaturized science instruments, in this case a compact thermal infrared instrument that could be used for land imaging and water management needs, to effectively deliver highly-calibrated and scientifically-significant data while reducing overall costs.

Another technology demonstration, NASA's Green Propellant Infusion Mission (GPIM), will launch later this year to test a high-performance replacement to hydrazine fuel. On GPIM, NASA is collaborating with a Ball Aerospace team that includes Aerojet Rocketdyne, the U.S. Air force Research Laboratory and the Air Force Space and Missile Systems Center.

The mission will fly on Ball's BCP-100 class spacecraft, providing a flexible and agile small sat solution with standard payload interfaces and streamlined procedures, allowing rapid and cost-effective access to space. GPIM validates a new technology in an affordable way, creating a pathfinder for green propellant to be incorporated into future missions with reduced risk.

NASA is also capitalizing on smallsat architectures with its Explorers Program, which offers low-cost access to space for world-class scientific investigations. NASA's X-ray Polarimetry Explorer (IXPE), designed on the same BCP-100 configurable bus as the GPIM mission, demonstrates the diversity of small sat science mission architectures. From LEO, IXPE, an astrophysics mission, will examine the makeup of some of the most high-energy astronomical objects in the universe such as neutron stars and black holes.

Commercial

New market applications for smallsat platforms and constellations continue to arrive, expanding opportunities and increasing competition.

This environment is triggering a change in mindset for government customers who traditionally own and operate systems, and who are now open to considering how commercial data can be used to supplement existing capabilities. Government customers are becoming more open to procuring systems and or data in a more commercial way, such as using commercial acquisition practices or buying data results not hardware.

Understanding customer needs and providing data and answers are still the most important priorities for industry partners. For companies looking to do business in the commercial smallsat arena, the challenge lies both in developing reliable and resilient technology, and in integrating small satellite systems into the solution space.

Here again, Ball's work with Spire demonstrates the utility of fusing small sat data with data from existing government platforms and creating an integrated solution using a commercial model.

Commercial markets are also emerging for persistent imaging capabilities using results from stratospheric balloons which provide a platform that is complementary to smallsat constellations.

Ball and World View are collaborating on a proof of concept for high-altitude imaging using World View's Stratollites and Ball's sensors and analytics. This paves the way for new markets such as public safety, homeland security, and civic resource mapping and monitoring, by bringing together hardware and analysis at a fraction of the cost of existing technology.

People

Smallsats are also having a positive impact on the aerospace and defense industry's workforce.

The relatively low cost of smallsats, especially cubesats, enables university students in science, engineering and related fields to do hands-on work with space hardware — from design to launch and on orbit operations. The data resulting from these small satellites is increasingly more accessible to students who can learn from their results and test new operations.

Students are entering the workforce today with more hands-on experience on both hardware and data, and with the capability to immediately apply their skill set into the workforce in different ways than previous generations.

Single Answers or Tools for Greater Solutions? - Yes

Smallsats are opening doors to new data, partnerships and practices, and can be complementary to existing architectures and traditional programs.

Among the potential markets for smallsats, only one demand is constant in all of them: answers. Government and commercial customers care more about the quality, readiness, applicability and reliability of their data than what platforms those data come from.

In today's diverse marketplace, integrators must be prepared to merge small sat data and capabilities with that of other architectures – large and small – to produce the answers customers need.

www.ball.com/aerospace

Debra Facktor is the Vice President and General Manager of Strategic Operations and of the Commercial Aerospace strategic business unit for Ball Aerospace. As the leader of Strategic Operations, Facktor is responsible for increasing Ball Aerospace's profile in the market and facilitating collaboration across the company. She is the company's senior executive in the Washington, DC area and leads Washington Operations, Marketing & Communications and Strategic Development.

As the leader of Ball Aerospace's Commercial Aerospace strategic business, Facktor is responsible for developing and executing new business strategies across the company, and pursuing and performing commercial work in the areas of traditional space, integrated solutions and transformational communications for airborne and space platforms and data analytics.

An NSR Analysis

Destination Constellation: Too many passengers?

By Siddharth Shihora, Analyst, NSR

The space industry's wagon is packed with constellations — and that wagon is getting heavier by the day.

Deployment plans continue to come from emerging players to disrupt the market and from traditional players to counter this disruption. The question is: how many constellations can remain aboard, and how many will exit?

Commercial satellite constellations are not new — they came into full force in the 90's, although back then, they were heavy, complex, expensive and were comprised of fewer satellites.

Today, constellations are comparatively less expensive, weigh as little as 5 kg. and can be comprised of 100's of satellites.

Additionally, with the rising number of announcements of mega constellations financially backed by billionaires and multinational corporations, the possibility of future constellations consisting of 1,000's of satellites is on the drawing boards and is quite likely to occur.

Artistic rendition of an EO smallsat constellation on orbit.

The How and Why of Constellations

Analyzing the current market conditions, and anticipating the future manufacturing and launch market dynamics in conjunction with terrestrial competition, NSR forecasts more than 3,600 smallsats to be launched in the coming decade (2017-2026) as a part of constellations across all verticals, as opposed to the 10,000+ satellites cumulatively announced by constellation operators globally.

The first decade of the 21st Century saw the true potential of smallsats begin to be realized: early investors and entrepreneurs understood there were opportunities that could revolutionize the space industry. During this phase, the focus was on the manufacturing and launch side of the space architectures.

Start-ups, such as GomSpace and former Clyde Space (AAC Microtech), undertook the development of smallsat buses and payloads, while organizations such as Rocket Lab began developing dedicated launchers. Thus began the process of developing a market eco-system around smallsats.

The major contributors that brought about the smallsat revolution were the consumer electronics industry and educational institutions, with the support from national space agencies.

The consumer electronics industry provided low cost, high-performance Commercial-Off-The-Shelf (COTS) hardware at lower weight footprints, thereby reducing a barrier to entry, while establishing the preliminary technical foundation.

Educational institutions provided the skilled workforce with experience in smallsat design, integration, testing and operations by utilizing their in-house resources to develop nanosatellite programs.

Additionally, these institutions provided the demand for educational smallsats and stimulated the confidence to commercially utilize nanosatellites and microsatellites.

Commercial smallsat constellations entered the space industry between 2009 and 2010, with announcements of 22 microsatellites from Skybox Imaging (now Planet), and 150 nanosatellites from Planet Labs (now Planet). Since then, more than 70 commercial smallsat constellations have been announced.

The majority of satellites projected to launch are from the communications segment and originate from mega-constellations that are similar to OneWeb.

Prior to these mega communication constellations, Earth Observation (EO) applications were the most dominant market segment for constellation operators, with plans of deploying a variety of payloads with different spectral bands, resolutions, and revisit rates.

Who is Boarding?

Organizations participating in this commercial space race aim to enter the market with constellations that provide greater coverage and lower latencies in order to satisfy the requirements posed by emerging applications such as Machine-to-Machine (M2M) communication, Internet of Things (IoT), Big Data analytics, and internet services.

Investors and financiers view this as a big investment opportunity, thereby engaging and funding emerging constellations to the tune of $3 billion since 2000.

Operators, such as Hera Systems and Satellogic, intend to target the EO market with near real-time imagery and on-demand tasking, while providing multiple revisits per day over high-priority regions.

On the communication side, constellations such as OneWeb and Starlink (SpaceX) leverage low-latency alternatives to existing space-based internet services from Low Earth Orbit (LEO).

Nevertheless, these revenue opportunities are tied to the applications noted above and come at the cost of developing constellations with large numbers of satellite that are CAPEX-intensive.

Smallsat constellations are seen to leverage either innovative or disruptive technology, to address the demand of downstream space applications with both commercial and public service objectives.

They intend to provide solutions to real-world issues such as connecting the unconnected billions, playing a vital role in tackling illegal activities in fishing, mining, and forestry.

Planet's NGA contracts, Sky and Space Global's Beeptool contract and Spire's contract with the National Oceanic and Atmospheric Administration (NOAA) are some examples that demonstrate their commercial potential.

On the other hand, among the several constellations that have been announced in the last seven years, only one has been completely deployed and only one organization has seen a lucrative buy-out.

This overall performance triggers alarm bells when objectively looking at the market. Partially, the eco-system surrounding the smallsat market is to be blamed, especially dedicated smallsat launch service providers, some of whom have gone years past their 'official' market-entry timelines and are part of the smallsat launch bottleneck problem.

At the same time, some operators are to be held accountable, as well, as they spend a large portion of their time vertically integrating and/or undertaking R&D tasks for systems that can be outsourced to commercial manufacturers, thereby delaying their entry to the market.

The opportunities offered by smallsats are now being used in overdrive mode, especially when there are numerous copycat constellations planned, most with similar technologies and plans to deploy 100's and 1000's of CAPEX intensive satellites.

Buying the CAPEX Ticket

Constellation CAPEX is directly related to the number of satellites in a constellation and the design life of those satellites.

Constellations are fueled by satellites and the efficiency of this fuel depends on the satellite design life. More than seven operators across all major applications are seen to compromise design life for one-time CAPEX savings — a strategy that may not prove cost effective especially when 100's of satellites are to be launched.

On the other hand, some operators possess satellites which are designed for longer lifespans but have selected to replenish their constellation prematurely in order to deploy more advanced satellites into orbit, thereby entering the replenishment phase much earlier and thereby incurring added costs.

CAPEX due to replenishments is inevitable, operators are buying the obligatory CAPEX ticket to destination constellation, but some among them are reserving first class tickets with an arsenal of shorter lifespan satellites.

Traditional large satellites are over-designed by default, leading to additional design and launch costs. The spacecraft components are more specialized and subsystems duplicated for redundancy. Also, in most cases, external contractors manufacture the satellites.

Alternatively, smallsats work on a completely different model, with a sizeable portion of operators aiming to develop satellites in-house and to learn the skill of designing and manufacturing satellites "on-the-job."

Such vertically integrated operators have a CAPEX intensive initial period, but CAPEX gradually reduces as operators maneuver over the initial hurdles and identify efficiencies through economies of scale and/or scope.

Narrowband and High Resolution (HR) EO systems benefit from a medium lifetime, limiting adjusted 10-year CAPEX costs to 150% initial deployment.

Bottom Line

Highly unlikely is that most operators can remain aboard the wagon en-route to destination constellations due to sky rocketing CAPEX and increasing competition from terrestrial and traditional satellite players.

This is particularly true of low hanging fruit applications that are already becoming over-saturated, even without fully deployed systems in orbit.

The few who enter the market in a timely fashion will gain significant first mover advantages, causing would-be competitors to fall away and requiring others to develop niche approaches or markets to gain success.

www.nsr.com

Mr. Shihora joined NSR as an analyst in 2017. His main focus is satellite manufacturing and launch markets, and in particular, the trends surrounding emerging constellations. Mr. Shihora focuses on the business case for Small Satellite Constellations and CAPEX associated with them. Additionally, Mr.Shihora co-authored NSR's Small Satellite Market 4th Edition report.

Mr.Shihora completed his Masters of Science (MSc) in Space Studies at the International Space University (ISU). Prior, to which he graduated with a Masters of Engineering (MEng) in Aerospace, Astronautics, and Space Technology from Kingston University. Moreover, Mr.Shihora has been active in promoting Space Science and Education through the Society of Aerospace and Astronautics (SAA) that he founded in 2016.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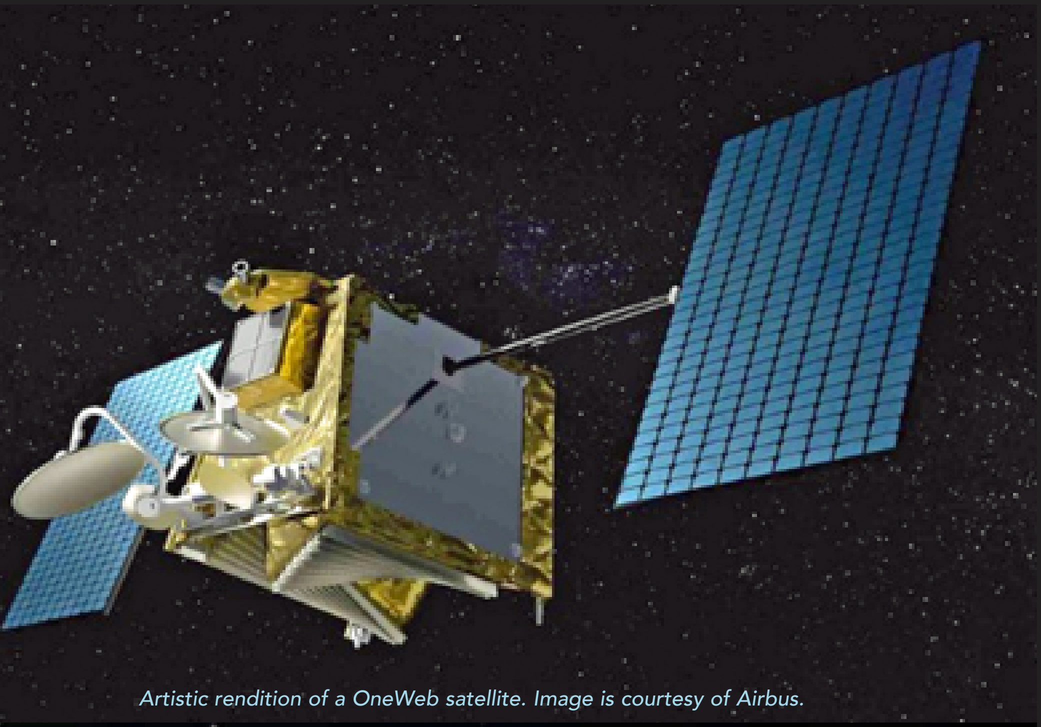
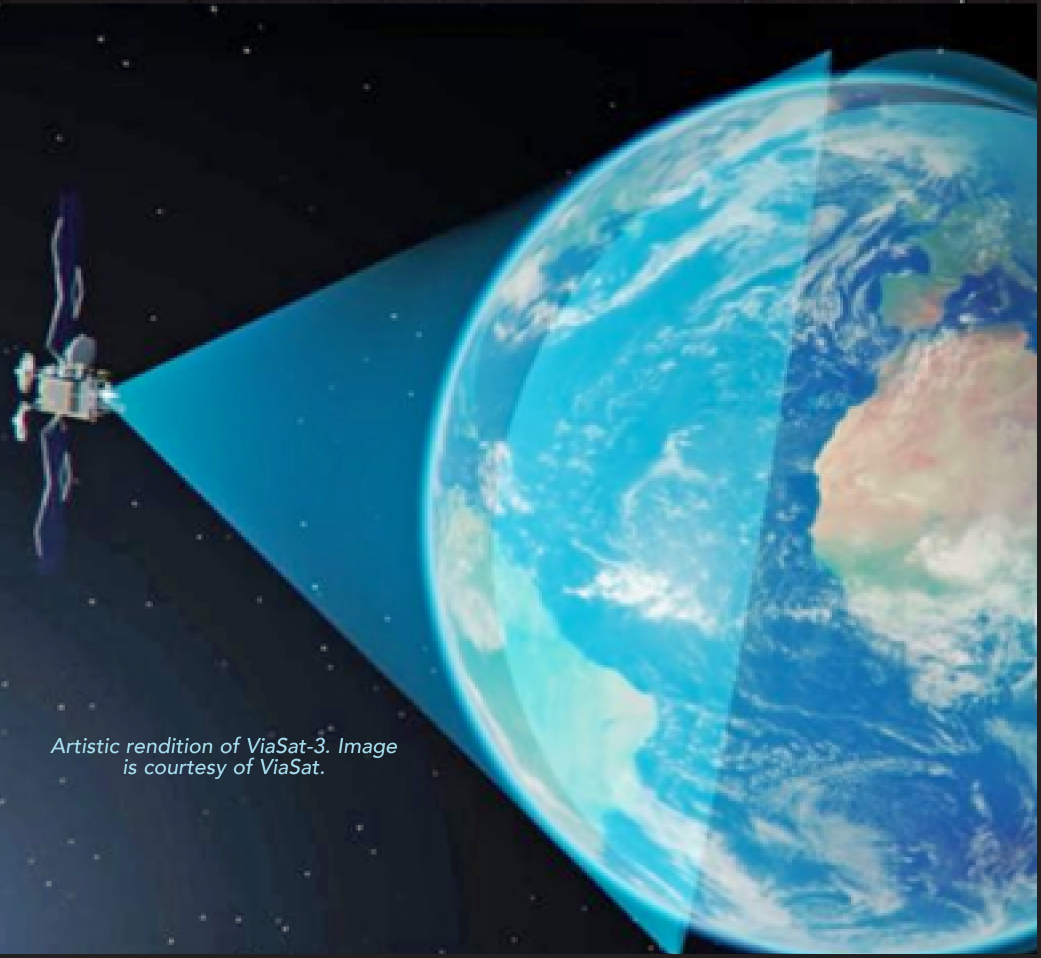
On a Personal Note...

Waiting for the shoe...

By Robert Bell, Executive Director, Space and Satellite Professionals International (SSPI)



Artistic rendition of a OneWeb satellite. Image is courtesy of Airbus.



Artistic rendition of ViaSat-3. Image is courtesy of ViaSat.

A little more than a year ago, I closed an article I had written for this magazine with the words "*Welcome to interesting times.*"

And it was indeed an interesting year full of change and challenge. Big deals were signed, from Northrup Grumman's acquisition of Orbital ATK to SpeedCast's purchase of Harris Caprock. MDA bundled SSL, DigitalGlobe and Radiant into a new company called Maxar, and Planet bought Terra Bella from Google. SpaceX announced that it planned a vast LEO satellite network and ViaSat filed for permission to add MEO satellites as part of its ViaSat-3 terrabit satellite network. Intelsat sought to acquire OneWeb with the help of Softbank but the deal proved too difficult to pull off.

However, looking back, what strikes me most is the number of things that began to happen in 2017 or before, and which have not yet occurred — this left us at the end of 2017 waiting for the other shoe to drop.

That phrase about the shoe comes from an experience known to every apartment dweller. Your upstairs neighbor comes home after you have gone to bed and wakes you by clacking across the bedroom floor in shoes that seem to have brass soles. Finally, you hear the thump of one shoe hitting the floor as your neighbor prepares for bed. Then you wait for that next shoe, which will signal your chance to go back to sleep as brass soles give way to stockinged feet.

Capacity Surge

The past couple of years have had plenty of brassy thumps in them. The raw transponder capacity of the satellite network continued to grow as extremely larger bandwidth HTS satellites entered service.

Flickr Image: SpaceX launch of ORBCOMM payload.

Downward pressure on prices materialized with a vengeance, and incumbent satellite operators responded with a variety of strategies. Those with profitable video neighborhoods focused on making the most of that niche. Those with significant data businesses, where competition from new high-throughput satellites is fiercest, expanded their own HTS capacity and sought out partnerships with, or acquisitions of, technology and service providers in high-potential areas like maritime and the connected car.

But all of this action involved GEO and MEO spacecraft — with the significant exception of the L-band players such as Inmarsat, which added a fourth I-5 satellite in 2017, and Iridium, which finished launching 40 of the satellites in its 66-spacecraft NEXT constellation at the end of the year. For the companies operating in C-, Ku-, Ka- and higher bands, the LEO shoe has yet to drop.

OneWeb, with its multi-billion-dollar financing, is in the lead. In 2015, that company committed to have Airbus build its initial satellite fleet and signed on Arianespace and Virgin Galactic for the launches. In 2017, the company received FCC approval to launch their constellation, broke ground on the firm's own satellite manufacturing facility in Florida, and predicted that they would put the first 10 pilot satellites into orbit in 2018.

Coming up behind OneWeb are operators that have raised enough money, or already have a sufficient track record, to initiate contracts for services and technology. Iridium Kepler Communications had announced plans to launch their first nanosatellite for Machine-to-Machine (M2M) service by the end of 2017 — the deadline came and went without result.

LeoSat and SpaceX forecast 2019 as the year for their initial deployments and the massive planned Boeing constellation has yet to announce its schedule. Meanwhile, SES has applied for permission to add as many as 48 new satellites to their already successful MEO constellation (formerly O3B), as well as a wider range of frequencies.

NSR has estimated that this LEO high-throughput capacity could drive pricing as low as $50 to $60 per Mbps per month, or about 40 percent lower than the lowest-cost GEO HTS cost. This applies to the target market of broadband connectivity but seems inevitable to impact enterprise data and commercial mobility sectors as well.

Steven Zwerink Startup Weekend in Cancun.

make their businesses work unless the smallsat constellations succeed.

2017 was an exciting year to hear the first shoe dropping for these companies: the financing deals, the hot-fire tests and test flights, the prototypes delivered to LEO. A small ecosystem of suppliers has already sprung up around them to offer everything from smallsat assembly lines to shared ground communications networks.

But that other shoe has yet to hit the floor. For the past half century, satellite and launch startups have been rarer than hen's teeth. To have so many at one time is without precedent.

Indeed, in 2017, one satellite executive complained to me about mining companies in Australia switching their expensive committed-rate data services from traditional VSAT to the National Broadband Network's broadband network at a tiny fraction of the cost. Data rates, competition and availability were not on the same level but the customers considered it good enough.

A lot depends on how new capacity is used. Consumer broadband is the target market common to most of the LEO systems — but it was also the original target market for O3b. The experience of that company, which set out to connect the world's Other 3 Billion, but wound up finding success in maritime and energy, suggests caution about the future.

So does the story of Iridium, as told in the marvelous book *Eccentric Orbits*. The bankruptcy of what that book calls the world's most expensive start-up will haunt the LEO business until OneWeb or one of its competitors proves that, this time — as we all hope — it truly is different.

Smallsat Constellations and Low-Cost Launchers

At last year's *Smallsat Symposium* in Silicon Valley (hosted by this magazine's publisher), a speaker on a finance panel made a point that has stayed with me ever since. He noted there are ever-increasing numbers of companies proposing or building constellations of smallsats as well as a number of new launch providers proposing to bring low-cost LEO launch capacity to market.

What is not sufficiently appreciated, he said, is how interdependent those groups are. The satellite companies will only be able to get their constellations into orbit if there are a lot more launches happening at much lower prices. The launch providers will not find nearly enough customers to

Research and Markets recently estimated that the satellite payloads market could be worth $18.15 billion by 2022, up from $11.84 billion in 2017. The 8.9 percent CAGR will be driven, the company says, by increased demand for hosted payloads (think smallsats), satellite miniaturization (smallsats again), and the lower cost of satellites (smallsats, anyone?). In this scenario, the constellation and launch providers embrace in a mutually reinforcing partnership, such as the Wintel duopoly that drove the fortunes of Microsoft Windows and Intel for so long.

So far, smallsats for Earth observation (EO) have been the effective partner on the satellite side. They are bringing to market a new capability for rapid revisit of sites at lower costs, and market demand appears to be strong. With that exception, all of the progress so far toward a Wintel-style growth cycle has come from the launch side.

A 2017 analysis by Ars Technica estimated that the Air Force's 2020 launch costs would average $422 million per launch if the military continued to use ULA's Delta and Atlas V rockets. By contrast, the Air Force awarded SpaceX two contracts at $83 and $96.5 million. That's a compelling proposition even for a governmental buyer with a major interest in maintaining government launch capabilities.

An April 2017 article in *Forbes* by *Gene Autry* ("***The Next Economic Revolution just (re)Launched***") notes that competition has already driven down the price for a mid-sized orbital launch (10 to 15 metric tons) from more than $150 million to under $65 million.

The article predicts that reusability will cut that price by another 30 percent or more — it could upend customer purchasing decisions. The article notes that satellite operators pay launch providers for one attribute — reliability — and the suggestion is that reusable rockets will not only be cheaper but more desirable as they have been tested in flight. He foresees customers paying more to place their payloads on previously flown vehicles.

For the next year or two, we will be waiting for the shoe to drop: will the smallsat constellations meet the market acceptance needed to continue powering this partnership that promises so much for the future?

Revenge of the Nerds

"*Space does not cooperate*," said Mark Watney at the end of the film *The Martian*. Space is high risk. People start companies that operate in space at least as much out of blind love for the high frontier as for sensible business reasons.

The career arc of Adam Maher, an ***SSPI Promise Award*** winner, shows that such love does not, however, have to be blind. After eight years working for Space Systems Loral, he founded a company to put EO hardware into orbit.

After struggling with funding, he and his team made one of those pivots that savvy entrepreneurs are known for — he realized that the world has no lack of EO data, mostly in the form of images. The gap to be filled is for commercial applications of that space-based data.

In response to this realization, his company, Ursa Space Systems, created a big data service that produces near-real-time estimates of global oil reserves. The roofs of oil storage tanks rise and fall depending on their load and satellite images record these changes.

Ursa developed software capable of automatically extracting estimates of roof height from the images and matching it with trade data. After achieving success with the global reserves service, Ursa has introduced a new product: a China refinery demand report provided in partnership with ClipperData.

The development of this secondary market for space-based services may not stir the pulse like a rocket launch. However, it represents a maturing of the industry's entrepreneurial surge that is deeply reassuring.

Space may not cooperate — but data does. A growing range of software-driven companies like Ursa Space are drawing on resources that hardware-driven companies provide at a reasonable cost. Their risk is minimal compared with putting hardware in space, and the returns from data services that shape financial decisions can be exceptional. There is no other shoe to drop. Instead, there are only endless opportunities to innovate for profit.

Making Leaders

Commercial space and satellite has always been comprised of a few large companies and hundreds or thousands of smaller ones that provide the "majors" with components, assemblies and services. The entrepreneurial surge of this decade has enriched that ecosystem enormously, while substantially disrupting the established business models of incumbents.

With 2018 and 2019 shaping up to be critical years, entrepreneurial companies are also posing a challenge to the ability of incumbents to attract and retain the talent they need to effectively compete. According to SSPI's research, 20 to 30 percent of companies in the industry do a good job of attracting talented people, engaging them in the mission and continuously upgrading their skills. The vast majority, however, treat talent management as something to think about after many more urgent priorities are handled.

I interviewed the senior "people executive" of one of the best-known new space companies this year for our series of "*Making Leaders*" reports. The topic was about bringing new hires on board.

When I asked him how long the process should take, he said "*It's not about time. It's about competence. Our goal for onboarding is to get a new employee from zero to 70 to 90 percent competence at their job and in navigating the organization. If you think you are going to get there in a day or two, you are fooling yourself. You need a successful, meaningful onboarding process. If you ignore it, you are going to have future retention issues — guaranteed.*"

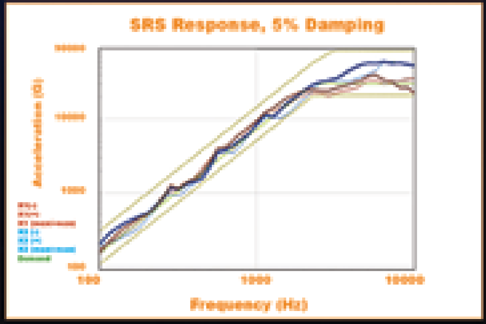
While waiting for the other shoe to drop, we must never forget that we are also in the business of making leaders, who will help our companies meet whatever challenges we face when that loud thump finally comes. When the second shoe falls in the apartment overhead, it is a signal that you can go back to sleep. For the space and satellite industry, it will be the ultimate wake-up call.

www.sspi.org/

Robert Bell is executive director of the Space & Satellite Professionals International, the industry's largest membership association, which works to make the industry one of the world's best at attracting and managing the talent that powers innovation. He can be reached at rbell@sspi.org.

HIGH G

DYNAMICS TESTING



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#2	13,000 lbf	2" Stroke

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- Sine Burst
- Random
- Sine on Random
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- SRS Shock
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