

December **2019** Year in Review issue

SatMagazine



*Telesat's Phase 1 LEO satellite on-orbit.
Artistic rendition is courtesy of SSTL.*

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Upcoming HTS Satellite APSTAR-6D

Your One-Stop Mobile Satcom Solution

Service Life	15 years
Orbit	134°E
Beams	90 Beams
Capacity	50 Gbps
Beam throughput	up to 1Gbps
Gateways	Beijing, Shenzhen, Xi'an, Hong Kong, Kuala Lumpur, Perth
Platform	DFH-4 Enhanced Bus
Launch Vehicle	Long March 3B Enhanced
Launch	Q4 2019

■ SA1 Coverage
 ■ SA2 Coverage
 ■ SA3 Coverage

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A Nightmare for the CBA

The CBA 'Fat Lady' has not stopped singing just yet..

By Chris Forrester, Senior Columnist



The FCC's decision to adopt a "public" auction of C — band frequencies over the U.S. was not the news the C — Band Alliance (CBA) wanted to hear.

Goodness knows how history will look back at its year of extensive — and expensive — lobbying and whether lessons could be learned. While the CBA had in the final days of their pre-decision lobbying made some significant compromise suggestions to the FCC in terms of how much the CBA would pay over to the U.S. Treasury, it wasn't enough and — seemingly — Capitol Hill's senatorial lobbying won the day.

The CBA was up against Senator *John Kennedy* and his promise to be a true thorn in the side of the FCC and CBA should a 'private' auction be decided upon. Kennedy said *"I'm not going to let [the matter of a public vs. private auction of the C — band] go. I'm going to continue to pursue this issue like a hound from hell. And if the FCC wants to go forward and screw the American taxpayer, I will remind them of the mistake they made every day for the rest of their natural lives."*

The FCC demands that significant spectrum for 5G must be freed up and that action must be accomplished quickly — revenue must also be generated for the U.S. federal government and the continued delivery of C-band services must be ensured.

Those months of CBA lobbying came to naught with FCC Chairman *Ajit Pai's* decision, Tweeted on November 18th, saying, *"After much deliberation and a thorough review of the extensive record, I've concluded that the best way to advance these principles is through a public auction of 280 megahertz of the C-band conducted by the FCC's excellent staff."*

The FCC decision also managed to wipe billions of dollars and euros from the values of Intelsat and SES. Share prices crashed and Intelsat, for example, tumbled from \$26 earlier in November to just \$6 following the FCC verdict.

The FCC decision is also truly heart-breaking for Intelsat's senior staffers who had been planning their own renaissance and had hoped to use its C-band 'windfall' revenues to cut the firm's debt and start building for a future, if not free of debt, then without much of its massive debt burden.

SES is not so badly exposed to borrowings and a cash injection would have given SES a much greater opportunity to invest in its future.

All the signs are that the arguing is far from over. While the original CBA proposal must now be seen as being in its "death throes" (as investment bank *Jefferies* described the situation), there is a growing consensus that the CBA still has a few powerful options, not least the threats of never-ending legal activity, or simply stopping the current process completely.

A *Jefferies* report on November 21st was blunt, saying, *"We're now in a period of maximum uncertainty as the favorable features of the private auction give way to FCC Chairman Pai's surprising U-turn toward a public auction. The information vacuum is acute: Pai's about face was done via a Tweet; coincidental to which was the announcement by Senators Wicker and Thune of their "The 5G Spectrum Act." A mere*



Satellite operator executives involved with the C-Band Alliance.



two pages of text, the bill (in its current form) instructs the FCC to hold public auction (without definition of form, now how band will be cleared) by the end of 2020 for at least 280 MHz of C-band and for at least 5 percent of gross proceeds before costs be given to the U.S. Treasury, with a portion of the gross proceeds thereafter to be transferred to licensees that have relinquished their rights to the band."

The Jefferies report continued, "The only thing that's categorically dead is the CBA proposal: But while the FCC record on the matter of clearing the band is brim full, the Tweet and the two page bill say nothing. We see this point as key. The public auction route can't, and never has been able to, clear the band in a short timeframe without the cooperation of the CBA. The FCC certainly has the authority, but the adherence to due process would afford the CBA countless opportunities to defend its interests at the expense of expediency (and all the while the MNOs would be barracking the FCC for its fecklessness). It's these basic truths that made the C-band trade so investable in the first place. So as the CBA's proposal completes its death throes, we see a fresh window of opportunity open: the FCC will call the CBA (alongside staff from the offices of Wicker, Thune, Kennedy and the Administration?) in for a fresh discussion of how all agendas can be met — that creates a chance that a fresh Order can be cultivated that blossoms in the vacuum of the Wicker / Thune bill to give political and legal legitimacy to fairly compensating the CBA for vacating the band (something which the CBA proposal was unable to achieve)."

The bank's Giles Thorne speaks somewhat optimistically about the position for SES, but less so for Intelsat. He said, "Intelsat is the sharpest of falling knives; SES is in value territory: In our view, playing the C-band trade through Intelsat was always for the brave. The massive pullback is hard to argue against. We estimate that the equity now discounts 280 MHz sold at \$17c / MHz / Pop and 50 percent of proceeds to the U.S. Treasury. For our reasons given immediately hereto, we see a path to C-band proceeds of some sort as still possible. Our \$30 PT looks a distant possibility but not quite zero (and so we leave it unchanged pending better visibility). Equally, we see a zero proceeds public auction outcome as unlikely (also

giving us cause to leave our rating / PT unchanged here). Turning to SES, we're of the contrarian view that the core business is worth c.€16 per share. For the stock to retrace in lock-step with Intelsat has put it into value territory at €11.60."

Analysts at research firm MoffettNathanson, in its note on the C-band fallout, says that the U.S. market is "starved" for mid-band spectrum for 5G, and there was and is very real political pressure on the FCC to bring more mid-band spectrum to the market as soon as possible.

MoffettNathanson adds in its report that the CBA satellite operators "don't actually own the spectrum they were supposedly going to sell." The satellite operators would strongly argue that point and say that their spectrum is theirs insofar as it is licensed to them in perpetuity.

There are two major elements in terms of the CBA's ability to consider the spectrum to be under their total stewardship. First, the operators have paid a lot for their spectrum. SES paid a high price to acquire GE Americom, for example, but along with Intelsat, the industry has invested billions of dollars over decades in the infrastructure that uses the spectrum.

Of course, Intelsat and SES have an obligation to their shareholders to protect these investments and assets. And second — and legally more importantly, of course — this spectrum has been officially licensed to them.

There are rights attached to these licenses, above all the right that these licenses are protected and not fundamentally altered or taken away against the operators consent. This protection is core to the role of the FCC and the legal framework of the U.S. Communications Act.

MoffettNathanson, and some other analysts, suggested that Intelsat's "implosion" might help Charlie Ergen's Dish Network. "The scarcity of mid-band spectrum works in [Dish's] favor, at least to the extent that one believes that Dish is still a potential spectrum seller rather than a network builder. By this line of thinking, Verizon desperately needs mid-band spectrum, and the C-band always was (and perhaps still is) their

preferred option. But if C-band isn't an option anymore, at least in the timeframe Verizon needs, then that can only be good news for Dish Network, which may once again be the only source of available mid-band spectrum. If Sprint and T-Mobile lose the antitrust case brought by the State Attorneys General, as many increasingly view as likely, and Dish is therefore freed from the spectrum sale prohibitions that came with that settlement, then might we not be looking at Dish as a seller of spectrum again?"

CBA to Fight Back?

The immediate response to the FCC's decision from the CBA sounded like a clear threat, stating, "The announcement does not address the critical involvement of the incumbent satellite operators in executing the complex task of reconfiguring and transitioning their networks. Nor does the announcement address the fundamental modification of the rights afforded by the existing FCC licenses held by the CBA members which would be required under a public auction approach."

Indeed, the CBA let it be known that they would be "collaborating with the FCC on an effective alternative plan."

Investment bank Jefferies said the FCC's proposal is the "least worst path forward" and suggests that the FCC has engineered a Gordian knot: "a public auction that has political and legal legitimacy but a roadmap of relentless disruption by the CBA to stop this administrative re-allocation of the band; and a private auction that has shakier legitimacy but the benefit of expediency through the full cooperation of the existing licensees. We still see room for a fudged middle-ground but, inevitably, timing is going to be pushed out."

In other words, this particular 'Fat Lady' hasn't stopped singing just yet.

Senior Columnist Chris Forrester is a well-known broadcasting journalist and industry consultant. He reports on all aspects of broadcasting with special emphasis on content, the business of television and emerging applications. He founded Rapid TV News and has edited Interspace and its successor Inside Satellite TV since 1996. He also files for Advanced-Television.com.



In November of 1998, Chris was appointed an Associate (professor) of the prestigious Adham Center for Television Journalism, part of the American University in Cairo (AUC), in recognition of his extensive coverage of the Arab media market.

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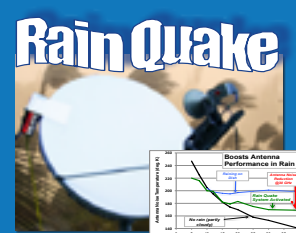
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2020's Industry Milestones

The year ahead for the space industry

By Maxime Puteaux, Senior Consultant, Euroconsult

The satellite industry is experiencing significant changes that are part of a long term from a legacy GEO satellite-based broadcasting business to more data centric use cases through new satellite architectures.

In Euroconsult's 22th edition of *Satellites to be Built and Launched by 2028*, the company anticipates an average of 990 satellites will be launched every year, driven by the deployment of constellations and the necessary replacements of commercial GEO satellites, in addition to the introduction of new government space programs revolving around security, manned spaceflight and exploration needs.

As part of this general trend, several milestones are expected in 2020, marking significant progress over the past year. These short-term events are either company / products related events or general milestones of on-going trends. However, the satellite industry — being no stranger to delays — should realize that several announcements could be subject to further delays and slip into 2021.

C-Band Reallocation to Spread Globally

The combination of both the decline in the legacy satellite broadcasting business (historically using C-band) and the rollout of 5G (using some frequencies of the C-band) has triggered discussions about reallocating more spectrum for ground networks — this trend broke the common front of the satellite industry against the ground networks industry.

U.S.

In the U.S, Intelsat, SES and Eutelsat (which eventually left the alliance) created the C-Band Alliance to lobby the U.S Federal Communication Commission (FCC) for a private

Several milestones are expected in 2020, marking significant progress over the past year.

auction, while the U.S Government would prefer a public auction. Both parties have yet to settle on this issue.

Depending on the results of the auctions, both Intelsat and SES could recover several hundreds of \$ millions.

Globally

Following the World Radiocommunication Conference (which took place in November of 2019), other ITU regions are expected to transfer more satellite-dedicated spectrum to 5G cellular services. Several spectrum regulators have already started to do so, but without ITU coordination. Smallsat-oriented regulations are also to be enacted

The U.S. FCC and other regulatory bodies are expected to update new smallsat and mega-constellation regulations to follow the industry's evolution into these technologies. The multiplication of smallsat projects is challenging existing licensing governance and processes to launch and operate commercial satellites in both number and technical parameters (size, lifetime, concentration on-orbits, debris). However, discussions around new standards about collision avoidance and space traffic management have yet to be formalized into law.

The Telesat LEO Vantage Satellite Selection

The Canadian operator is expected to select one company from among Maxar, Airbus and Thales Alenia Space to build their 300 LEO Vantage constellation satellites for deployment ongoing from 2022. This contract is seen as a lifeline for some of the aforementioned companies that are noting the low level of satellite orders and, therefore, their difficult financial situation.

Expected GEO Satellite Manufacturing Contracts Recovery

Satellite manufacturers are expected to receive more orders than acquired during the past few years (nine satellites in 2019, nine in 2018 and seven in 2017). After a few years of a wait and see approach driven by declining DTH (Direct-To-Home) business as well as skepticism toward constellations, operators such as Eutelsat,



Intelsat, SES, Telesat, Nilesat, Hispasat and the government of Nepal are about to order a dozen satellites — that will boost back orders to 2010's level.

Flexibility and Diversity of GEO Comsat

More satellite operators are expected to order flexible GEO satellite platforms following the increasing demand for smallsats with fully reconfigurable payload, all within the two to three tons mass range. These requirements were triggered by SES which has yet to select suppliers; however, Inmarsat with Airbus and Ovron with Maxar were the first adopters. Thales Alenia Space, Boeing and Saturn have announced similar platforms but have yet to secure customers.

On-Orbit Servicing Demos to be Performed

Northrop Grumman's MEV-1 is expected to demonstrate its on-orbit servicing capabilities by docking to the Intelsat 901 satellite, taking over the attitude control and then relocating the spacecraft for the next five years. This back-packing configuration could open the door to new servicing offers, such as refueling or on-orbit assembly.

Oneweb and Starlink Deployment and Commercial Service Initiation

Two of the largest smallsat-based mega-constellations are expected to initiate full operational capabilities — both companies are targeting a high launch rate, with less than three weeks expected between two launches. They intend to test their services over specific areas, like Alaska for Oneweb, before entering full, global service in 2021.

SAR Multiple Deployments

Several smallsat constellations projects with high resolution SAR sensors emerged recently to build commercial businesses and disrupt the imagery market. Among them, Umbra Lab and Synspecive intend to launch their first satellites in 2020. Umbra's satellites will capture 25 cm-resolution images of specific sites with pricing comparable to optical imagery

of equivalent resolution, while Synspecive will provide global coverage of the Earth at a resolution of one to three meters. Capella Space, developing a 36 satellite, high-revisit constellation with 0.5 meter also ground resolution, should start full operations.

VHR Optical Projects and New Sensors to Deploy

Because the French government decided not to commercialize the follow-on to the Pleiades HR optical system, Airbus is developing its own VHR constellation of four satellites. Named Pleiades NEO, this constellation should launch from 2020. Also, ImageSat International should launch Runner, a prototype for an SSO constellation that will provide video and sub-meter multispectral imagery. These projects will allow a wide range of security and monitoring applications.

New types of sensors are being explored for potential commercial purposes in specific application areas. This is the case of PlanetIQ — for GPS-RO (GPS Radio Occultation) — as well as Bluefield and Hypersat for emissions monitoring, who plan to launch the first satellites of their constellations in 2020.

First Crewed NASA Mission by Boeing and SpaceX

Both suppliers of NASA's Commercial Crew Program are poised to perform their first operational mission carrying NASA astronauts to the International Space Station after years of delays. While SpaceX has already launched and successfully recovered their Dragon 2 capsule, Boeing has yet to perform their uncrewed demonstration of Starliner before they fly crew.

Several Missions Targeting the Moon

Three space agencies announced a Moon mission in late 2020. They are: Chang'e-5, a complex sample return mission from China; The KPLO orbiter, South Korea's first lunar mission; and Capstone, a NASA cubesat that will test lunar navigation technologies and operations in the orbit planned for the lunar Gateway. NASA is also expected to place additional orders to the U.S industry of commercial lander delivery of scientific payloads to the Moon's surface.

bidder regarding the duration and the number of suppliers to be selected.

New Generation of Launchers

Ariane 6, Vega-C (Arianespace), H-3 (Mitsubishi Heavy Industries), Launcher One (Virgin Orbit) Alpha (Firefly), SSLV (ISRO), these are all expected to perform their first launches of their new generation of rockets. The market adoption and seamless transition to reach operational capabilities will be instrumental to their success.

SpaceX to Push the Reusability Envelope

SpaceX is expected to break several milestones related to reusability. The company is expected to break the threshold of 30 launches, driven by the company's own needs for Starlink orbital slotting. In addition, the company aims to improve its reusability and refurbishment skills by re-flying the same booster over five flights. SpaceX is also testing its next generation launcher Super Heavy / Starship.

Arianespace, SpaceX to Start Dedicated Rideshare Services

In August of 2019, SpaceX announced the SmallSat Rideshare Program that will provide monthly launches via their Falcon 9 rocket. In addition, the company will offer monthly opportunities using excess capacity on launches of their Starlink satellites to SSO (Sun-Synchronous Orbit) and mid-inclined LEO. Arianespace's Vega SSMS is poised to demonstrate proof of concept with more flights in the near future.

ISRO to Select a Partner to Build PSLV

As India opens to the private sector, ISRO announced a plan to collaborate with the industry to build and launch PSLV. In August 2019, NewSpace India Ltd., the new public sector space business company, issued a formal search for companies or consortia that can initially produce five launchers end to end and to be launched starting in 2021.

The aforementioned industry milestones only represent the tip of the ongoing evolution of the satellite industry. For more details and insights, a deep dive into the Euroconsult report is highly recommended. Euroconsult would also be delighted to conduct strategic studies to assess the needs and requirements for companies that desire to address and compete within targeted market sectors during the next ten years.

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U.S Air Force to Award a Major Launch Contract

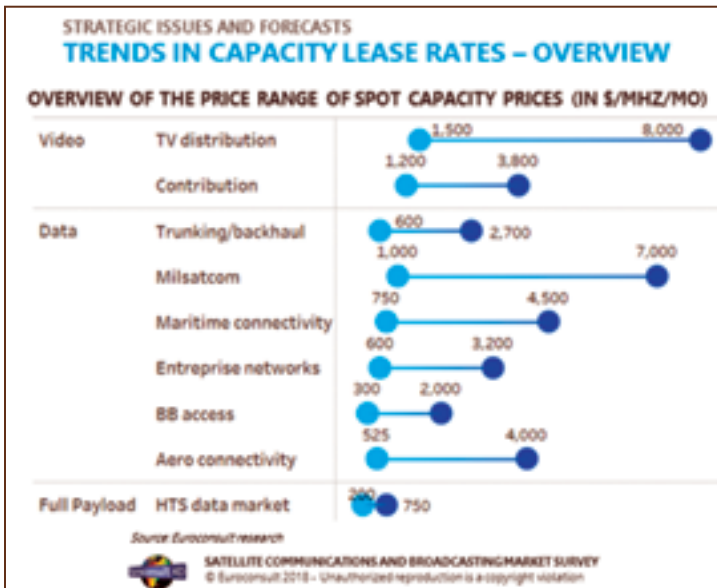
The U.S Air Force is expected to shortlist two launch service providers for the second phase of the National Security Space Launch (NSSL) program among the four bidders: United Launch Alliance, SpaceX, Northrop Grumman and Blue Origin. The contract will significantly shape the U.S launch supply landscape by awarding as many as 34 missions from 2022 to 2026 in a split 60/40. The tendering conditions are being challenged in court by the

Maxime Puteaux is a Senior Consultant at Euroconsult and has been based in Paris since 2012. He is the Editor-in-Chief of the 22th edition of Euroconsult's Satellite to be Built and Launched by 2028. His expertise focuses on launch vehicle and satellite market studies, the manufacturing industry, access to space, as well as emerging markets and constellations.



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**A Conversation with Bob Hansen,
Vice President,
Global Sales & Marketing,
Terrasat Communications, Inc.**

Bob, what is the focus of the company's business efforts?

Bob Hansen (BH)

For the past 17 years, and for many years to come, Terrasat has only focused on building BUC's. We have deployed more than 22,000 BUC's in over 130 countries.

Currently we supply BUC's from 4 Watt to 400 Watt in C-, Ku-, X- and Ka-band. We support most major vertical market segments, such as government, military, telecom, broadcast, maritime, enterprise and energy.

Our BUC's are considered to have the highest quality and reliability in the industry. To back this statement up, we offer a standard 3 year warranty on all our BUC products.

What is the difference between the firm's GaN IBUC and the GaAs IBUC models and the advantages of each technology?

BH

We supply both GaN and GaAs BUC's in all power ranges for C-, Ku-, X- and Ka-band. There are clear advantages for both technologies and it really depends on the application on which BUC to use.

The advantage of GaAs BUC's is the linearity of the power devices which allows you to support multiple carriers and wide carrier spacing. If you are planning to transmit multiple carriers from your BUC, we always recommend using GaAs BUC's.

GaN amplifier devices deliver greater gain and are capable of producing higher output power per device. What this should mean for the uplink terminal buyer is greater output power in a smaller, lighter package.

There likely are more, but two applications lend themselves to these characteristics: A small, lightweight product for high mobility applications such as manpack or flyaway terminals. Higher power BUCs/SSPAs as a reliable alternative to Traveling Wave Tube Amplifiers (TWTAs).

**Ku-Band
IBUC 3G**
Compact Size Without the Compromise



Does the company address the commercial and military/ agency/government (MAG) market segments? Please explain the various solutions provided for each environment and what company successes have been experienced in both realms.

BH

We enjoy a huge market share in supporting both market segments.

For commercial, our major markets include telecom, broadcast, energy, maritime and supporting GEO, LEO and MEO constellations. One our recent success stories is a \$5 million contract award for one of the largest telecom operators in the world.

We are supplying BUC's across all power ranges for new 5G services, broadcast service, teleport replacement of TWTA amplifiers and private enterprise customers. We also recently received a large contract from an antenna manufacture for high powered C-band BUC's to replace aging TWTA's for a satellite operator.

Our government and military business has been one of our largest growth markets. Because of our superior quality and reliability, we are the clear choice for mission critical networks. We are not the least expensive, but for this market share, reliability is the key factor. We have recently received a very large contract to supply our high powered Ka-products to support hundreds of military remote terminals.

What technology does the company offer in terms of reliable redundancy in case of a client's satellite terminal failure?

BH

Terrasat, as an industry innovator, developed the IBUC 1:1 redundancy system. Rather than rely upon earlier technology that used an external, rack mounted logic controller, Terrasat took advantage of the intelligence in the IBUCs to rethink redundancy. The secondary BUC continuously monitors the primary and if an alarm is triggered, the secondary IBUC initiates the switch-over. We deliver our 1:1 redundancy system with IBUCs and switch integrated and ready to install. No assembly required.

Are there some exciting technological advances en route from the company over the next several months?

BH

Terrasat is continuing to develop higher powered GaAs and GaN BUCs but one our biggest developments is cyber hardening the administrative interfaces of the IBUC.

We are operating in a different world than just a few years ago. Cybersecurity experts warn that there are two types of networks — those that have been hacked and those that are unaware that they have been hacked.

Our line of IBUCs will include feature and protocols to tighten security:

- Secure terminal sessions
- Secure file transfer
- HTTPS
- SNMPv3
- Secure firmware updating
- RS232 auxiliary interface

What product(s) or technologies were introduced by the company at the IBC2019 event?

BH

Terrasat has recently released our IBUC3 (GaAs) and IBUC 3 G (GaN) IBUC. This is our smallest and lightest IBUC available today in Ku band up to 40 Watts.

Customers will enjoy the same quality and specs as in our other IBUC's. Perfect for smaller aperture antennas and also with a three year warranty.

Advantech Wireless Technologies

Baylin Technologies Company

This has been a busy year for Advantech Wireless Technologies.

In January of 2018, Baylin Technologies (“Baylin”) acquired the Advantech name, logo, and brand along with the RF product lines comprised of Solid-State Power Amplifiers, Frequency Converters, SNG Antennas and Terrestrial Microwave products.

Additionally, in July 2018 Baylin purchased Alga Microwave & MitecVSAT bringing increased engineering and manufacturing capabilities that includes a complete line of microwave passive components.

In 2019 Baylin officially announced the grand opening of Advantech Wireless Technologies’ (“Advantech”) Center of Excellence, located in Kirkland, Quebec. The 66,000 sq. ft. facility currently houses the operations of Advantech, Alga and MitecVSAT.

Together, these teams have embarked on one of the most ambitious R&D road maps in the industry. Combining the three entities into one symbiotic operation has enhanced processes, design philosophies and market strategy.

Baylin made significant investments in the facility, creating one of the best state-of-the-art manufacturing facilities in the SATCOM industry.

Melding two competing companies into one consolidated team is a complex mission — and it’s extremely satisfying when the parts come together.

The new location includes a machine shop with a dozen CNC machines, enhanced quality systems,



Ku-Band-300W-400W-500W BUC SSPB SSPA GaN.

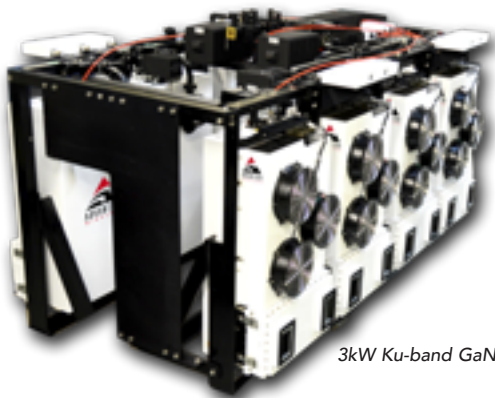
advanced ESD protection, CO2 distribution, a new data center, anti-static flooring, power, LED lighting, ventilation, 15,000 square feet of new office space and superior working conditions, which have optimized the operational efficiency.

The bulk of Advantech’s business is comprised of Solid State Power Amplifiers, however they also design and produce a line of Frequency Converters, Terrestrial Microwave Radios and Pulsed Amplifiers.



The main differentiator for Advantech is the portfolio of SSPAs that range from 8 watts to more than 10,000 watts in S-, C-, X- and Ku-band frequencies.

Advantech is one of a small number of companies experienced in the provision of high-power, soft-fail SSPA systems which are featured



3kW Ku-band GaN.

in the 'Summit' product line.

Thousands of watts of RF power can be pushed, thanks to Advantech's proprietary, high efficiency combining structures.

Current R&D initiatives also include high-power Ka-band, Q- and V-band amplifiers for LEO and MEO applications, pulsed amplifiers for RADAR and Troposcatter amplifiers and LNBS.

The Advantech design team is hard at work on 'hybrid' initiatives to combine the best elements of multiple products and increase performance and manufacturability.

Collaboration is both important and powerful when it comes to meeting the goals that have been set for the brand.

Melding two competing companies into one consolidated team is a complex mission — and it's extremely satisfying when the parts come together.

The multiple perspectives and leading industry expertise have the team excited for 2020 and the years ahead.

Tony Radford has amassed a 30 year career in the satellite communications industry and has worked in a variety of roles including engineering, sales and sales management at such companies as Scientific Atlanta, VertexRSI, STM Wireless, Paradise Datacom and Teledyne Technologies. Incidentally, Tony co-founded Telecom International, a SATCOM systems integration company that was ultimately purchased by STM.



www.advantechwireless.com



Atlantic Microwave

A ETL Systems Company

2019 has given Atlantic Microwave a new parent company, greater global presence and the opportunity to exhibit the firm's satellite communications test solutions and RF and Microwave components and cables at more tradeshows.

With the continued growth in SATCOM terminals, an increasing demand for test equipment in particular is being noted. As the satellite industry evolves, testing is becoming increasingly vital, especially for operators who are trying to maintain good customer service to remain competitive in this new landscape.

Joining ETL Systems

At the start of this year, Atlantic Microwave became a part of ETL Systems, a leader in RF distribution and satellite communications equipment. The joining of the two companies is well aligned — both companies have a shared focus on providing custom RF solutions. The acquisition has resulted in a strengthening of the firm's global RF product range to enable growth and to find new opportunities as a team.

Currently, more than half of the sales are to UK based companies, and with ETL's strong international presence and reputation, further expansion to the customer base is a goal well within reach.

Atlantic Microwave continues to witness the satellite industry innovating their products and technologies to become even more successful in providing next generation solutions.

Project Wins

This year, a range of RF and microwave components were supplied to influential players in key markets to address their mission critical applications. The company's cables and components have been used by key organizations in Aerospace, Defence and Security that includes an airborne search and rescue program and refitting of naval crafts. In fact, Atlantic Microwave is the only UK supplier for a key component within a radar detection system.

Working within the telecoms test industry, the company was selected by a U.S. manufacturer of electronics test and measurement equipment — components and cable equipment were successfully implemented for the customer's high grade, mobile phone, testing applications.

The scientific research community continues to use the company's RF attenuator components products, including several UK and European-based universities for cryogenic work, as well as a leading manufacturer of cryostats.

Sales have gone from strength to strength and the company is proud to be the components supplier for a UK communications regulator.



Atlantic Microwave's family of solutions.

Growing Presence in North America

Since the acquisition by ETL Systems, the North American market has become an increasingly significant region, with a growing customer base operating in the SATCOM, aerospace, defence and scientific applications markets.

To support this international focus, in August of this year **Taylor Pritchett** was named as North America Sales Manager. This has enabled Atlantic Microwave to build on current customer relationships as well as introduce new contacts to the benefits of the firm's products.

Exhibiting the latest RF simulation and testing products at NAB and Satellite 2019 proved there is growing demand and interest in cost effective testing as well as the importance of test equipment to ensure smooth operations. This is hardly surprising — the satellite industry is challenged with ever more complex networks that can be quite expensive to test.

Atlantic Microwave received excellent feedback at NAB and Satellite 2019, with many satellite companies looking to run extensive tests without having to go live to accomplish these tasks. There remains, apparently, some confusion concerning the difference between Test Loop Translators (TLTs) and Satellite Simulators.

TLTs and Satellite Simulators have a wide range of applications and uses in SATCOM. They can be used in the 'factory test environment' where live satellite access is not possible, to allow for measurement and characterize the complete end-to-end systems or sub-systems before they are installed into their final locations.

They can also be used to assist in fault diagnosis where a signal may need to be injected directly into a frequency converter or antenna waveguide. They can be adopted 'on site' and 'in the field' for final 'pre-live' testing and confidence checking prior to ground systems going operational with a live satellite.

Essentially, the fundamental difference between the two technologies comes down to the connection. Typically, TLTs connect directly to antenna hardware via coaxial cable, as opposed to satellite simulators that deliver a 'dummy' RF signal over the air to an antenna feed.

Demos in Europe

Atlantic Microwave exhibited at one of the largest exhibitions in Europe, the International Broadcasting Convention (IBC), for the first time in 2019, which provided the perfect platform for the firm to network and showcase the brand and the products.

A superb response was received to the company's Ka-band Satellite Simulator, a cable-less offering for RF testing on mobile satellite communications systems (e.g., Satellite News Gathering (SNG) vehicles) and TLT range, which are designed to replace the satellite link for test and alignment of Earth station systems.

Conclusion

2019 has certainly been an eventful year for the company and has also been an eventful one for the industry.

Within the SATCOM market in particular, there is a great deal of discussion regarding numerous LEO launches on the horizon and impressive innovations continue to debut from the satellite industry, such as new tools for SNG, plus a number of operators are launching solutions that pair satellite with IP networks. Satellite is challenged with increased competition; however, this year the industry continues to rise and meet those challenges.

As 2020 approaches, there are likely to be more and more demands to be met for the satellite industry; however, with new opportunities for satellite will present themselves as companies power the next generation of connections and broadcast, from 5G and Internet of Things (IoT) to IP broadcast.

Atlantic Microwave continues to witness the satellite industry innovating their products and technologies to become even more successful in providing next generation solutions. Simultaneously, testing will remain important, if not more so.

Atlantic Microwave looks forward to continuing the delivery of the correct solutions to ensure networks stay connected as well as working with the new parent company, ETL Systems, into 2020.

www.atlanticmicrowave.com

About the Author

Colin Wood is the Senior Sales Manager for Atlantic Microwave.

This year...

ETL Systems acquired Atlantic Microwave in early 2019.

ETL Systems operates globally with manufacturing and R&D sites based in the UK which, combined with offices in Washington DC and Dubai support, finds the firm serving customers in 112 countries. ETL's key international clients include CNN, BBC, Airbus, Thales, General Dynamics, ESPN, DirectTV, Associated Press, Inmarsat, BAE Systems and SES Astra.

Ian Hilditch, joint Managing Director, ETL Systems, said, "Atlantic Microwave offers a wide range of complementary RF products and a different customer base. We will be able to use our experience as a global manufacturer to support Atlantic around the world. Atlantic is also very focused on customization of its RF range and so it was a well aligned company to acquire."

Based in Braintree, UK, Atlantic has specialist design, manufacture and test facilities and employs more than 15 staff. Currently, the company distributes 14 different satellite communications product lines covering 10MHz to 110GHz, which includes test loop translators and satellite simulators.

With this shared focus on custom design and providing customer service that's second to none, the acquisition will see Atlantic expanding its range of RF based products. Atlantic's clients will also benefit from ETL's engineering expertise covering RF, PCB and CAD design.

Geoff Burling said, "We are delighted to welcome the support of ETL Systems, especially as they have a similar reputation for specialist RF design. We look forward to continuing to grow our RF testing markets around the world."

It is business as usual as the two companies collaborate to offer a wider product offering to ETL and Atlantic customers.



Ian Hilditch



AvL Technologies

From the outset, AvL has been an engineering-led company. What this means is that AvL products are engineered and re-engineered to the point of ultimate performance.

Founded in 1994, AvL Technologies reached a huge milestone this year: 25 years of connecting the world with mobile satellite communications!

From the company's humble beginnings — founded in Jim Oliver's garage as he tinkered together a custom solution at the request of BAF Communications — AvL Technologies has grown into a global mobile SATCOM industry leader.

What started as Jim's passion for solving problems and helping a former customer grow into a business, which then grew into a new passion for creating jobs in Jim's beloved adopted community of Asheville, North Carolina.

In 25 years, the company has outgrown several small industrial spaces to occupy two custom buildings with 100,000+ square feet of product development, manufacturing and testing space — and created an AvL Technology Park in the process.

The company's 300 skilled employees continually innovate and create new products, and find new ways to work with customers to solve challenging communications problems. The company has shipped more than 30,000 antennas, most of which are still in operation today.

If you were to ask Mr. Oliver about these achievements, he would tell you that 25 years passed in the blink of an eye and the company is on a trajectory to continue growing, innovating and creating lasting jobs in Asheville.

The 25 Years milestone was celebrated during the entire year. The company's Sales and Marketing teams enjoyed hosting in-booth events at trade shows and made sure to reconnect with customers, business partners, vendors and competitors at every opportunity.

Company celebrations were held for employees and their families, with yet a few celebrations planned before the end of the year (as well as a surprise for Mr. Oliver).

Though AvL shipped 1,200+ antennas this year, the company's passion for product development did not slow. In 2019, the company

AvL Technologies' 1.35 meter manual ARSTRAT antenna.





The AvL Technology Park.

embarked on several new products, many product improvements, new low-PIM and cyber security capabilities, and several ARSTRAT certification efforts.

AvL's product developments for U.S. Department of Defense (DoD) applications were numerous. The company continued its development of a Ka-band electronically steered array antenna (ESA), which is on track with respect to AvL's SBIR contract with the U.S. Air Force.

AvL incorporated enhanced cyber security protocols into the AAQ Antenna Control System this year for a specific military program, and the capability will be available by request to other customers soon. The company also integrated protected SATCOM modems as requested for key customers.

A next generation 1.2 meter, tri-band, flyaway tripod antenna, Model 1235-T, currently undergoing Inmarsat GX and ARSTRAT certification, was a priority.

AvL's engineering team built upon years of experience with 1.2 meter reflectors (the company's most popular aperture size) to design a robust, ultra-accurate and ultra-lightweight reflector for ARSTRAT operations.

The tri-band antenna is a modernized version of our Model 1035 terminal including an AAQ Antenna Control System, new packaging, an upgraded tripod and wideband Ka-band capability for operation with commercial Inmarsat GX and WGS.

AvL's new 85 cm. Model 824i and 1.2 meter Model 1224i flyaway antennas with two-case pack-ups have integral bonded cellular capability. The compact and functional designs enable either terminal to be set-up and operational in minutes by one person.

This is one of the many reasons these terminals have been selected for the FirstNet program and have been widely adopted for homeland security, law enforcement and public safety applications.

As part of the General Dynamics Mission Systems GBS solution, PathFinder Digital selected AvL to provide the 85 cm. Ka-/Ku-band flyaway antenna as part of the BAT-GBS-85 Terminal.

This robust terminal packs into two airline checkable transit cases and operates with GBS one-way wideband transmissions to support the timely delivery of classified and unclassified data and video products for mission support and theater information transfer.

The terminal completed MIL-STD-810G environmental testing and late in the year received ARSTRAT certification.

Several new configurations of AvL's Family of Integrated Terminals were developed in 2019. A lightweight weight version of the 1.35 meter tri-band terminal was selected for ARSTRAT certification to support the ISR Stingray program by Sigma Defense. Now in Phase 3, the 1.35 meter terminal is expected to be certified by year-end.

Two of AvL's larger trailer-mount antennas, sized at 2.5 and 3.8 meters, received design upgrades to operate with multi-carrier low-PIM X-band operation and EMI/EMC hardening. The 2.5 meter antenna also completed Ku-band certification testing by the GVF.

AvL was selected for important refurbishment and modernization programs in 2019. In doing so, the company is enabling the warfighter to use modernized equipment at a significantly lower cost than for new equipment.

Modernization efforts include adding the AAQ Antenna Control System, new RF equipment and the latest technology modems.

From the outset, AvL has been an engineering-led company. What this means is that AvL products are engineered and re-engineered to the point of ultimate performance. And sometimes re-engineering comes in the forms of improving parts of the antenna that are often overlooked but have a significant impact on performance.

One of those parts is the latches that hold together AvL's segmented reflectors. Latches are critical parts as they can contribute to the stiffness of a reflector or cause it to sway. They can impede reflector pack-up, cause damage to other reflector segments while packed, or nestle so as to hold reflector segments safely within a case.

During 2019, AvL's engineering team relentlessly pursued improvements to several types of latches and made monumental breakthroughs. Though difficult to describe, the improvements have made AvL's reflectors even higher performing, if that's possible.

To see proof in action, stop by AvL's booth at the upcoming SATELLITE 2020 show and ask one of our engineers to show you just how cool latches can be.

www.avltechnologies.com

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



Blue Canyon Technologies

Smallsats provide a lower-cost, compact solution to demonstrate advanced methods for understanding the space environment to benefit a range of systems and end-users that depend on a reliable space infrastructure.

For the smallsat industry, 2019 was a year of not only prolific growth, but also one that demonstrated the many reasons why the sector is primed for success in 2020 and beyond.

Advancements in technology; increased innovation; competitive economics and a growing demand from a broad variety of verticals and government agencies have resulted in a thriving smallsat economy.

This economy is further reducing barriers of entry to the space industry, as well as enabling many of today's most promising next-generation scientific and commercial innovations.

By demonstrating increased value, versatility and performance, the small satellite category is poised for more growth in 2020 and long after, in sectors that include weather prediction, defense and scientific research.

Here's a look at a few of the advancements in smallsat technology during 2019:

More Precise, Immediate Weather Prediction

For decades, an average weather satellite typically had revisit time of about five times per day, providing meteorologists with somewhat up-to-date readings for weather forecasting. Current innovation in the

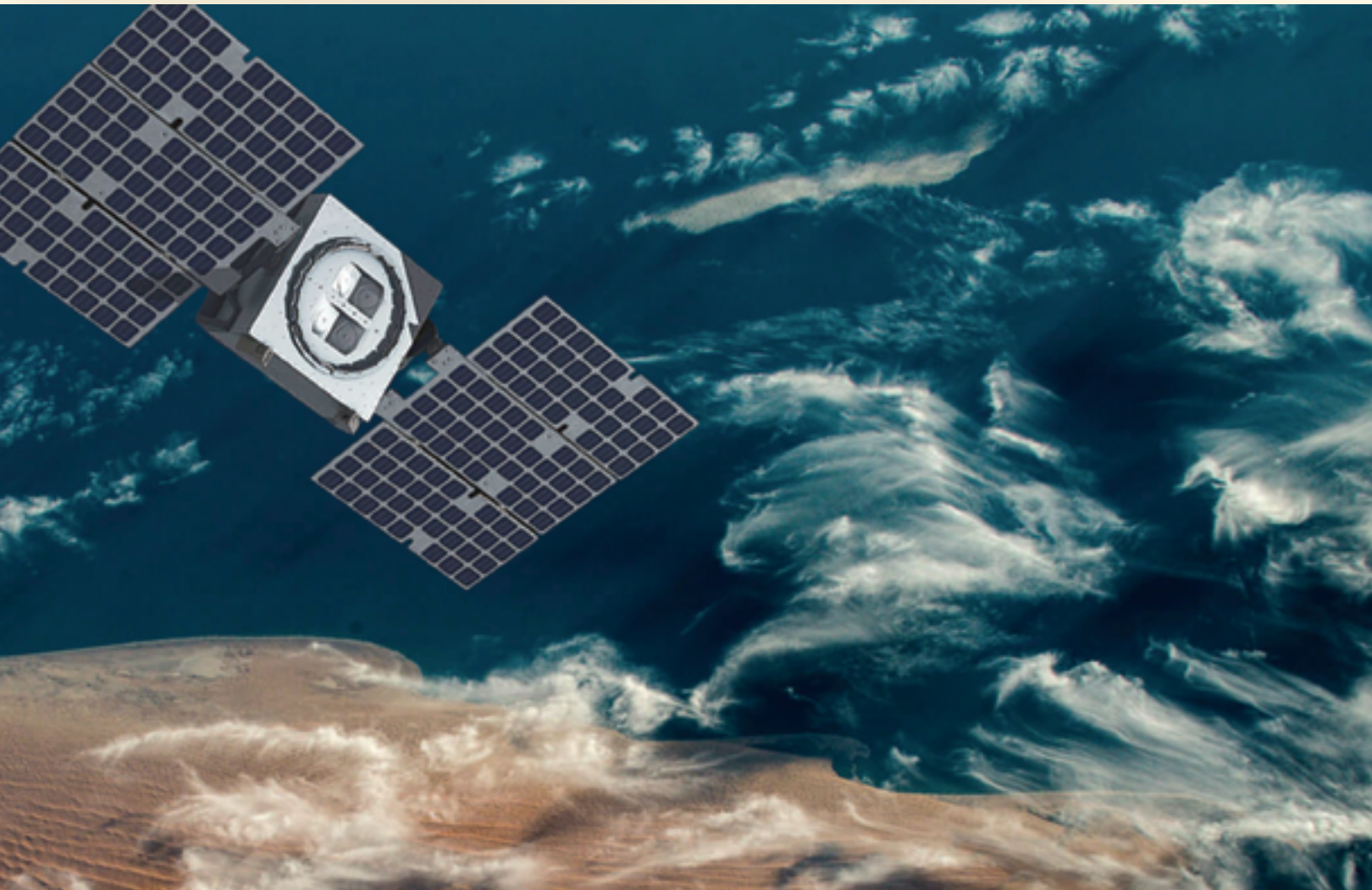
field is seeing the potential for this number to shrink — and shrink significantly — to the benefit of many end customers as large LEO constellations become economically viable and drive down revisit times.

For example, in 2019 Blue Canyon Technologies (BCT) began building the smallsat bus critical to PlanetiQ's "GNSS-RO" mission, designed to demonstrate the use of Radio Occultation (RO) technology to significantly improve global weather forecasting.

This game-changing, even life-saving, weather forecasting technology offers the size, strength and stability PlanetiQ needs to accomplish their mission goals and change the way we monitor and forecast weather systems moving forward.

Once fully operational and broadly deployed, such constellations could potentially make five-to seven-day forecasts as accurate as one-day forecasts.

BCT also partnered with TEMPEST-D, the NASA Earth Venture technology demonstration mission that performs science-quality global measurements of water vapor, clouds and precipitation using a highly-precise, five-channel millimeter-wave radiometer that fits in a 6U cubesat.





The mission is mapping soft X-ray oxygen line emissions across the sky in order to constrain the location and distribution of hot gas in the Milky Way.

Another great example is the Naval Research Laboratory's combined initiative between the U.S. Department of the Navy and the UK Ministry of Defense for a demonstration mission called CIRCE. CIRCE, which stands for Coordinated Ionospheric Reconstruction CubeSat Experiment, will use two 6U cubesats flying in a tandem LEO formation to measure the ionosphere and radiation environment space from multiple vantage points.

As the day-to-day structure and density of the ionosphere can vary depending on the sun's activities, and because space weather affects satellite communications and radar, a thorough understanding of the environment is essential to commonly used satellite infrastructure including GPS and communications systems.

The technology, used most recently in tracking and monitoring applications for Hurricane Dorian, revealed rain bands in four layers of the storm, showing where the strongest convective storms within the hurricane were located.

However, the benefits of better weather forecasting and prediction extend beyond storm prediction and safety. Advancements in weather technology also benefit a broad range of industries, for example, trucking and delivery services.

Given current limitations, fleet managers and drivers can only plan so well in advance for longer trips. If they encounter unforeseen storms and weather patterns that can't be predicted with current weather satellite technology, they may have to re-route, costing them time and fuel

Reliable Support for the Defense Sector

Low Earth Orbit (LEO) technologies and applications remain relatively untapped territory for advancements in defense, and small sats are poised to continue unlocking new opportunities in the sector.

For example, Viasat's Link 16 mission, partnering with the U.S. Air Force Research Laboratory (AFRL) Space Vehicles XVI, is pilot testing the first-ever, Link 16-capable, LEO spacecraft. Using a 12U cubesat, the pilot project will test the feasibility of using small satellites in LEO to relay more and better information to units in the field.

By demonstrating Link 16's ability to operate in a space environment using smallsats, the U.S. military can gain Beyond-Line-Of-Sight (BLOS) tactical advantages on the battlefield and, ultimately, keep our troops safer.

DARPA and the U.S. Air Force's (USAF) "Blackjack" program is another example of smallsats helping improve military space communication. The program leverages an ESPA-class microsat for Blackjack and incorporates a commoditized Flexbus spacecraft architecture.

Ultimately, with these technologies, the Blackjack program aims to develop and demonstrate the critical technical elements of a global high-speed LEO network platform that enables highly networked, resilient, and reliable Department of Defense (DoD) payloads.

Nimble, Scalable and Affordable Scientific Demonstrations

As cubesats are smaller and quicker to bring to market and present significantly better economics compared to conventional satellites, the smallsat industry in 2019 demonstrated to a range of industries and organizations the potential of conducting rapid demonstration missions at a cost-effective price.

Take, for example, the MIT Lincoln Labs' CubeSat Agile MicroSatellite (AMS) mission, which will use a 6U cubesat to demonstrate the potential of low-altitude cubesat performance. Funded by the USAF, the mission will refine the framework for conducting rapid space experiments.

This first-of-its-kind mission will demonstrate that a cubesat can operate and send data from a very low altitude. The AMS will initially launch to an altitude of 500 kilometers and then use a propulsion system to gradually lower its orbit to determine the lowest-possible altitude for a cubesat to collect and transmit data.

By demonstrating cubesat performance at such low altitudes, the USAF and others will be able to leverage the technology to conduct more rapid, less expensive space missions.

Smallsats are also being used for NASA's HaloSat mission, the first ever, astrophysics-focused, cubesat mission, which is being used to increase understanding of mass distribution in galaxies by bounding how much certain particles, called baryons, contribute.

Smallsats provide a lower-cost, compact solution to demonstrate advanced methods for understanding the space environment to benefit a range of systems and end-users that depend on a reliable space infrastructure.

Of course, these missions are just a few of many examples from the last year and signify the tip of the innovation iceberg. Approximately 8,600 smallsats will be launched in the next decade, with a range of potential implications in additional fields like telecommunications, Earth Observation (EO), information, and more, according to a report from the research and analysis firm, Euroconsult.

If 2019 was any indication, it's clear that 2020 will continue to see rapid progression in the smallsat industry, serving more versatile and critical functions than ever before.

bluecanyontech.com

Josh Duncan is the Business Development Lead at Blue Canyon Technologies, focusing on pre-sale systems engineering, customer support, sales, and business development. Josh has held multiple roles at BCT leveraging more than 15 years of experience in the industry and supporting the company's growth from 30 to 200+ employees. He is passionate about BCT's contributions to New Space and enabling customer science and innovation.



Bridge Technologies

In theory, 5G also represents a challenge to satellite companies, although the consensus at IBC 2019 was that such was not the case.

Every year, the broadcast industry descends en masse on the RAI Convention Centre in Amsterdam. Once again, IBC provided invaluable insight into what's going on — and where we're going.

One of the great things about the timing of IBC — in September — is the opportunity it provides to get a snapshot of the state of the industry towards the end of any given year — as well as a look forward to what we might see in the coming year and beyond.

IBC this year was particularly interesting, not least because several discussions with the foremost satellite companies revealed an interesting shift in how they see themselves. That shift was very much reflective — inevitably so — of the wider shift in the broadcast industry.

There was much discussion of “the customer journey” — the different points on the path towards wholly embracing IP that each organization is on, and the need for vendors to acknowledge that and provide situationally-appropriate solutions. Some organizations, for example, are still wedded to the on-premise paradigm while others have wholly embraced the cloud.

Wherever those organizations are, however, it was certainly clear that the age of monolithic data centers is long gone. IBC saw much talk, and not for the first time, of distributed intelligence and edge computing. That's inevitable: media distribution has become all but mission critical and, as such, potential points of failure.

Hybrid

If “customer journey” was something you heard repeatedly in Amsterdam, another frequently used word was “hybrid”. Everyone, it seemed, was talking about hybrid solutions. And: that was certainly true of those satellite companies.

According to a senior manager at one of these firms, his company is building an ecosystem exactly in line with the challenges he sees his customers experiencing. They were, he said, looking for a converged approach to the problem of using the appropriate connectivity technology for many disparate requirements: no single connectivity technology could be the best for every environment.

As such, his company — in common, it must be said, with others — was in the process of reinventing itself: satellite would still be at its heart, but that would be only one of the connectivity solutions it would be able to offer. As with so many other exhibitors, satellite operators are looking to become full service providers, providing complete end-to-end solutions.

It would have been easy, based on these conversations, to conclude that satellite, as a way of getting content from point A to point B, was diminishing in importance.

Nothing, of course, could be further from the truth: in many environments and for many applications, satellite remains the only show in town. Increasingly, however, it has become part of a communications ecosystem and satellite companies are seeing how they can be uniquely placed to play successfully in that world.



The RAI in Amsterdam.



While IP is inexorably changing the broadcast world — for the better — satellite companies continue to face their own unique challenges. At IBC, we saw significant interest in our VB273 Intelligent Redundancy Switch.

Originally developed in response to a major operator's request for a redundancy switching solution, it provides full dual path redundancy for satellite signals with autonomous operation and deep signal analysis on both signal paths for the ultimate in switching decision making. The solution is ideal for providing fast and robust redundancy switching for permanently installed satellite up-links or in outside broadcast systems.

Intelligence at the Edge

One of the characteristics of the VB273 for satellite companies is how — in line with what's happening throughout the industry — it moves intelligence to the network edge, distributing decision-making way beyond the confines of the data center.

In automatic mode, the VB273 system is fully independent and makes its own switching decisions based on the pre-set switching rules. In manual mode, the unit can be controlled from any overlying NMS system via the extensive XML-based Eii (External Integration Interface) or via SNMP triggers.

Previously, it was the case that simple, relatively crude ETR alarm analyzers and black box switching solutions were deployed, but these were a much less than perfect response to broadcasters' requirements: they were inflexible, and could even themselves cause problems and increase costs by generating 'false positives' or missing complex error conditions.

The Bridge VB273 system's analysis capabilities and decision engine make it more comprehensive and accurate, giving greater security as well as delivering the cost reductions that can be achieved through running a more intelligent solution that can be trusted to operate with a greater degree of autonomy.

By incorporating a full implementation of Bridge Technologies' advanced ETR290 analysis engine, the VB273 can use a greater range of criteria, and base decisions on a more nuanced and realistic assessment of the data. Error conditions are evaluated against a set of user-defined rules to determine the appropriate automated action in any operational scenario.

The ETR290 engine is an ETSI TR 101 290 alarm monitor and advanced analysis functionality feature for the series of devices. A device can be configured with up to eight individual ETR290 engines running in parallel on the Ethernet interface providing highly scalable monitoring and analysis.

Even More Sophisticated

Bridge Technologies has also developed Gold TS to provide capabilities that are even more sophisticated than those featured in the ETR290 engine.

Conditions such as failures of the conditional access system, errors in the program guide, and unintended language changes seriously affect subscribers — but standard monitoring systems based only on ETR290 do not raise an alert for these conditions.

Services protected by Gold TS catch these 'ETR290-legal' errors and provide a much more valuable real-world quality assurance for operators of digital media services.

The VB273 also features a unique superlocal mode feature to deliberately cut off overlying NMS control for emergency manual override situations via the front button panel. All parameters can be controlled via the built-in web GUI. The web GUI also gives a visual overview of parameters used in switch decisions and system status.

Multiple layers of redundancy are also a feature of the VB273. The 1RU chassis offers dual redundant power supplies and the VB273 switching card has magnetically latching relays to protect against signal disruption, even during a complete loss of power.

In use, the VB273 Intelligent Satellite Redundancy Switch integrates readily into the Bridge Technologies monitoring ecosystem, providing exceptional advanced data analysis functions through rich graphical displays, with full reporting capabilities to external network management systems.

The data from the system is made available for remote monitoring by the built-in web server so that engineers and maintenance staff can be kept aware of operating status and can interrogate the system from any location.

Challenges

The VB273, then, is designed to address an important challenge for satellite operators — but, at IBC 2019, it became clear that it's not the only challenge that they're addressing and successfully overcoming.

Returning to the 'hybrid' theme, one particularly compelling live demonstration saw a new technology being demonstrated that synchronizes OTT and satellite broadcasts to provide a consistent experience for viewers — potentially eliminating a source of consumer frustration in which, for example, an OTT viewer hears a shout of "Goal!" from those in the apartment above him before the goal has actually appeared on his screen.

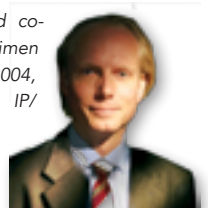
In theory, 5G also represents a challenge to satellite companies, although the consensus at IBC 2019 was that such was not the case: 5G will simply represent a complementary delivery mechanism to all the others, and will just form part of the connectivity mix.

IBC 2019 was, then, all about an industry in transition — and that applied equally to satellite operators. When will that transition end, such that we'll reach a final state — the promised land?

The answer, of course, is: not any time soon. The rate of change in media creation, distribution and consumption is accelerating rather than slowing down — uniquely enabled by IP — and IBC 2020 promises to be no less fascinating in terms of the opportunity, once again, to gauge where we are and where we're going.

bridgetech.tv

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



Over the past year, the theme for Calian SED continues to be growth and innovation. The company is a global supplier of sophisticated satellite communication systems, products and services, and they have been serving customers for over 50 years.

Calian SED's business line includes communication ground systems and services, communication gateways and planning systems, as well as lines of communication products that are tailored to support customers in the satellite industry.

Calian SED offers a tightly integrated approach with the offered engineering design services and manufacturing capacity co-located in a single purpose-built facility. The company has the expertise, capacity and resources required to design, build and fully test each component of the deliverable ensuring performance in the most demanding environments.

Satellite advancements in capacity, functionality, speed and complexity are bringing significant opportunities, as well as, industry challenges including requirements for increased performance and flexibility of the ground system hardware and software. Calian SED, along with its partners, has been developing innovative new technologies to ensure these challenges are met. Recent contract wins are evidence of the company's leading position in the delivery of complex satellite Earth station projects and programs.

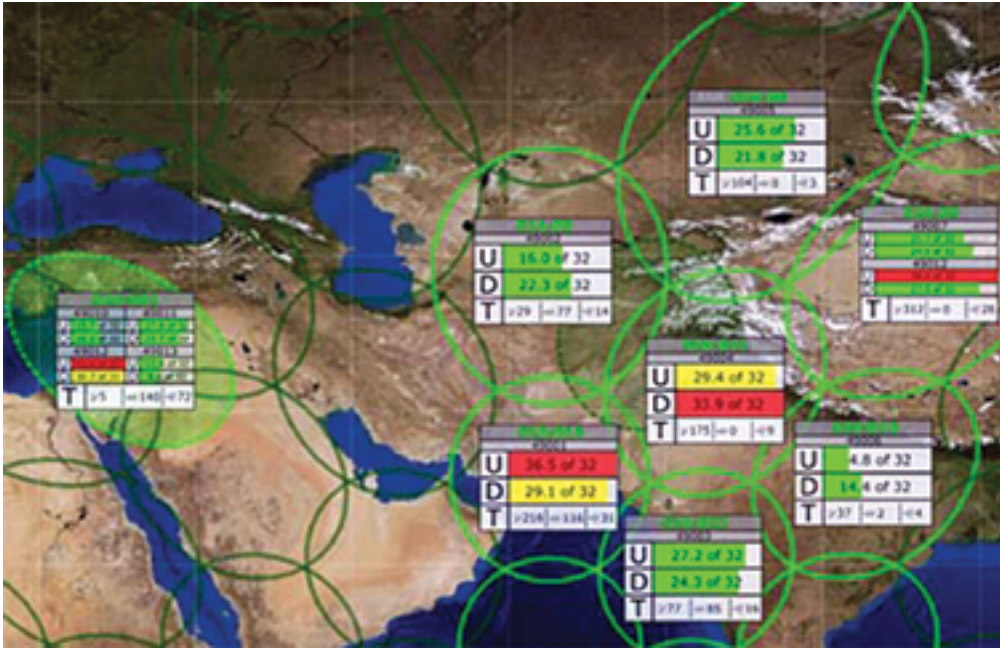
Communication Ground Systems and Services

At Calian SED, the communication ground systems and services business unit provides RF ground systems for satellite tracking, communications and control.

The big announcement this year was Calian SED's new line of composite carbon fiber reflector medium and large-aperture antenna systems with cutting edge performance for the most demanding satellite applications. This new composite carbon fiber reflector technology positions Calian SED for provision of the future higher frequency Q/V band RF systems. With growing bandwidth demand, satellite operators are looking to exploit the higher bands, with higher bandwidths and additional throughput to their network offerings. The company is uniquely positioned to provide the antenna systems required to meet these new demands.

Calian SED continued, this year, to supply numerous RF ground systems and equipment upgrades to customers, meeting the most demanding requirements, capabilities, and environments. With a focus on customer satisfaction and management of requirements, the ground communication systems group, provides solid turnkey RF gateway solutions for L-, S-, X-, C-, Ku-, Ka-band, as well as the higher frequency bands with challenging requirements such as Q- and V- bands.





Calian SEDs' SATCOM Gateways.

Communication Gateways and Planning Systems

The company's communication gateways and planning systems business unit provides software solutions for satellite communications, capacity management and performance monitoring. Over the past year, Calian SED has deployed a variety of satellite capacity and real-time management solutions around the world.

Satellites with flexible payloads have been driving interest for next generation capacity planning and payload management tools to leverage the satellite's dynamic configurability that align with changing customer and network demands.

Calian SED has been addressing this need by providing innovative real-time satellite resource management and capacity planning software solutions that allows customers to efficiently plan and direct satellite capacity to meet

their geographical demands and changing business needs.

Calian SED has invested in a large engineering staff with experience in systems engineering, software development, hardware development and embedded logic design.

With the growth of the company's engineering pool over the past year, this experienced team has the agility and experience required to support the most complex needs of their customers and the satellite industry in general.

Communication Products

Calian SED's line of satellite communication products continues to provide customers with innovative and high performance units that are used in their networks and integrated into their service offerings. These communication products also serve as the building blocks for the delivered

systems, which offer a more compelling value proposition, providing cost-effective innovative technology, while also reducing risk and time to market.

In 2019, the company introduced the Decimator D4 Spectrum & Signal Analyzer, which is the fourth generation model of the firm's flagship product line.

Decimator is popular for standalone operations in teleports and gateways, as well as for inclusion in satellite carrier monitoring systems from Calian SED and other vendors.

The Decimator D4 includes expanded capabilities as well as new features for spectrum and signal analysis. The Decimator D4 platform has ample processing power and substantial capacity for further enhancements — stay tuned in 2020 for additional Decimator product evolution.

While the existing modulator product line supports standard DVB-S/S2/S2X applications, the company specializes in developing custom and innovative products based on the latest technology and architectural concepts.

Calian SED's multi-channel modulator and intelligent switching technologies offer an attractive and reliable way to reduce capital and operating expenses. In addition, this SDTS modulator continues to have a significant presence in the satellite precise positioning market.

Development is underway in several new and exciting areas, with product announcements forthcoming next year.

Calian SED's satellite test and monitoring systems continue to be popular in the marketplace. Mon-A-Co, the Monitor and Control Systems product, has proven to be comprehensive and reliable for satellite gateways.

Coupled with innovate uplink power control capability and the company's carrier monitoring system, the M&C is a critical application for always-on Ka-band and higher frequency Q/V-band gateways and TT&C systems.

As part of the test systems product line, Calian SED has deployed multiple in-orbit test systems to test complex communication payloads after launch to validate operating characteristics.

2019 has been an exciting year for Calian SED. Together, with its partners, the company is looking forward to continued growth, challenges and opportunities in 2020.

www.sedsystems.ca



CPI Antenna Systems Division

The organization looks forward to pursuing strategic partnerships and acquisitions that strengthens the CPI brand while adding value to the solutions offered to the firm's global customer base.

During the past year, the Antenna Systems Division (ASD) of CPI has reached major milestones as the company moves further in building a diverse antenna portfolio with the quality brand that's expected worldwide from CPI.

In the first full year of operation of the consolidated Antenna Systems Division, which includes the former Malibu Division, ASC Signal Division and recently acquired Orbital Systems and Quorum Communications, the combined talent has yielded enormous synergies from R&D collaboration as well as realizing significant operational benefits.

Orbital Innovations

One of the major areas of focus in FY19 was the integration of Orbital Systems into ASD, following the August 2018 acquisition. Orbital Systems continues to be a leading supplier of full-motion TT&C (*Telemetry, Tracking and Control*) and EOS-DB reception antenna systems. In 2019, they expanded their technical capabilities by designing dual-band antennas using dichroic sub-reflectors that minimize the need for combiners, which in turn allows for best-in-class G/T performance.



CPI ASD's three-axis 5 meter S- and X-band antenna system with a Cassegrain X-band feed and prime focus S-band feed.

Two new designs were completed and shipped; first a three-axis 5 meter S- and X-band antenna system with a Cassegrain X-band feed and prime focus S-band feed, and a second system design consisting of a 3 meter, three-axis, Ka-band antenna with integrated S-band. The latter antenna incorporates a Ka-band Cassegrain feed, with the S-band feed mounted at prime focus.

A frequency selective (dichroic) surface sub-reflector is used to split the bands between the feeds. Today, Orbital Systems is able to ship these new products with similar lead times to the legacy product designs, with typical delivery averaging four to five months.

In addition, Orbital Systems has developed a new "RF over fiber" option that is integrated into these antenna systems. This capability provides superior performance in dynamic range, and adjustable matching of the range to the antenna, compared to aftermarket "RF over fiber" solutions.

Plus, Orbital Systems has shipped antenna positioners to radar systems developers for specialty radar applications in use today to help fight wild fires in California.

Internal Collaboration Continues to Pay Off

ASD has focused on technology and service enhancements. The company has advanced their development of products for high bandwidth SATCOM at Q- and V-bands by collaborating across the pools of expertise within their three operational facilities in Texas and California.



ASD's advanced, multi-disciplined simulations have validated their technical approach toward an optimized system from IF to RF. As a testament to their efforts to exceed customers' expectation on project execution, this year they have deployed two, turn-key, Ka-band large-aperture gateway systems in record times.

The company's mobile solutions have become the products of choice for many demanding applications. Sophisticated features such as ARSTRAT compliance and low PIM operation have distinguished their 2.5, 4.0, and 4.6 meter products.



The company's manufacturing facility in Whitby, Canada, is now able to produce antenna up to 13 meters in diameter.

Whitby operations has made significant strides towards streamlining their manufacturing operations and have now demonstrated their capability to produce large quantities of LEO/ MEO antennas, having shipped more than 100 during 2019 for a leading LEO constellation.

Some of these antennas have been in active service for TT&C since February 2019. ASD believes that the experience gained from such a large undertaking will serve them well on future pursuits of a similar nature.

Popular Trifold System Update

The ASD Trifold trailer-mounted antenna continues to set the standard for versatility and reliability and has been widely adopted by commercial and military end customers.

The company has commenced Trifold deliveries to satisfy commitments made as a result of a significant award from an existing customer on a major program of record, with expected duration of 10 years.



CPI ASD's Trifold trailer-mounted antenna.

ASD has had a long history of using composite materials in the firm's antenna solutions and expects the market demand for composite materials to increase due to their unique thermal and mechanical properties.



CPI has been incorporating proprietary techniques in the composite material reflectors to meet certain required specifications, such as the stringent low PIM (passive intermodulation) performance requirements for ARSTRAT. These sophisticated features that facilitate ARSTRAT compliance and low PIM operation have distinguished ASD's 2.5 to 4.0 meter products from competing systems.

ASD's Camarillo, California (Malibu), operations has followed a similar strategy in 2019 as they did in 2018; build upon the existing customer base by focusing on the core technologies for ground and airborne Line of Sight (LOS) data terminals.

The Camarillo operations have won several major programs this year, including solutions for the coveted MQ-25 program with Cubic, which will introduce a new variant of their AT-2 airborne terminal with a short-can configuration, plus the Sentinel program with Raytheon, which will incorporate their custom- designed high precision Radar pedestal.



ASD continues to manufactures the complete line of the former Andrew/GRANGER brand HF antennas operating in the 2 to 30 MHz frequency range.

CPI ASD is one of a few remaining suppliers of such antenna systems in the world and continues to supply these systems to NATO and several foreign governments.

Additionally, the company received a major order for their L-band ATC (Air Traffic Control) Radar antennas, with additional orders expected in 2020.

Continuing to Strengthen the CPI Brand

On August 5, 2019, CPI announced that the company had entered into an agreement to purchase SATCOM Technologies, the antenna systems business of General Dynamics Mission Systems, a business unit of General Dynamics.



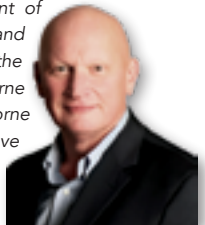
SATCOM Technologies designs, manufactures and installs satellite communications antenna systems used in commercial, defense and scientific applications.

This business will complement CPI's existing portfolio of communications products for government, military and commercial applications and enables them to provide their customers with a wide range of complementary products, capabilities and resources to support this dynamic and growing market, making it an excellent fit for CPI.

www.cpii.com/division.cfm/14

Author Tony Russell is the President of CPI Antenna Systems Division and possesses 36 years of experience in the RF industry, primarily serving airborne and maritime radar, ground and airborne communications, and millimeter-wave science segments.

Mr. Russell has been with Communications & Power Industries (and its predecessor) for more than 25 years, serving in technical and management roles in CPI's electron device solid-state HPA and antenna businesses. Currently, he serves as the president of the CPI Antenna Systems Division. Mr. Russell has an Honors degree in Physics from the University of York (UK) and an MBA from York University (Canada).



ETL Systems

As the satellite industry continues to evolve and with such a vast number of new launches planned for the coming years, we are continuing to develop our products to meet those ever-changing needs.

2019 has been one of the most exciting years for ETL Systems. Kicking off the year with the acquisition of Atlantic Microwave in January, launching key new products, attending more global shows than ever before, ending with a royal visit at our headquarters in the heart of rural Herefordshire, UK.

Moving into New Markets

The year started with us acquiring Atlantic Microwave, a leading provider of RF and microwave components and satellite communication test equipment. Atlantic Microwave is well suited to ETL; offering a wide range of complementary RF products but providing to a different customer base, enabling us to grow and find new opportunities together.

The strategic acquisition of Atlantic has meant growing our RF product range and presence to diversify into new markets such as SATCOM testing. Testing is obviously important to our customers and Atlantic's high-quality products are providing another avenue of resilience for ETL.

This year we have co-exhibited at several international trade shows, including NAB and 3CDSE, with our cooperative relationship going from strength-to-strength, we have further collaboration planned for 2020.

New 4th Generation Enigma RF Matrix

In March, we launched six new upgraded models of our flagship Enigma L-band 32x32 Switch Matrix, for downlink and uplink signal management.

There are already more than 1,000 of our Enigma Switch Matrices in operation worldwide, with new features added to our most popular matrix including variable gain, improved noise figure and increased power savings. Variable gain on each output as a standard feature allows greater control of each signal level.

Unused routes on the splitter cards are unpowered to help save power. As with previous models, the latest generation has hot-swap, dual redundant CPU, PSU, and hot-swap single RF cards for enhanced resilience and minimal downtime.

The Enigma is a versatile Switch Matrix that can be used across a range of applications, including satellite communications, broadcasting, military, and government communication systems.

Expanding the RF Components Sales Team

In response to growing demand for our RF components, we appointed **Bethan Sant** as our newest Components Sales Executive. Since the team expansion, we've won multiple large projects in Poland and Latin America for Waveguide RF components and amplifiers with RS485 controlled communications protocol.

The addition of an extra component's sales executive has meant increased support for our global customers, with Bethan heading up sales for West and East Europe, Scandinavia, Russia, Africa, and Latin America, helping us to grow further across these regions.

Focusing on other projects of note, we also provided a sizeable system upgrade for an Eastern European Government, which included



The Enigma L-band 32x32 Switch Matrix.



The Hawk 1U L-band RF matrix.

adding a second Vulcan Matrix, plus StingRay RF Over Fiber and Piranha LNB power supplies.

Another project success, in conjunction with a European integrator, included providing fiber links and an expandable 128 x 128 switch matrix for an automatically controlled teleport in the Middle East.

Attending Global Exhibitions

At ConneCTechAsia, a key show for our Asian customer base, the debut of our latest products occurred, including the new Enigma Switch and Harrier Switch Matrix.

We also co-exhibited with Atlantic Microwave at the Three Counties Defence and Security Expo (3CDSE). As well as demonstrating our 64 x 64 Hurricane L-band matrix, which is used to provide flexibility in the routing of antennas to receivers or modems, and our StingRay RF over Fiber range, which provides fiber links for short, medium and long distances.

We also showcased a range of Atlantic Microwave products and components. This included a miniature synthesizer, which enables customers to test satellite performance without having to send live signals over the network, as

well as the company's range of test cables and coaxial cable assemblies.

Launching New Technologies in RF Distribution

LEO launches are coming and will accelerate at an astounding speed, but no-one is really talking about the ground segment infrastructure that will be needed to support these launches. We have spent a great deal of time looking into this to ensure we are ready to support those launches.

Among numerous product launches during the year, our key product launches were at IBC this year. We launched a new compact 1U L-band RF matrix, Hawk.

As well as being suited for High Throughput Satellite (HTS) gateways and deployable VSAT terminals, the Hawk is designed for RF signal routing in Low Earth Orbit ground stations, which will require compact designs with high resiliency and flexibility.

The Hawk Matrix has capacity for two 8x8 matrix cards – which can be combining (fan-in) or distributive (fan-out) – for uplink and downlink applications.

We also launched our Falcon KU to L-band block down frequency converter at IBC. It is a completely new rack system product which is a major step forward in high density redundant frequency converter designs. This will be an important focus for us in 2020 offering more frequencies for conversion of uplink and downlink.

ETL Systems Receives a Royal Visit

ETL was honored with a visit from HRH The Prince Of Wales due to the huge success the company has afforded globally, while working from a rural location.

HRH Prince Charles commented "It is wonderful to see such skilled engineering being applied in this particular field. Clearly you are producing very high quality, high standard equipment which is used to great effect by customers in over 180 countries. Ladies and gentlemen, I hope you go from strength to strength."

HRH The Prince of Wales was given a tour of our facilities, met the staff working at our Herefordshire HQ and presented us with a commemorative plaque. We are extremely proud of our rural heritage, developing cutting-edge technology amongst the apple orchards of Herefordshire, so it was a great honor for that to be recognized by such an important visitor.

Growth and Innovation: Plans for 2020

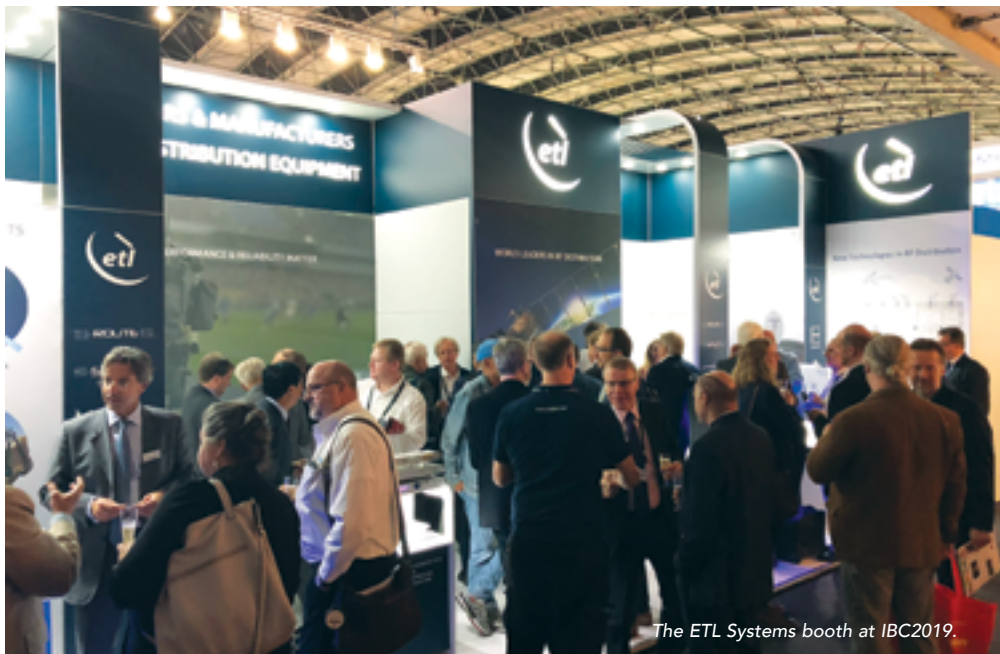
As the satellite industry continues to evolve and with such a vast number of new launches planned for the coming years, we are continuing to develop our products to meet those ever-changing needs.

ETL continues to grow and we have extensive growth plans in place for 2020 including the launch of more frequency converters, development of some exciting new technology and attending more new global trade shows.

We look forward to an exciting year ahead.

www.etlsystems.com

The author is Andrew Bond, the Sales and Marketing Director for ETL Systems.



The ETL Systems booth at IBC2019.

Gilat Satellite Networks

Looking into 2020, Gilat will continue to focus on the market segments of IFC, CBH, and Broadband, bringing to market technical innovations to best address its extensive customer base worldwide.

Gilat Satellite Networks is committed to the ongoing development of cutting-edge technologies and products that improve the quality of lives by enabling broadband communication that reaches all parts of the world, on land in the air and at sea.

2019 was a remarkable year for Gilat with significant achievements, which are a testament to Gilat's recognized leadership and innovation. Four of these achievements are discussed below. First, the landmark achievement of becoming a prominent player in the ground segment for Non-Geo Stationary Orbit (NGSO) Satellites. This achievement was marked in November this year, with SES selecting Gilat's ground segment for its next-generation platform, O3b mPower Medium Earth Orbit (MEO) constellation.

In the Inflight Connectivity (IFC) market segment, Gilat has increased its presence with the selection by a Tier-1 Business Aviation service provider for a full aero terminal, thus expanding Gilat's aero offering from Commercial Aviation into the Business Aviation market segment. This win also broadens Gilat's portfolio to include a tail-mount antenna (TMA) for business jets, in addition to Gilat's leading airborne modem. In the Mobile market segment, Gilat's cellular backhaul solution was recognized this year by the industry analyst NSR, as the world leader in shipments of cellular backhaul over satellite, with 35 percent market share in modem shipments. During 2019, Gilat continued to expand its presence worldwide with additional tier-1 Mobile Network Operators (MNOs).

And finally, in the Broadband market segment, Gilat has reached an important milestone in Australia with NBN Co launching the largest operational satellite network installed in Australia. Gilat's comprehensive ground equipment and network management system are the infrastructure for this vast network now installed and operational throughout Australia, meeting NBN's stringent requirements for uninterrupted communication.

Non-Geo Satellite Orbit (NGSO) Landmark Achievement

In 2019, the market for Non-Geo Satellite Orbits (NGSO) has seen a significant move forward as the list of NGSO constellations grew, and new large players such as SpaceX and Amazon have entered the market and are influencing the market dynamics.

In the fourth quarter of this year, Gilat marked an outstanding achievement reaching a major landmark in fulfillment of its strategy to be a significant player in the Non-Geostationary Orbit (NGSO) Satellites. Gilat's multi-orbit GEO/NGSO platform was selected by SES for its revolutionary mPOWER Medium Earth Orbit (MEO) constellation. Gilat was selected for its technological innovation and proven track record worldwide. The innovative ground network design significantly reduces cost per bit, provides best-in-class spectral efficiency, and demonstrates a step function in modem performance, all vital for revolutionary multi-terabit high-performance constellations such as mPOWER.

In addition, a series of successful tests were conducted throughout the year over Telesat's Phase 1 Low Earth Orbit (LEO) Satellite. A first-ever live in-flight demonstration for broadband connectivity over LEO was the result of Gilat's cooperation with Global Eagle at the end of 2018. Then in early 2019, Gilat further demonstrated exceptional mobility connectivity, this time with a tier-1 maritime service provider. This was an industry-first milestone for maritime applications requiring exceptionally low latency and high bit-rate. And, most recently another remarkable industry milestone was recorded of the fastest ever modem speeds of 1.2 Gbps total throughput using Gilat's modem over Telesat's Phase 1 LEO Satellite.

Gilat is heavily engaged in this upcoming market, and is positioned as a major player for the ground segment requiring higher performance, better efficiency and reduced cost per bit.



Gilat Satellite Network Headquarter Offices

Inflight Connectivity (IFC) Entry to Business Aviation

In the Inflight Connectivity (IFC) market segment, several milestones were noted, marking Gilat's global IFC leadership. Gilat has increased its presence from Commercial Aviation to Business Aviation with the selection of a Tier-1 Business Aviation service provider. The Business Aviation segment requires premium service and therefore calls for a high-end robust solution that must be based on innovative technology. Gilat is therefore, particularly proud to have met the customer's demanding high performance and reliability requirements. This win not only adds to Gilat a new IFC market segment but also strengthens Gilat's IFC portfolio with an additional 12" tail mount antenna (TMA) in addition to its industry-proven Taurus aero modem.

Also, Gilat aero modem, Taurus, has been selected by Honeywell for its Jetwave Satellite Communication Solution. The integration of Gilat's aero-modem will enable Honeywell to offer its JetWave solution within territories as well as to roam in-and-out of territories where Gilat's ground network is deployed. The Honeywell-Gilat solution is to be deployed first in China over Gilat's already deployed HTS Ka network for both domestic and cross border flights, and then expected to expand to additional regions around the globe.

On another front, a significant industry trend to offer free WI-FI for airline passengers has been declared by several US airlines and, as such is a tailwind in Gilat's business. This is due to a significant expected usage increase and particularly a usage shift to a mix of business and leisure travelers. Free WIFI is likely to enhance the usage of higher bandwidth applications such as streaming and social media.

To support this trend of an increase in the IFC bandwidth, additional equipment is required to provide the required satellite resource utilization. Gilat is well-positioned for this opportunity, with its field-proven, high-performance solution that easily meets the demand for hundreds of concurrent passengers, providing hundreds of Mbps. with an excellent user experience.

Gilat's Taurus aero modem is being used by Gogo for Commercial Aviation for some time, providing an excellent user experience and is more than capable of delivering the required additional free WI-FI service. Gilat's solution is installed in a large number of airlines, including Aero Mexico, Air Canada and Delta Air Lines delivering Gogo's 2Ku service, which is installed to date on more than 1,300 aircraft.

Cellular Backhaul (CBH) Market Leader

In the Mobile market segment, Gilat's cellular backhaul (CBH) solution was recognized by the industry analyst NSR as the world leader in shipments of cellular backhaul over satellite, achieving a 35 percent market share in modem shipments. In the fast-spreading 4G/LTE networks, Gilat has over 80 percent of satellite-based cellular backhaul installations worldwide.

Gilat supplies its renowned backhaul solution globally to Tier-1 Mobile Network Operators (MNOs), so these large mobile carriers can extend their network coverage to remote locations, as well as to islands, highways, and tourist attractions to support their subscribers who require high-quality broadband connectivity wherever they go. Gilat offers the backhaul network and VSATs as well as full turnkey solutions providing managed services in numerous deployments such as in the Americas and Asia.

In 2019 Gilat expanded its installed base with Tier-1 logos such as NTT DOCOMO in Japan and TIM in Brazil. These success stories add on to continuously expanding coverage of existing customers that include among others: Sprint and T-Mobile in North America, EE in the UK, Telstra and Optus in Australia, SoftBank, and KDDI in Japan and Globe in the Philippines.

In addition, Gilat is leveraging its 4G superiority to becoming a significant player in 5G. The required high speeds, low latency, and flexible network architecture are addressed by Gilat with its proven technology and roadmap. Speeds over 1Gbps. will be provided based on innovative wideband technology, and the integration of the ground segment into the 5G eco-system will utilize SDN/NFV, Cloud, Edge Computing and Network Slicing.

Gilat is a SaT5G Project member and as such is involved in bringing satcom into 5G and has participated in several tests with industry partners. This year Gilat also participated in the first-ever successful test that was conducted, demonstrating 5G connectivity over Telesat's Phase 1 LEO Satellite powered by Gilat's modem. The successful test was done at the 5G Innovation Centre at the University of Surrey in the UK and was conducted by a tier-1 European operator, demonstrating 5G backhauling with Gilat's modem.

Broadband Launch of Massive Network in Australia

Gilat has reached an important milestone in Australia with NBN Co. this October, with the launch of NBN's business satellite services meeting the connectivity demands for businesses and government customers throughout regional and rural Australia. Gilat's comprehensive ground equipment and network management system are the infrastructure for the largest operational satellite network installed in Australia to meet NBN's stringent requirements for uninterrupted communication throughout Australia.

The commercial launch of this flagship project initiates the commencement of Gilat's managed services to NBN. During the launch event, NBN's CEO, Stephen Rue said: "We're redoubling our commitment to regional Australia with a focused Business Unit responsible for engaging with regional customers and meeting their needs."

The successful launch, coupled with the declared focus on regional and rural areas of Australia, demonstrates a growing commitment for satellite communication based on Gilat's multi-service platform for cellular backhaul, mobility services and enterprise offerings.

Bottom line

The win with SES positions Gilat at the forefront of ground networks for NGSO constellations and puts Gilat in an excellent position to win additional opportunities in the vast market that NGSO creates, and further than that, Gilat's product roadmap will serve not only NGSO but also the new generation of GEO HTS and VHTS satellites.

With the growing importance of mobility applications and the emergence of NGSO constellations, Electronically Steered Array (ESA) antennas are another key focus area for Gilat and will indeed carry into 2020. Major progress is being made on Gilat's joint development with Airbus of an ESA antenna for in-flight connectivity, as part of the European Commission's Horizon 2020 program. This Ka-band ESA terminal is based on Gilat's chipset for its Phased Array Antenna (PAA).

Gilat is investing in ESA antennas for the aero market to address the expected efficiency challenges of the upcoming market transformations. The characteristics of ESA antennas such as flat panel, instantaneous bandwidth, beam agility, multi-beam connectivity, scalability/modularity, and longevity — are imperative for unlocking new business opportunities and for maximizing performance of satellite networks.

Looking into 2020, Gilat will continue to focus on the market segments of IFC, CBH, and Broadband, bringing to market technical innovations to best address its extensive customer base worldwide, as it continues to materialize the vision of broadband connectivity for all, anywhere, anytime.

www.gilat.com

Doreet Oren (doreeto@gilat.com) is Director of Product Marketing & Corporate Communications for Gilat Satellite Networks. Doreet Oren has been in this role since 2012 and has been responsible for defining product positioning, messaging, go-to-market strategies, market research, and analyst relations.

Oren has more than 20 years of industry experience, and has held management positions in R&D, product management and product marketing, for international high-tech companies. In this capacity she contributed to next generation product definition and was responsible for delivering the company's vision to the media and analyst community. Oren has published thought leadership articles in renowned international journals, and has spoken at numerous industry conferences worldwide. Oren received a BSc in Computer Science from George Washington University.



Intuitive Machines

Nova-C draws on the heritage and lessons learned from NASA's Project M lunar lander and Project Morpheus experience.

Intuitive Machines is disrupting the aerospace standard, accepting the best minds and putting aside the pieces that drive the cost of spaceflight sky high.

In 2013, *Steve Altemus*, left his post at NASA's Johnson Space Center and started Intuitive Machines with Dr. *Kam Ghaffarian*, chairman, and Dr. *Tim Crain*, Vice President of Research and Development.

Six years later, the aerospace company has more than 100 employees seizing the opportunity to become the first commercial company to land on the lunar surface.

"It's a very powerful statement for the United States to show the rest of the world the depth of our technology and innovation," said Altemus. "In the United States, a small business can fly to the moon, that's incredible. It shows how innovative the American people are and I'm proud to be a part of that small business."

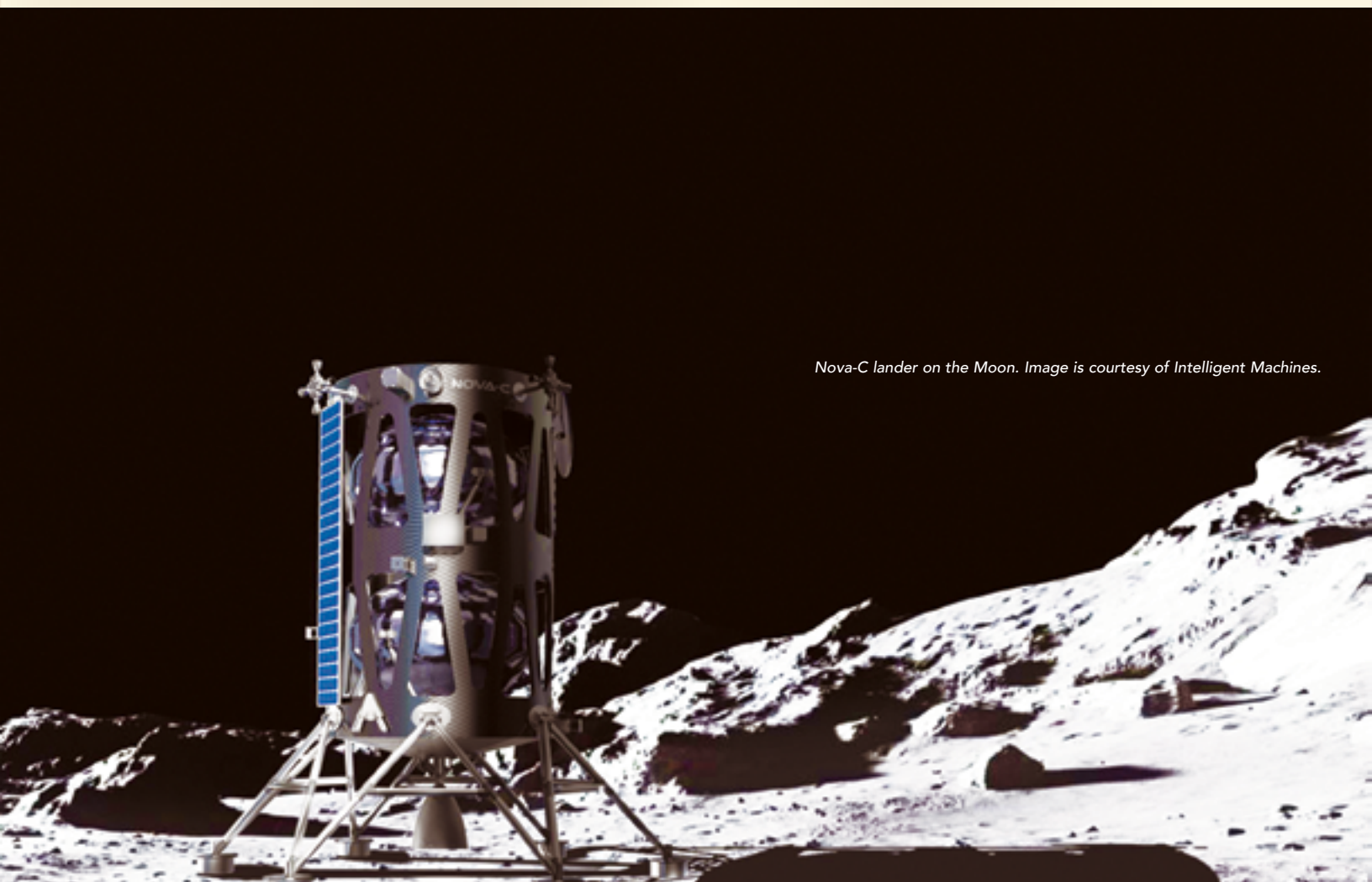
On May 31, 2019, NASA awarded Intuitive Machines the first mission task order under the space agency's Commercial Lunar Payload Services (CLPS) program.

Under the CLPS contract, NASA tasked Intuitive Machines to develop, launch and land its lunar lander, Nova-C, on the lunar surface with a payload of NASA-provided instruments that will conduct science investigations and demonstrate advanced technologies on the lunar surface.

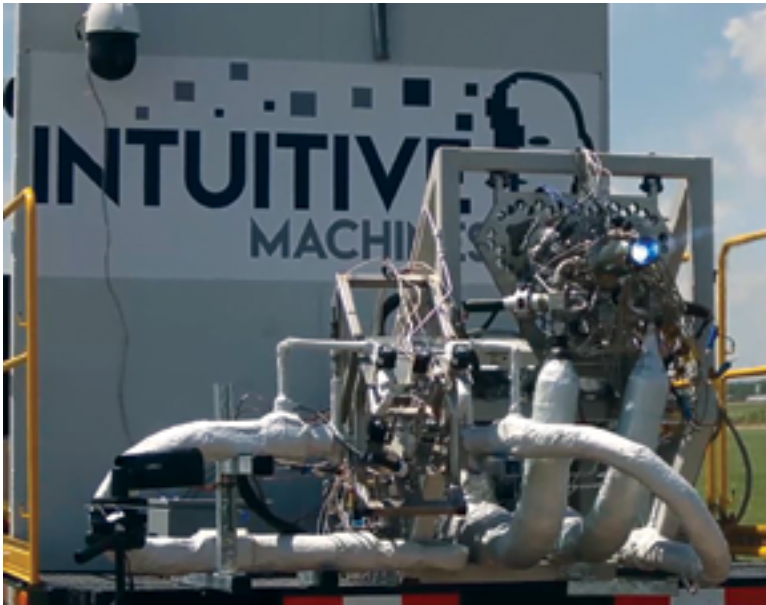
Nova-C weighs 3,300 pounds and stands roughly 10 feet tall. It will carry up to 220 pounds of payloads to the moon's surface.

"Intuitive Machines has had a lot more visibility over the past two years," said Altemus. "We started building Nova-C last summer with funding from a private investor and more than \$77 million from NASA's fixed-rate CLPS contract with an additional incentive of \$2,500,000. People were surprised there were three sub \$100 million mission bids. The verdict is out whether that holds but we're confident that we are right, and we'll stay in this cost range. We are not looking to raise prices; we are looking to fly reliably for less than \$100 million per mission."

The first Nova-C mission includes five NASA instruments, including a navigation doppler lidar for range measurements during decent, stereo cameras, a navigation demo payload, sensors to conduct radio wave observations and a retroreflector.



Nova-C lander on the Moon. Image is courtesy of Intelligent Machines.



The lander's main engine. Image is courtesy of the company.

Aside from NASA instruments, Nova-C will also carry commercial and academic payloads including a camera from Altemus' alma mater, Embry-Riddle Aeronautical University.

Prior to landing on the lunar surface, the camera will detach from Nova-C so that it can capture the landing for further examination. Right now, about 121 pounds of the lander's 220-pound payload is filled for the first mission.

"We have a sliding scale of price per each kilogram that partners want to fly to the moon," said Altemus. "The base cost is \$1 million per kilogram but if a payload requires power or things like special integration measures like a quiet vehicles while taking samples, we have an algorithm that changes the price."

Nova-C draws on the heritage and lessons learned from NASA's Project M lunar lander and Project Morpheus experience. Project M and its terrestrial counterpart, Project Morpheus, were designed, developed and tested by NASA Johnson Space center to demonstrate new technologies for planetary landing including autonomous hazard avoidance, precision landing and high performance cryogenic liquid oxygen (LOX) and liquid methane (LCH4) integrated propulsion.



A test firing of the main lander engine. Image is courtesy of Intuitive Machines.

"We aren't afraid to take a risk," said Altemus. "We've been pushing the development and acceptance of space cryogenic LOX. For us to take that on and say we'll do that is because we have confidence to do that. We are confident, we bid it and convinced NASA we have a handle on the risks."

In October, Intuitive Machines officially selected SpaceX to launch Nova-C to the Moon in 2021 on a Falcon 9 rocket.

"Intuitive Machines is thrilled to sign with SpaceX to take Nova-C on its first mission to the moon," said Altemus. "SpaceX's ability to make low-cost quality lunar transport is paramount to completing NASA's CLPS contract and Intuitive Machines becoming the first commercial company to land on the Moon."

The decision came after the company reviewed proposals from multiple launch providers and ultimately selected SpaceX for its proven record of reliability and outstanding value.

SpaceX will provide Nova-C cryogenic propellant loading through a fluid connector into the rocket's payload fairing until the final minutes before liftoff.

The last-minute propellant loading will allow Nova-C's LOX and LCH4 to remain between minus 250 degrees Fahrenheit and minus 300 degrees Fahrenheit.

Intuitive Machines' Vice President of Aerospace Systems, **Trent Martin**, said SpaceX's ability to top-off LOX and LCH4 very late was a key reason the company went with SpaceX. "That allows us to top off and keep it full up until launch, which was our biggest concern when it came to cryogenic storage.

Once we're in space, it is easier to store, and our mission duration is relatively short. So, we can do that with nominal effectors for storing cryogenics in space."

Once launched from Launch Complex 39A at NASA's Kennedy Space Center in Florida, Intuitive Machines anticipates Nova-C will make a soft landing on the lunar surface in about six days. The lander is designed to operate on the lunar surface for around 13 days during one lunar day.

"The lander dies on the surface after the first lunar day, which is 13.5 days," said Altemus. "It goes into a frozen mode; we have not added tech to wake it up on the next lunar day."

Moving forward, Intuitive Machines is looking toward building upon its scalable propulsion system and to continue building engines for Boeing's Human Lander System (HLS) Technology Development Initiative.

Boeing selected Intuitive Machines to build, test and deliver prototype main stage and reaction control (RCS) engines for their HLS NextSTEP-2 BAA Appendix E – Architecture Studies and Technology Prototypes contract that support's NASA's goal of returning humans to the lunar surface in 2024.

"The relationship between Intuitive Machines and Boeing combines two stellar companies with ambition to fulfill NASA's goal of returning humans to the Moon in 2024," said Martin.

The Appendix E technology prototyping effort will work to mature this technology and enable HLS elements to use a common system across the architecture to meet the preliminary goals for all elements and reduce development and operation costs by using a single propellant combination for space flight.

www.intuativemachines.com

Steve Altemus is a Founder and President and CEO of Intuitive Machines.



Marlink continues on the company's mission to deliver the innovation needed for Maritime customers to save money and operate responsibly.

At Marlink, a significant amount of innovation, time and funding goes into the development of services and solutions that allow our customer to operate more efficiently and with less environmental impact.

This growing wave of digitalization is happening across all maritime verticals, from cruise and fishing, to shipping, offshore and superyachts, and throughout 2019 our digital enablement strategy has supported diverse customers and vessels to leverage the power of connectivity and data sharing.

Marlink's satellite network, which currently comprises 21 satellites and 50 beams, provides global coverage with high resilience and redundancy as the foundation for maritime digitalization, but demand has continued to grow throughout 2019 for solutions in a wider network and technology context. To meet the market needs, we continue to build out our network and introduce new capabilities that make going digital becomes easier and more secure.

Combating the Cyber-Threat

Optimal access to connectivity and high network quality are increasingly fundamental expectations for crews and customers. However, as more data is used on board, the risk of cyber attacks grows. Considering the risk factors, maritime networks must be comprehensively protected against the ever-present threat of malware and more targeted attacks. Marlink has been tackling the issue head-on with ongoing enhancements to our fully-integrated ship- and shore-based Cyber Guard portfolio of cyber security solutions in 2019.

Combining state-of-the-art tools and processes in its role of securing maritime IT networks, Cyber Guard operates based on the 'Protect, Detect and Resolve' principle, covering all aspects from data encryption, threat detection and incident investigation through to secure remote access and remediation.

At our Nor-Shipping stand in June of 2019, we launched a new module within the Cyber Guard portfolio; 'IT Breach Policy' monitoring. Straightforward and effective, the monitoring identifies abnormal and/or suspicious network and internet usage which doesn't conform to a client's IT policy, and will automatically issue an alert.

Issues found can then be resolved with the integrated tools provided in the Cyber Guard portfolio. Cyber Guard services recognize more than 50 distinct threat categories, from intrusion attempts and confirmed intrusions to social engineering.

2019 saw its use increasing by early adopters in readiness for the IMO's mandate to include cyber risks within every vessel's International Safety Management (ISM) Code by January 1, 2021.

Marlink's introduction of 'IT Breach Policy' monitoring was just one direct consequence throughout the year of enhancements to the Cyber Guard portfolio which were brought about thanks to detailed customer feedback. Enlisting the invaluable collaborative input of more than 4,000 crew from 200 tankers, container vessels and bulkers has enabled us to take new risk scenarios and use cases on board as a systemic method of advancing Cyber Guard's sophistication and reinforcing its performance.

Digitalization and Compliance

Another Marlink milestone in 2019 was the launch in June of our ITLink portfolio: an exhaustive suite of IT solutions enabling fleet owners and operators to fully manage their fleet-wide IT environment on a 24/7 basis, with complete transparency, by standardizing, simplifying and automating their IT operations. The benefits include time and money saved by automating time-consuming and complex tasks including managing, administering and updating onboard IT networks and applications. ITLink also facilitates strict compliance — a must in the light of multiplying regulations including the IMO's aforementioned 2021 cyber security ruling and TSMA version 3, which promotes best practice management and self-assessment for tanker operators.

Available as a standalone portfolio, or integrated within Marlink's global multi-band Sealink network and XChange communications management system, ITLink operates on a scalable, flexible, three-tier 'Design, Deliver and Manage' basis, ensuring that clients' specific needs are securely addressed and fully supported. Marlink IT management services are used on more than thousands of vessels already, with several major fleet installations in 2019.

IT in Action

Danish shipping company J. Lauritzen selected Marlink to deploy fully integrated and managed IT services with ITLink including the KeepUp@Sea platform on all Lauritzen Kosan managed gas carriers.

The solution enables automation of software and security updates, network and PC health monitoring and remote access for fast issue resolution. Lauritzen Kosan's fleet is tasked with the secure and dependable ocean transportation of liquefied petrochemical gases. The ITLink managed services optimizes vessel IT infrastructure and processes, enabling a reduction in operational and support needs while simultaneously improving the stability of onboard networks.

Marlink is also providing a similar solution to Höegh Autoliners' 38 strong car and truck carrier fleet. Marlink will provide managed services designed to ensure the resilience and compliance of the vessel IT networks on Höegh vessels. Onboard implementation of the service started in September, after hardware delivery and shore tests have been completed.

Through standardization, automation and remote network management, KeepUp@Sea will enable Höegh to keep its IT systems always available, updated and secured, and to achieve material cost savings in operations. Over-the-air (OTA) applications and file distribution will limit the risk of human error, and dramatically reduce the resources and time required for updating software and anti-virus manually.





Marlink's multi-band connectivity will help OFW ships provides seamless crew connectivity, including enabling the crew to use their own devices onboard.

By replacing the outdated process of using physical media to upgrade onboard networks, Marlink is also assisting Höegh Autoliners to improve IT compliance, ensuring readiness for new regulations and guidelines, including the IMO 2021 Cyber Security section. Marlink's ITLink solutions portfolio is also future-proofed to accommodate fleet expansion and processes of controlled change.

OT Joins IoT

At the end of 2019, the company introduced a new pillar in our digital enablement strategy. Joining Smart Connectivity, Cyber Guard and IT Link, Bridgelink is a technology agnostic solutions portfolio designed to interconnect on board Operational Technology (OT) within a standardized data structure. It addresses compatibility and interfacing challenges by providing an open, technology agnostic platform for unifying on board equipment and sensors with network infrastructure and satellite IP connectivity, so that data from any system can be accessed in a single interface at sea or ashore for visualization and analysis in a secure matter.

And while reducing operational costs, BridgeLink can also help ship owners and operators to reduce their environmental impact — that is certainly a win-win situation for everyone.

We also added even more value to our already industry leading Inmarsat Fleet Xpress offering during 2019, including a new customer portal providing detailed service information on board and ashore, such as what part of the Global Xpress network — Ka- or L-band — a vessel is currently using. The information ensures that customers can adapt their usage patterns should they need to continue operations on the lower bandwidth L-band channel.

The portal joins a wealth of value adds for Marlink Fleet Xpress users, such as access to our extensive portfolio of business critical solutions designed to enable customers to fully leverage the power of the connectivity they have on board.

Green Innovation

By harmonizing data from OT such as radar, automation, power and propulsion systems, BridgeLink supports our customers by enabling the development of scalable remote ship management and smart maintenance systems, which can improve vessel efficiency using secure data collection for specialized analysis and applications.

Sustainability and green initiatives continued to be in focus throughout 2019 and of course, will be for decades to come.

With developments such as ITLink and BridgeLink, we are enabling our customers to operate more efficiently. Every drop of fuel a ship doesn't use saves money, but it also contributes to saving the planet.

While our customers reduce their environmental footprint, through i.e., remote monitoring and diagnostics, and smart maintenance, Green issues are reflected across Marlink's own innovations. For instance, ship owners can send less engineers and support functions to ships because our resilient global network and unique IT solutions help us to deliver high service availability in the first place. Should something go wrong, many issues can be resolved over the air.

As 2020 approaches, Marlink continues on the company's mission to deliver the innovation needed for Maritime customers to save money and operate responsibly. In turn we are lucky enough to work with customers innovating in their own market, such as Ocean Fresh Water, who this autumn contracted us to deliver broadband for a unique marine bottling plant, designed to turn seawater into drinking water.

From specialist ships like this, to offshore, merchant and fishing vessels, as well as luxury yachts, 2019 has been a fantastic year for Marlink and the customers that depend on us for global communication and connectivity.

With the SATCOM industry always moving forward, Marlink is positive that we'll have just as many new developments to discuss this time next year, as well.

marlink.com



A Stella Kosan LPG Tanker.

Laser-powered networks in the air and in space promise to include rural and remote regions as well as developing countries and LDCs.

This year saw the starting pistol fired on a new epoch in telecommunications.

The first bold steps were taken to move high-speed, ubiquitous connectivity from the ground to the upper atmosphere and beyond into space. No longer would the world only be connected to high-speed internet through physically cabled fiber-optics dug deep into the ground or stretched hundreds of miles across ocean beds.

While there have been previous efforts to establish high-speed connectivity via multiple satellites before — indeed, those old enough will recall the (eventually doomed) efforts of Teledesic and Globalstar to establish commercial broadband constellations in the 1990s — a new, highly commercialized market, driven by the private sector, is fueling a renaissance in space as the solution to all of our ever-growing connectivity needs.

The companies operating in this market — largely in the hands of private individuals and management teams who are keen to exploit the private sector's desire to profit from the incredible returns being promised and led by first movers such as OneWeb and SpaceX — are already in the throes of actively building this new generation of global communication constellations. Constellations that, for once, genuinely promise to transform the nature of connectivity for the 'always-on', data hungry 21st century.

What's changed? Well, everything and nothing. The concept and physics behind constellations remain as they were in the 1990s: inter-connect satellites in LEO to ensure global availability of connectivity regardless of where one is: in the middle of the ocean, in the underserved Mid-West of the United States, or plonk in the middle of the Atacama desert.

What has changed, however, are the technologies and the economics. Satellites are now built to specifications that were unthinkable just 20 years ago and launched on rockets whose fairings and boosters can be recovered and reused. The effect on cost has been considerable.

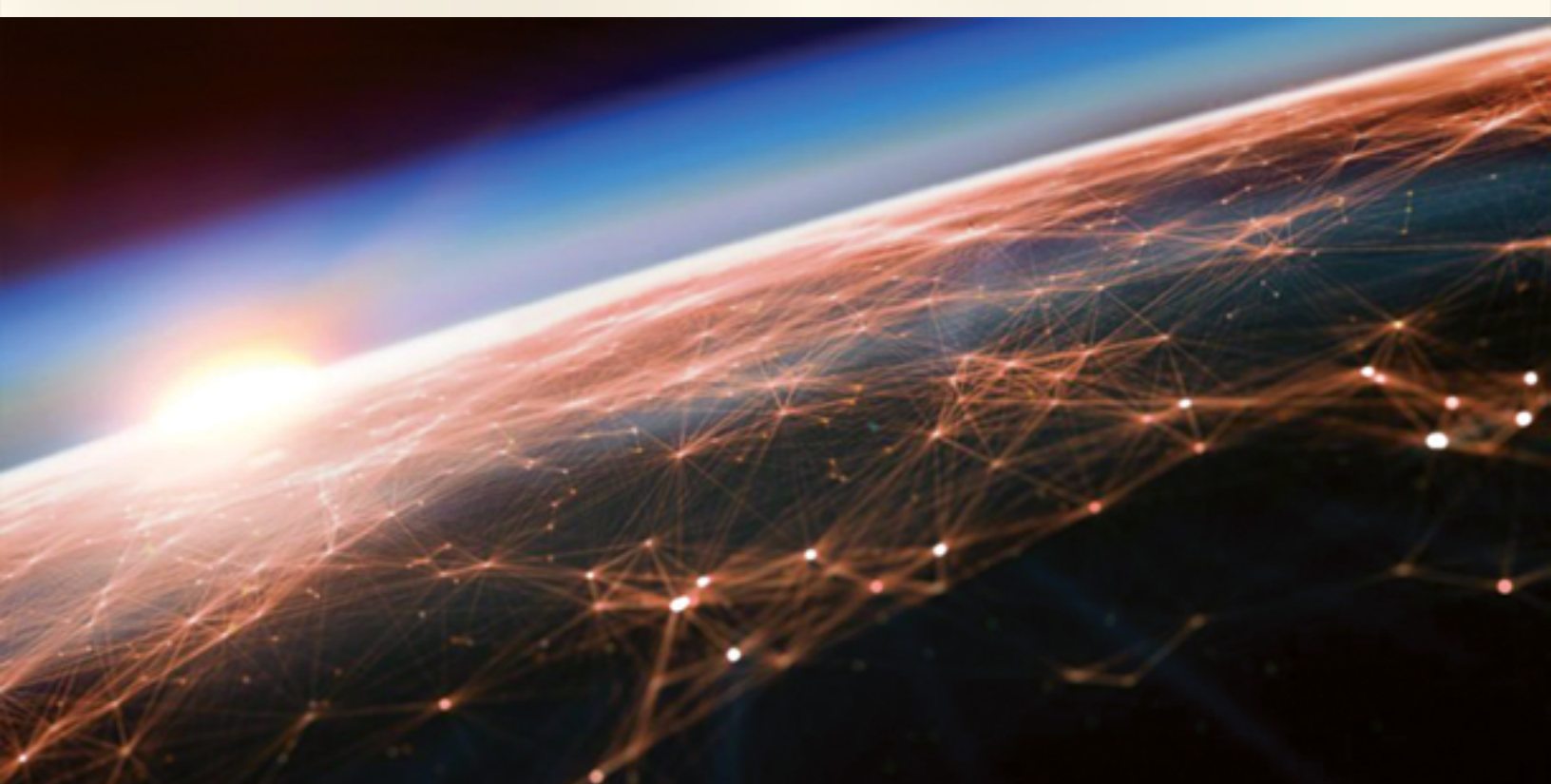
Twinned with the drive and vision of the high-profile individuals who are pushing these efforts — the *Musks*, *Bezos*, *Bransons* of the world — the effect is dramatic. Here is a market looking to Ford for its inspiration — not Fabergé: serial production precipitating reduced cost not individual, one-off projects that come in at huge prices.

In the last six months, the first batches of satellites that will form the cornerstones of these various new constellations have been launched. As 2020 progresses, so will the launch manifests and the number of satellites in LEO will grow and constellations will start to live up to their name with hundreds of constituent parts.

What differentiates many of these new constellations from earlier incarnations (and the one existing, completed constellation — Iridium's Certus broadband constellation employing 66 linked satellites in LEO) is the choice of technology that will provide backbone connectivity.

All of the following companies have launched — or will shortly launch — the first satellites of their constellations: Laser Light Communications, Cloud Constellation, LeoSat, SpaceX, Telesat, Analytical Space.

All of them share not just a strategy to provide connectivity from LEO (with one — Laser Light — opting for MEO) but also a commitment to employing free space optical communication — laser communication.



Laser Communication: A Natural Advantage

And the reasons for this? The inherent physical benefits of laser communication over the established means of communication from the air and space — RF. The benefits are numerous.

An RF beam — and RF beams are how satellites currently communicate with ground stations — spread out like a fan from their origins, whereas lasers maintain their narrow shape over vast distances. This makes them nearly-impossible to tap, jam or spoof.

As data security for institutions operating in highly data sensitive arenas, such as finance and government, moves rapidly up the agenda, so does the need for a unhackable internet. With quantum computers worryingly close to rendering existing means of internet security redundant, an even more urgent need for an alternative to RF exists.

Another key benefit over RF is the increased bandwidth available. The current record data transfer achieved by millimeter wave technology, that is the current state of the art radio technology, is 40 Gbps. Compare that with the current record for laser communication — a mere 13,160 Gbps — and you start to understand that future-proofing and technological advantage of these constellations is really only achievable with lasers.

The companies building constellations are doing so as they are identifying a core need from telecommunication providers who themselves are seeing two very distinct strands of connectivity developing. These are surveillance applications, such as Earth Observation (EO), and communication applications such as high-speed broadband.

Delivered through laser communication, unhackable security and ultra-high-speed data rates translate into not only an unsurpassable technological advantage, but also a highly lucrative financial model allowing constellation builders to maximize returns on their outlay and future-proof their aerospace networks. All of this while delivering high-speed internet to people hitherto unconnected and establishing and developing new markets for IoT, 5G and the like.

As the well-respected Professor of Information Systems at California State University, **Larry Press**, stated, *"In addition to mitigating the digital divide by serving rural areas and small organizations, Musk and his competitors at OneWeb, Telesat, Amazon, and LeoSat hope to service high-end, high-margin customers like enterprises, governments and maritime, airline and mobile phone companies. ISLLs (Inter-Satellite Laser Links) are necessary for serving those lucrative high-end markets."*



Space ground station for lasercomms. Image is courtesy of Mynaric.

Laser Communication: Timed to Perfection

Laser communication is currently going through a key stage in its commercial development and roll-out. This relatively new market is hitting an inflection point as technology validation moves into product validation. Companies that have identified the market for laser communication in aerospace networks, such as Mynaric, have spent years harnessing laser communication into prototypes that have been successfully tested and validated to demonstrate the efficacy of the technology.

With the technology proven, products are now being introduced which the aerospace networks industry is beginning to launch on Phase 1 demonstrations to assess and qualify prior to full roll-out as constellations are built out.

However, with companies such as SpaceX, Amazon and OneWeb talking about hundreds — even thousands — of satellites, each of which could require up to five laser terminals, where does the laser communication terminal supplier industry stand on the cusp of these launches and roll-outs.

The few companies producing laser communication terminals, historically, sit in one of two camps: companies with high levels of technical maturity and heritage but focused on one-off, highly expensive items for government and research purposes or companies with a greater commercial focus but lacking the technical background.

Mynaric has taken a very disruptive approach — a unique approach — to this particular issue. Grounded in years of laser communication research and heritage from its founders' time at the German Aerospace Center (DLR) it has coupled this knowledge with a long and deep held conviction that a new aerospace connectivity market will emerge based on new connectivity constellations based in LEO.

Now, as these new constellations begin to launch and take shape, Mynaric finds itself ahead of the competitive curve and into serial manufacture of a full product portfolio of laser communication terminals just as the companies building constellations need to assess available products' suitability for backbone connectivity.

A Successful Mix of Synergies

In an article for the International Telecommunications Union earlier this year, the Chief Strategy Officer for LeoSat — **Diederik Kelder** — stated *"more data [has been] created in the past two years than in the entire history of the human race. Communications networks are already carrying more than 1 Zeta Byte of traffic globally, and this is forecast to grow exponentially."*

Read alongside figures recently released by the ITU reporting that 4 percent of the Earth's population still remain unconnected from the internet, it is clear to see the desperate need for greater connectivity.

Laser-powered networks in the air and in space promise to include rural and remote regions as well as developing countries and LDCs. Plus, this digital revolution will potentially tap trillions of USD of economic development as internet-based services and products are adopted.

The true commercial benefits of this approach of providing connectivity from LEO and the stratosphere match the humanitarian benefits: it is quite simply cheaper to connect a larger area from the sky or space than you could by terrestrial infrastructure.

Both SpaceX and OneWeb have stated that they will be in a position to offer (partial) services from their constellations next year and this will formally usher in the new era of connectivity from LEO.

It is a matter of not only watch this space but watch space — *the new epoch in connectivity is now upon us.*

mynaric.com

Dr. Carlos Carrizo is the project manager for R&D of new applications of free-space laser technology. He explores new market possibilities for laser satellite communications and solves customer needs by offering customized solutions for lasercoms in space.



Paradigm

Additional feature sets for all terminals will continue to be released by Paradigm, working closely with partners and key customers to deliver enhancements and developments to suit specific requirements.

Paradigm has continued with their industry leading goal to make SATCOM simple and used their expertise in technology, manufacturing and integration to swiftly respond to market requirements.

Central to this progress has been the popular PIM® (Paradigm Interface Module) which allows an unskilled user to easily and rapidly point a VSAT by using onboard audio cues with a visual cross-hair LED target

The PIM provides the modem, baseband switching, power management, assisted pointing and setup functions for VSATs. Temperature management and maintenance-free operation is achieved with fanless convection cooling or heating. This makes it ideally suited for the harshest of extreme environments proven by its successful deployment in the sub-zero climate of Antarctica and the dust and high heat of the African desert.

The PIM is already certified for use on all major satellite networks using a range of RF, antenna and modem combinations. By integrating the PIM into existing and new terminals, the time needed for network testing and certification is drastically reduced thus shortening a product's development time. All of Paradigm's terminals below are PIM-enabled and present a range of terminals all linked by a common operation process which also minimizes training requirements.

MANTA®

Launched in 2018, the MANTA is Paradigm's solution to satellite Comms-On-The-Move (COTM) and Comms-On-The-Pause (COTP). In less than a year, it has transformed mobile SATCOM and become the most reliable, proven solution for COTM and COTP applications.

Its rapid adoption is partly due to it requiring no specific satellite skill set from the user and, once fitted to a vehicle or used straight from its case you just need to add power to be transmitting and receiving in minutes.

Even the vehicle or vessel fitting process has been made simple by Paradigm with the MANTA quickly attaching to standard roof bars using the supplied quick deploy vehicle kit.

Global roll-outs of the MANTA have been achieved over 2019 with high levels of demand from aid agencies and governments. Following trials and feedback from operational customer deployments over the year to date, demand is expected to increase even further.

Paradigm's Hornet terminal in use in Antarctica.



MANTA®+

During a demo of the MANTA in late 2018, a user suggested adding an integrated cellular capability to the terminal. Rather than just a rudimentary plug-in cellular connection, this request was for a sophisticated terminal system that could offer users complete autonomy over the backhaul method from a ruggedized, single user interface with smart routing and a VPN capability.

In response, and by end of Q1 2019, Paradigm had developed and launched the MANTA+, the first flat-panel COTM/COTP VSAT system with a fully integrated cellular capability. An impressive turnaround in an industry traditionally slow to respond to technological advancements.

Paradigm's MANTA+ offers all the advantages of the MANTA but with the added benefit of services either connected via various satellites or routed via available 2G/3G/4G LTE, 2.4/5GHz Wi-Fi services, with UHF/VHF radio connection options also available.

The MANTA+ is a discreet, plug and play unit that provides seamless network switching between cellular and satellite to offer an 'always connected' service. The user can 'weight' their operational services depending on their specific needs for availability, least cost routing, load balancing and failover/ fallback.

As the MANTA+ transitions between cellular, Wi-Fi and satellite (or any other sequence), the IP (Internet Protocol) path automatically routes without the need for any user intervention (e.g., creating of routing tables or port re-wiring) and, depending on the weighting rules implemented, will keep the user's services connected. In addition, VHF and UHF solutions can also be connected to the MANTA+ to provide extended reach communications for the connected operator.

The MANTA+ has revolutionized COTM capabilities for its users by harnessing the best of both worlds in mobile connectivity. As High Throughput Satellite (HTS) networks grow and cellular coverage expands, the MANTA+ will act as

a force multiplier for the NGO and first responder communities. It is ideally suited for border protection, coastal surveillance and any areas of critical operation where constant connectivity is required through communication blackspots.

HORNET

Paradigm's PIM-enabled HORNET terminals are designed to be lightweight, portable and simple to use. They are ideal for situations where a tough and rugged solution is needed without compromising simplicity and throughput.

In 2019 the HORNET was developed further so as to be available as an interchangeable modular system operational on Ka, Ku and X-Band frequencies. This provides a highly flexible solution for users needing to configure antenna size and frequency bands either in the field or at the planning stage. This interchangeable solution is available on all major network providers.

The HORNET terminals are extremely rugged and weatherproof with low power consumption. They are modem agnostic, supporting all high performance modems and provide single case solutions which are IATA compliant for easy transportation.

Using the integrated PIM, pointing HORNET terminals is very fast and simple using the audio and visual cross-hair cues and target of LEDs. The PIM also integrates adjustable legs to provide a low and wide operational footprint to maintain stability.

By fulfilling requirements for flexibility, cost reductions, rapid tool-free deployment and portability, the HORNET is the ideal solution for first responders, government and broadcast users.

HORNET deployments during 2019 include providing fast, reliable and critical communications for the Argentine Antarctic Summer Campaign at a number of sites including Argentina's southernmost permanent base; a fantastic example of how 'internet at the Earth's extremes' is a reality.

As Paradigm's MD Ulf Sandberg remarked, "not only can our PIM-enabled terminals be operated by anyone, this also proves that location is no longer a restriction."

SWARM

Demand for this discreet and powerful terminal continues to grow, with key 2019 global deployments.

The SWARM terminal provided broadcast-level communications for a 6,000 km. African continent motor rally and a television production company filming in the sparsely populated Patagonian region of South America.

Once more, the SWARM was able to provide vital communications channels to aid agencies: in Mozambique following Cyclone Idai and in the Bahamas after the devastation caused by Hurricane Dorian.

The SWARM and the CONNECT100T terminal have now been adopted by the UN and other NGOs. Together, they enable assessment teams to respond rapidly to emergency situations, using the ultra-portable SWARM to provide critical emergency communication channels with the co-ordination teams following up with the larger CONNECT100T to provide higher throughput for longer-term setups.

Developments at Paradigm

As Paradigm continues to grow, the company's main facility in the UK expanded further during 2019 to accommodate an increase in manufacturing and staff. Paradigm's website was updated in Q4 to give prominence to the latest PIM-enabled terminals and to underline the company's ethos of *Making SATCOM Simple*.

Additional feature sets for all terminals will continue to be released by Paradigm, working closely with partners and key customers to deliver enhancements and developments for the terminals to suit specific requirements.

2020 Plans and Opportunities

Paradigm sees lots of really exciting industry developments coming on line into 2020. The introduction of new satellite constellations, in particular, the potential of Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites which will bring new capabilities to a variety of users.

Paradigm will continue to position and structure their products to enhance these advances.

www.paracomm.co.uk

Ulf Sandberg, the Founder and Managing Director at Paradigm, has more than 30 years of experience in the global satellite and telecommunications world. He served in the Swedish Armed Forces and, from there, Sandberg joined Notelsat, the operating company for Tele-X, one of the earliest Nordic Communication satellites. From there, he was with the Swedish Attaché for Science and Technology office, based in the USA. Leaving the Government sector, Mr. Sandberg worked for Swedish Telecom International and then Unisource, where he advanced to be Managing Director for the satellite business based in the Netherlands. Mr. Sandberg was also involved in the start-up and creation of a number of companies and ventures in Europe and the USA. In 1993 Sandberg became Managing Director, EMEA for ComStream, where he was responsible for growing regional operations. He was then with ACT Networks prior to starting Paradigm in 1996, where he has spent the past 23 years as Managing Director.



United Nations SWARM training. Photo is courtesy of Paradigm.

Phasor

Though 2019 has been a year where milestones have been achieved in preparation to get the product to market, years of hard work have provided a solid foundation for the future.

It's been a non-stop year for Phasor, where the antenna developer has been in the midst of the transformation that will take it to the commercial market.

As the company has focused on its end goal of bringing about seismic change to the global satellite mobile connectivity market, it has been busy reaching key milestones in terms of technical development and the move to commercialization. The enterprise-grade electronically steered antenna is poised to offer a new level of connected experience to passengers and crew on land, sea and in the air.

Technology Development

Phasor has been working with Vicor, a manufacturer of high efficiency power supply systems, and the two companies have developed a new power architecture that enables Phasor to deliver extremely high current at low voltage, thus ensuring robust mobile communications. The power solution provides connectivity speeds and bandwidth previously unachievable while on the move.

The Factorized Power Architecture™ (FPA) represents a major breakthrough in the delivery of satellite connectivity in aeronautical, maritime, land mobile and defense applications. However, it will also enable the end user traveling on any mode of transportation to enjoy true mobile broadband connectivity, and all the applications that this will enable.

The FPA technology plays an integral role in Phasor's ESAs and the support of Vicor in the technical innovation of the products helps to differentiate Phasor in what is a very competitive marketplace. Vicor's FPA package consists of a Pre-Regulator Module (PRM) and a Voltage Transformation Module (VTM)/Current Multiplier which together deliver the full, regulated, isolated DC-DC converter function. The Voltage Transformation Module (VTM) is a resonant converter and therefore also has very low noise when compared to a hard switched converter.

Vital to realizing performance targets in small and large aperture Phasor ESAs is the ability of Vicor's systems to transform a 48V supply into a 1.5V supply (1V in the next generation of antenna with even higher current).

Phasor's desire to make this transformation at 65A (or even 80A) represented a major design challenge for powering its application-specific integrated circuits (ASICs). Offering superior power delivery and efficiency than traditional DC/DC converters, Vicor's approach to

transforming voltage eliminates the need for multiple hard-switching converters with several different phases to attain 65A.

Certification

Phasor achieved ISO 9001 Certification ahead of the release of its product range. ISO 9001 is the internationally recognized standard for a quality management system (QMS). This enables companies to operate more effectively on several different levels, including the ability to focus on customer requirements and constantly finding ways in which to improve and become resilient and sustainable.

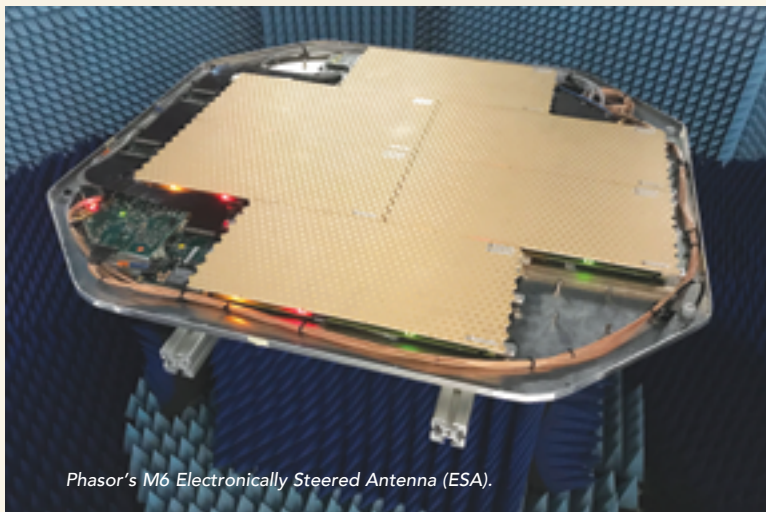
Why is this significant? It shows Phasor's evolution from development company towards a process-centric commercial products organization. The processes and procedures that have been implemented and also approved by BSI, will enable better management of the business and will demonstrate to customers that Phasor will support them as they grow.

Preparation for Production

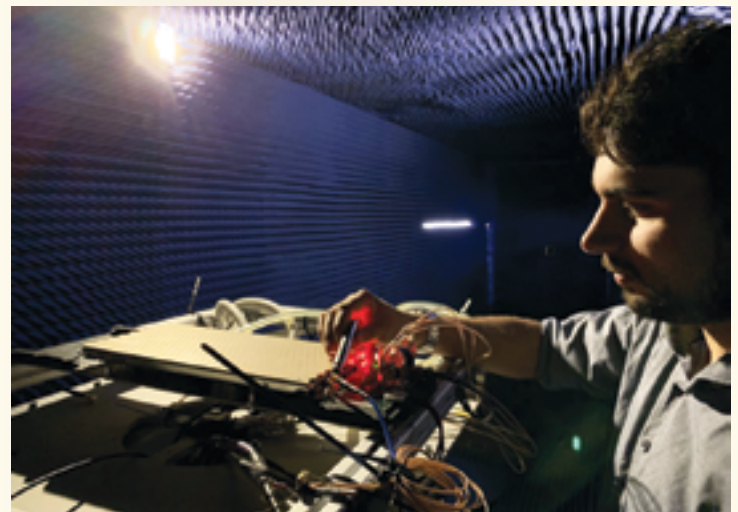
In order to prepare for commercial production, and to be able to scale -up to meet projected demand for its revolutionary ESA system, Phasor created a partnership with industry-leading electronics contract manufacturer Surface Technology International, (STI). STI will bring best-in-class manufacturing capability and will enable Phasor to continue to focus on new technology and product development. In a rapidly expanding market such as mobile broadband, it is important that production is scalable and able to grow with the projected market demand. Therefore, contract manufacturing with a leading partner is a core tenet of Phasor's strategy.

STI is a specialist Contract Electronics Manufacturer, serving world-class customers in high-reliability industries by providing a complete set of electronics design and manufacturing solutions in both printed circuit board assembly (PCBA) and full box-build manufacturing. The products will be manufactured in the STI Poynton facility, in Cheshire, UK, which is an industry-leading center manufacturing high-quality electronic systems.

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



Phasor's M6 Electronically Steered Antenna (ESA).



Showcasing Capabilities

The Mobile World Congress (MWC19) in Barcelona gave delegates the first glimpse of Phasor's land mobile Advanced Compact Terminal (ACT) for connected emergency vehicles from partner, HISPASAT.

The satellite operator participated in a demonstrator of a 5G and satellite communications (satcom) connected ambulance at the stand of the Generalitat de Catalunya, showing how future satellite and cellular-based hybrid connectivity will make it easier for emergency medical personnel to receive instructions from specialists in a hospital enabling a full ubiquitous audio-visual connection between the vehicle and the hospital. This will allow the specialist to monitor the patient's status in real time, which may be key to their survival and subsequent recovery.

An ambulance equipped with Phasor's Advanced Compact Terminal, will enable the crew to connect via satellite so that the first responder team may use applications such as video teleconference, real-time operational telematics links and high-quality Internet access during the journey to the hospital, regardless of their location or access to terrestrial networks. The ACT including an ESA, which is designed and in-development by Phasor in cooperation with HISPASAT, has full electronic steering and enables mobile connectivity services to be efficiently and reliably offered with high bandwidth.

It was another opportunity to highlight the versatility of the system and its ability to deliver mission critical connectivity, when every second counts.

Our Partnerships

Airbus

Phasor announced a Memorandum of Understanding (MoU) with Airbus through its Network for the Sky (NFTS) program. The two companies are working together to adapt Phasor's commercial-off-the-shelf (COTS) aeronautical electronically steerable antenna (A-ESA) already in development, for use on Governmental air-transport aircraft and unmanned aerial vehicles (UAVs).

Reliable, resilient aero connectivity that can support the highest data rates is essential to Network Centric operations today to enable a broad range of applications and services.

The Phasor ESA will be capable of supporting high bandwidth data communications with Ku-band satellites in both commercial GEO and LEO orbits and will also include an integrated radome, as a single line replaceable unit (LRU). Delivering as one, NFTS securely and reliably connects airborne assets together with the rest of operations. Operating over a mix of technologies to form one, resilient, high speed global network. NFTS sets the foundation for connected airborne network centric operations.

Gogo

Phasor and Gogo also confirmed that their development partnership achieved its initial core-technology performance objectives and will progress to the productization phase. During the next phase, the technology will be packaged as an airborne terminal to address the commercial aviation market.

Gogo identified the promise of Phasor's innovative solution due to a range of factors, including its multi-constellation capabilities and form factor and sees a number of potential applications for the technology, with initial applicability targeted at smaller commercial aviation aircraft.

its next-generation SATCOM connectivity solutions, in conjunction with Phasor at AIX in Hamburg. The new SATCOM inflight connectivity antennas feature electronically steered array (ESA) technology that will deliver unprecedented connection reliability for both civil and military aircraft.

Available in three configurations and with an ultra-low profile, the E-Series will provide Ku- and Ku-HTS connectivity for today's Geostationary Earth Orbit (GEO) networks, as well as tomorrow's Medium Earth Orbit (MEO) and Low Earth Orbit (LEO) networks. The system also will offer dual-beam capability, enabling it to support the future "make before break" requirement of non-GEO networks from a single array, or the ability to communicate with two independent GEOs or a LEO & GEO network simultaneously.

Astronics' E-Series antennas will feature Phasor's active electronically steered array to provide maximum antenna performance. Unlike competing systems, the E-Series will feature technology that enables a simultaneous transmit and receive from a single antenna array, with no need for bulky extra panels that drive up costly size and weight.

Everywhere On

As Phasor approaches the year of its product launch, it can reflect upon five years of development of a system that will bring fundamental change to on-the-move connectivity.

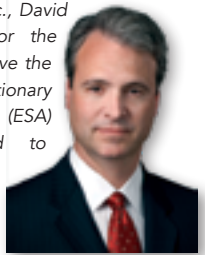
Though 2019 has been a year where milestones have been achieved in preparation to get the product to market, years of hard work have provided a solid foundation for the future.

The team relishes the challenge of bringing this transformative technology to the people that want and need a completely new and connected experience that is always on, no matter where they go.

www.phasorsolutions.com

As president and CEO of Phasor Inc., David Helfgott has the responsibility for the company's strategic direction, to drive the development of its new & revolutionary Electronically Steerable Antenna (ESA) products and technology, and to implement its operational programs. As a 20-year industry veteran, he has extensive experience in satellite broadband, mobile telecommunications and commercial

& government SATCOM networking services. Mr. Helfgott has held leadership positions at Inmarsat, Cobham, DataPath and SES. He holds a BA Degree from the University of Virginia and an MBA from the Darden School.



Astronics

Astronics Aerosat previewed

QuadSAT

With more and more consumers and industries adopting online applications, we must be sure that the connectivity we are delivering is of the highest quality.

2019 has been a big year for both SATCOM and QuadSAT respectively. We've seen the first satellites launched into LEO for the planned mega constellations, processes being virtualized within the cloud and plenty of discussion regarding the 5G rollout.

Mega Constellations

We're entering into an interesting era in SATCOM; during the next few years, we're expecting the number of orbiting satellites to dramatically increase. With approximately 1,800 currently on-orbit, we could see numbers rise to as many as the tens of thousands of satellites. This increase is sure to raise operational challenges, both on-orbit and at the ground terminal.

LEO is promising more connectivity, something that consumers are expected to fully embrace. The increase in SATCOM use will see RF management become as important as ever; however, the industry must ensure it is as cost-efficient as possible. The need for SATCOM to be financially competitive must be offset by the need for high quality equipment to deliver reliable coverage.

The mega-constellations could potentially open up huge opportunities for the maritime and aviation industries. Offering consumers constant connectivity is appealing. But beyond this, the company anticipates that these industries will be adapting workflows and procedures to incorporate the seamless connectivity that LEO offers. The opportunities are vast — we just need to make sure that we have the tools to deliver the robust connectivity required.

5G has been one of the most talked about aspects of connectivity in 2019. There's no doubt the discussions around C-band have seen some of the most experienced professionals stop and consider the implications it may have on the industries involved.

The objective is clear; technology must keep improving to manage consumer demands. As always, when using radio frequencies, care must be taken to avoid accidental interference.

As more operators — and even industries — use RF, managing interference will become increasingly important to ensure that services don't inadvertently impact upon one another.

Use of the Internet of Things (IoT) is growing quickly. According to a 2019 report by Gartner, the enterprise and automotive IoT market will grow to 5.8 billion endpoints in 2020, a 21 percent increase from 2019. Consumers are turning more and more to the convenience that IoT offers, with building automation, utilities and physical security being some of the more common uses.

IoT is centered around consumers remaining connected with their surroundings, regardless of where they are located. But in addition to consumers adopting the tech, we're seeing industries employ the technology to improve efficiencies.

Maritime organizations are turning to IoT to streamline operations and to make data driven decisions that improve efficiencies. The





aviation industry is also noting huge benefits in adopting IoT tech. Predictive maintenance, in-flight customer behavioral patterns, in-flight data collection, baggage tracking and flight efficiency are all examples of the role IoT can play in aviation, which is saving airlines time and money.

As always, seamless connectivity is key in delivering these services. The aviation and maritime industries have an obvious need for satellite due to the geographically remote nature of work. This does also highlight the industries' reliance on SATCOM; there is little room for error in connectivity and reducing the risk of RFI is hugely important.

RFI RF interference is a challenge that has faced the industry since its inception, with human error and poor-quality equipment being some of the most common reasons for RFI incidents. An antenna that is being used daily, especially on a moving vessel, can easily become misaligned and see a break in connectivity.

Testing and calibration must be performed at regular intervals to mitigate RFI, although performing these tests can be costly, technically challenging and inconvenient on an in-service plane or ship. However, antenna testing remains important; we can see efficiencies improving in many industries as a result of improved connectivity.

Drone Tech to Reduce RFI and Increase Efficiency

During 2019, the company completed significant steps forward in reaching business goals. At the start of the year, QuadSAT's drone tech was in the early stages of development.

In January, QuadSAT secured 700,000 euros in seed funding, led by Vaekstfonden, with participation from Seraphim Capital and additional, existing investors. In addition to the testing and calibration capabilities mentioned above, QuadSAT has always aimed for the product to be used to deliver type approvals, allowing quality testing at the sourcing of equipment.

These investments were critical in developing the prototype for key testing and has allowed us to expand the team, as well as advance our technology. We moved the office to the Hans Christian Andersen Airport in Odense. This has given us useful access to the airfield as well as the great tech community at HCA.

The firm's drone technology applies a consistent method to determine the performance of new antenna models. All new antennas have to pass through a validation process to ensure that satellite users are sourcing the correct equipment and processes... QuadSAT plays the role as a portable farfield test range, making it location flexible and cost effective. The solution is set to promote consistent calibration and testing procedures of VSAT antennas and, in turn, reduce RFI.

Following months of development, July found the company signing an important contract with ESA, GVF and the Danish Technological Institute to develop the QuadSAT testing solutions to comply with the industry-wide antenna performance SOMAP (Satellite Operators' Minimum Antenna Performance) requirements, providing our product with certification to deliver compliant type-approvals.

The company's team traveled to Aflenz in September with SES and Eutelsat for a demonstration of our product and its testing results. We delivered thorough antenna testing on-site using this drone technology, which was witnessed by representatives of both organizations.

The results were sufficient enough for SES to consider adopting QuadSAT's antenna testing product for future, commercial, antenna qualification activity.

Increasing Connectivity and Minimizing RFI

2019 has undeniably seen many changes within SATCOM; organisations within the industry are adapting to the ever-increasing need for constant connectivity.

However, with LEO, 5G and IoT, companies must be confident in delivering uninterrupted services. RFI is linked to an increase in equipment cost and increase in antenna power levels. To keep SATCOM competitive, it is crucial to keep interferences low.

With more and more consumers and industries adopting online applications, we must be sure that the connectivity we are delivering is of the highest quality. RFI must be both prevented and mitigated to allow seamless connectivity to become a reality.

However, to promote discipline within RF management we must make the tools accessible and cost-effective.

www.quadsat.com

Joakim Espeland is the Chief Executive Officer of QuadSAT.



Rock Seven

Increased adoption of Rock Seven's established products have made this a great year for the company.

As 2019 draws to a close, Rock Seven can look back with justifiable satisfaction on a year of measurable success. Rapid growth since our acquisition by Wireless Innovation in 2018 is best illustrated by the appointment of four new job roles across development, marketing and production, demonstrating our commitment to constantly innovate new products, and to raise awareness of our existing ones.

With the backing of Wireless Innovation and Horizon Capital, the company has been able to expand more rapidly than we otherwise would have done and have been able to capitalize on rapidly growing markets, such as Internet of Things (IoT),

Machine to Machine (M2M) and Fisheries Monitoring

The latter market has been a big area of expansion for us this year, and our RockFLEET product has now made significant inroads into Vessel Monitoring System (VMS) and Fisheries reporting in markets across the world. This growth will continue throughout 2020 and beyond.

Our collaboration with Pivotal, a leading remote communication provider in Australia and New Zealand, has seen RockFLEET units fitted to more than 700 fishing boats. This number is likely to exceed 1,000 by the end of 2020 as fleets in both countries comply with existing and planned regulations requiring commercial fishing and charter boats to be tracked.

Pivotal selected RockFLEET due to the company's comparatively low capital and airtime costs as well as for ease of installation. The unit's global two-way communication ability, low cost of ownership and the reliability of the Iridium network give clear advantages over alternative VMS options.

Asked about installations in Queensland, Pivotal CEO *Peter Bolger* said, "*The partnership between Rock Seven and Pivotal has ensured fishers receive informative and timely support for all product queries. The RockFLEET device is a high-quality product that has proven easy to install and operate, but still offers the sophisticated data and coverage that the Queensland fishing industry requires.*"

In aviation, Rock Seven continues to consolidate the firm's already well-established position. The RockAIR unit — launched in 2017 — is now a regular sight in the cockpits of helicopters and light aircraft worldwide and, as far as we know, is the only dual-mode GSM/Iridium carry-on flight tracking unit available, giving flexibility to pilots and fleet operators globally.

This dual-mode communications ability allows users to send tracking information through your mobile network as frequently as every 15 seconds while in cellular coverage, only switching to use satellite credits once out of range. Message frequency can be configured independently for both modes, keeping costs under control.



A Rock Seven installed RockAIR unit.



The Maker Buoy is one such example: this solar-powered, Arduino-based research buoy measures ocean drift and sea temperature and carries a RockBLOCK 9603 for communications.

The unit can be built inexpensively by hobbyists and the data shared with research organizations to further understanding

Configuration for this product can be updated over-the-air, and in normal use, the device has a service life of up to 10 years. The internal battery will support twice-daily reporting for as many as five years, even if the unit is never exposed to sunlight. With the ability to operate unattended for extended periods of time anywhere in the world, this is an exciting new market and one to watch during 2020.

The company's RockSTAR device made the news in October when it was used by British Search and Rescue charity S.A.R.A.I.D for a natural disaster search and rescue demonstration, in association with Wireless Innovation and Iridium. Showcasing Iridium's high-speed Certus service, which is designed for critical applications, each SAR team member carried a RockSTAR, transmitting 15-second updates every minutes.

Iridium SBD is a market with huge potential and our work with Iridium Short Burst Data (SBD) goes from strength to strength. The RockBLOCK family of products maintains its status as a recognized brand in Iridium SBD, helping customers in every industry with their remote monitoring requirements. Specifically, we have seen great growth in Iridium SBD use in areas such as AgriTech and UAV/drone work.

of our oceans.

Another, innovative example of how a RockBLOCK can enhance a system's abilities was demonstrated by **James Dziadulewicz** in Malibu, California. Having built a home in an area with a high risk of forest fires, he built an off-grid fire detection and prevention system to protect his property.

He was 54 miles from home when he received a message to his phone, sent via a RockBLOCK attached to the system, notifying him that a fire was approaching his property.

He was able to remotely trigger 12 high-pressure sprinklers to drench his house and the surrounding area 35 minutes before the fire assaulted his property, leaving his home unscathed. His success has led him to found a company, Hot Shot Wildfire Fire Protection Systems Inc.

Until now, all our RockBLOCK products and the Iridium Edge modems on which they are based have required some form of external power. This year, however, Rock Seven has been selected as a beta partner for the new Iridium Edge Solar, a self-contained, solar-charged, programmable SBD device with GPS tracking, local wireless and Bluetooth communications capabilities.

The Certus platform gave the people on the ground a strong, secure internet connection that allowed them to tap into the RockSTAR tracking applications online and allowed the team leader to know where any individual was located and in real time.

Even the rescue dog carried a RockSTAR, demonstrating the versatility of these devices.

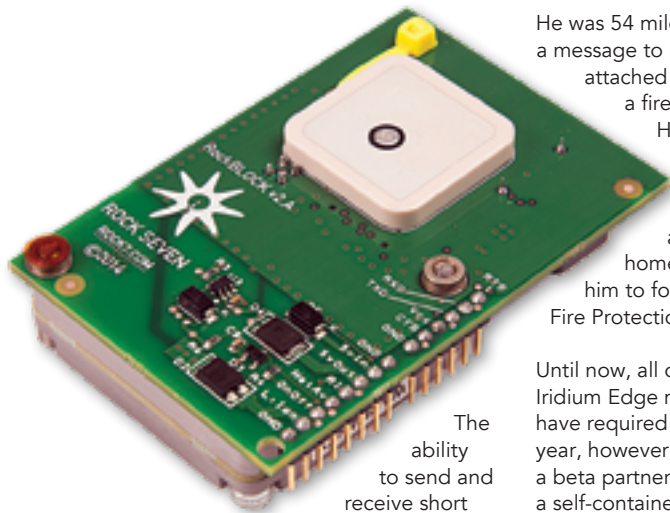
Increased adoption of Rock Seven's established products, teamed with extended market reach thanks to the firm's friends at Wireless Innovation, have made this a great year for the company.

The Rock Seven team expanded significantly during 2019 to support this growth and to ensure the company can continue to provide the recognized quality of service the firm supplies to customers.

This is certainly an exciting and challenging time for everyone, and Rock Seven has big plans for the future.

www.rock7.com

Nick Farrel is the Director of Rock Seven, based in Southampton, United Kingdom.



The ability to send and receive short messages anywhere

in the world opens up a broad range of applications. RockBLOCK products are used for messaging, tracking, equipment monitoring and control, fleet management, telemetry, remote network monitoring, oceanographic monitoring and security, amongst other things.

The units can be very small and light — the RockBLOCK 9603 units measure only 45x45 millimeters and weighs just 36 grams, yet offers full, two-way communication, making them ideal for small installations and even personal trackers.

They're also inexpensive both to buy and run, making them affordable to any customer, from big research ventures which might require thousands of units, through to individual hobby projects.



Satcoms Innovation Group

This is an exciting time to be participants in the satellite industry. Although challenges and threats must be faced, the new opportunities opening up are endless.

The Satcoms Innovation Group (SIG) was established 21 years ago and the organization, at that time, was known as the Satellite Users Interference Reduction Group.

The organization was initiated as the industry had a problem: *interference*.

At the close of last year, the name was changed to the Satcoms Innovation Group as the remit had moved beyond just interference. The group had always believed the change to SIG as inevitable.

This year has witnessed a big shift of focus for us due to the industry's change of course and the focus for SIG members is also shifting.

In GEO, we now have a better understanding of the problem — we have good relationships between most operators and the correct tools are now in place to tackle problems as they arise.

This means that interference is being dealt with on a far more immediate basis and, although it still causes the operations teams headaches as they work on resolving issues, they now know how to deal with interference and can often resolve these challenges... almost effortlessly.

What this means is that, in GEO, at least, interference is no longer the most important "I" word.

What has become acutely clear this year is that LEO is now at the identical place GEO was all those years ago. There is a great deal of uncertainty around what problems will be faced.

The LEO constellations have the potential to provide new opportunities for satellite; however, these constellations have the potential to negatively impact the entire space environment and that is clearly something that must be avoided.

Here are the top trends that SIG has witnessed...

1. Focus on Quality of Service

A number of challenges remain for satellite operators in GEO; however, what we have noted this year is a shift in focus from error resolution to improvement in quality of service. That includes ensuring error-free transmission as well as to ensure customers they can be provided with a positive user experience for their services.

Ensuring superb quality is nothing new, but it has never been more important, especially as satellite faces increasing competition from other transmission methods as users also expect flawless delivery of services.

2. Spectrum Battle Continues

The World Radio Conference (WRC-19) is underway at the time of this writing. That always brings up the matter of spectrum sharing and puts the satellite industry into action to defend vital spectrum. However, sharing is inevitable and conversations are moving in that direction. In fact, in Europe, it looks like C-band has been handed over and it may well be that other regions will follow suit.

The broadcast industry faces an interesting quandary. On the one hand, traditional broadcast continues to rely heavily on C-band to deliver services. On the other hand, most broadcasters are under increasing pressure to deliver video everywhere.

As consumers increasingly view video on mobile devices, while simultaneously expecting the same high quality as experienced with other services, those broadcasters are looking to 5G to ensure a solid user experience for their next generation services. That demand will either drive them to look at how spectrum sharing will work, or they will simply move away from satellite for their traditional services.

The author has said it before, and this salient point was made during a presentation delivered on SIG's behalf by Crystal's Roger Franklin at NAB this year, but we, the satellite industry, need to look seriously at how spectrum sharing could work without impacting our services.

5G **is** going to occur, and satellite services could well be negatively impacted.

3. Satellite Starting to Look to the Cloud

SIG is hearing numerous conversations regarding enabling cloud workflows and virtualized ground networks. This topic has come up at all of the SIG events this year and is also a hot topic at most of the industry conferences. With so many new, data-hungry applications scheduled to appear, it is not surprising that turning RF signals into IP has arrived — this means you can send data to the cloud via software modems. This, ultimately, means you can be more flexible, cost effective, able to handle more data and, generally, accomplish far more.



4. Industry Holds its Breath as LEO Launches Ramp Up

LEO launches have dominated the news this year with successful launches and scheduled lift offs. Most recently, SpaceX submitted paperwork for 30,000 more Starlink satellites. That filing, and the recent near collision between ESA and SpaceX satellites, typifies the concerns around LEO. With such a vast number of satellites due to launch, many of which will be introduced by companies that don't yet have a history in satellite operations, how do we ensure good space (and spectrum) situational awareness (SSA)?

LEO is facing a number of significant challenges, some of which we are acutely aware of, such as the potential of collision, debris and interference.

Other situations we may not yet even be aware of at this time and they might only become clear once those new satellite services have started their maturation process. At SIG's recent workshop at Work Microwave in Munich, we discussed some of these, including the impact LEO will have on the ground station, something that has had little discussion to date.

These are just some of the reasons that SIG will focus on LEO, the challenges facing those operators and how we can solve them at the next SIG workshop. Virtualized ground networks are probably imperative to a concrete solution.

5. The Use of Satellite is Changing but the Opportunities are Endless

This year, the uncertainty for satellite has been increasing as the use case for broadcast is reducing.

Broadcasters are under pressure to deliver more content to more devices than ever before at the same time as they are delivering more engagements and a positive user experience. This means broadcasters are looking to accomplish these tasks as cost-efficiently as possible and are moving toward methods other than satellite to distribute that content, the most notable technology being IP.

Add in the ever-closer rollout of 5G services which will deliver better connectivity than ever before possible, it is no wonder there is concern in the satellite industry. However, what we are starting to see is that satellite will have a different, but equally important, place in the future of communications. More services and higher bandwidth demands means that the industry still needs a way to deliver their services in a timely and reliable fashion.

SIG believes that, rather than looking at 5G and the Internet of Things (IoT) as a threat to satellite, they should be viewed as an opportunity. That being said, this author doesn't think satellite will be used for consumer applications but rather will be the enabler that makes those technologies function, using all of the layers of connectivity that are available to deliver better infrastructure and connecting 4G and 5G networks together for true, global, cell-to-cell connectivity.

The Year Ahead

This is an exciting time to be participants in the satellite industry. Although challenges and threats must be faced, the new opportunities opening up are endless. What will be important is that we innovate in order to be in the correct position to maximize on those opportunities.

As we move into 2020, what this author would like to see is LEO operators gathering around the table with the GEO operators to learn from one another, discuss the challenges, being faced by all and then work together to find solutions for this new satellite industry era.

The Satcoms Innovation Group can be the facilitator of such discussions and certainly encourages this to happen at the SIG workshop in May of 2020, taking place from May 19 to 21, 2020, at historic Goonhilly in the United Kingdom.

satig.space

Martin Coleman is Executive Director, the Satcoms Innovation Group (SIG). Since taking on the position in 2011, Martin has been active in spearheading several significant initiatives, leading the advance in new tools to resolve all types of VSAT interference using SatGuard and the campaign to introduce Carrier ID across all SCPC/MCPC transmissions and subsequent ongoing activities. Martin regularly addresses the industry on the issue of satellite interference and the management of Spectrum and Space, at global industry events and facilitates SIGs workshops throughout the year.



Space Data Association

We need the smallsat operators to feed their own data into an independent repository, such as the Space Data Center

2019 has been an interesting year when it comes to debris and space situational awareness, key focus areas for the Space Data Association (SDA).

While we have been watching from the wings, the organization has also been busy behind the scenes, determining the future of the group and the role it has to play in the future space environment, which is getting more and more complex to manage.

A 10 Year Anniversary

With so many changes and new challenges currently in the satellite environment, it is interesting to note that 2019 marked 10 years since the infamous collision between a Russian military satellite and an Iridium comms bird. The collision destroyed both spacecraft and caused a cloud of more than 2,000 pieces of debris. While this event was obviously catastrophic for both operators and the entire space environment, it did also bring about a positive change in highlighting the need for better tracking data to ensure this collision wouldn't be repeated again.

It is not coincidental that 2019 also marked 10 years since the formation of the Space Data Association. Recognizing the need for the industry to do more to protect itself, the major commercial satellite operators decided the best approach would be to work together and share data in order to ensure collisions could be avoided.

The SDA realized even then that the best data to do this was the data from the operators themselves. This is important, not only because we have precise information concerning the location of our fleet, but we also know about planned orbital corrections (so-called maneuvers).

During those ten years much has changed. The Space Data Center continues to provide valuable Collision Avoidance information and is certainly helping to keep space safe. However, at the same time, the space environment is changing and we recognize that there is a need to move with the times to accommodate these crucial changes.

A New Challenge in 2019

Over the next few years, we will see the launch of many mega-constellations. This will mean that we will end up with many times the number of satellites on-orbit than today. It is imperative that all space actors, including governments, agencies, operators, and standard setting bodies, up their game to manage the associated risks of having these extra objects in orbit.

The close approach between a European Earth Observation (EO) satellite and SpaceX's recently launched internet craft and the required evasive maneuver performed by the European Space Agency, which made the top news in 2019, has reminded LEO operators and Space Actors that safety of flight calls for reliable information exchange and close cooperation between all involved in the space environment.

Thankfully, 10 years on, we do have better methods for spotting potential conjunctions, so this potential collision was avoided. Even





so, this event again highlights just how important data sharing is to all concerned.

Yet, although members of the SDA account for 273 GEO-stationary satellites, equating to around 6 percent of all active GEO satellites, that is not enough data accumulation to ensure true safety of flight for all satellite operations.

Following the near-miss, the SDA issued a statement urging all space operators to improve operational data sharing and communication to enable effective space situational awareness and maintain the integrity of all orbital regimes.

This is as important in GEO as MEO (Medium Earth Orbit) and LEO (Low Earth Orbit) and needs input from every single operator in any orbital regime.

The Rise of Smallsats

This year has also witnessed a sudden increase in small, LEO satellite launches and announced launches. There are already more than 1,300 active, human-made, satellites in LEO.

Planned launches could see that number rising by ten times that number in just a few years. As mentioned previously, the SDA has already seen the potential damage that could be caused; however, imagine how much more complex tracking all of these will become and the satellite on-orbit increase in number by the thousands. It simply will not be enough to rely on third party sensor data for this volume of traffic.

We need the smallsat operators to feed their own data into an independent repository, such as the Space Data Center, in order to have accurate, up-to-the-minute and actionable data for all of these elements.

These developments have also shifted the conversation within the SDA. We have been talking about, and responding to the risk of, collision in GEO for some time, and will continue to do so.

Earlier this year, one of the SDA's Directors, Eutelsat's **David Zamora**, presented exactly that at CNES in Paris. However, we now need to also consider these same risks in the other orbital regimes and how those can be best addressed.

To that end, the organization is already in discussions with these operators and are looking to the organisation to understand how these could be best accommodated.

Change Within the SDA

As well as looking at our future services and how those need to be adapted for the future space environment, this year has seen some additional administrative changes.

At the start of November, the SDA chairmanship switched over to **Pascal Wauthier** to start SES' stint chairing the organization. As this article's co-author, Pascal wanted it clarified that Mark has done a sterling job over the past couple of years. This means Pascal has very big boots to fill.

Fortunately, the SDA has an excellent team of Directors to support him and he is certain we will continue with the great work started when Mark was at the helm.

Toward the end of this year, the SDA also accepted on a new member, Viasat. Of course, any membership organization is always pleased to add to its members, but in our case, perhaps even more so. Another member means more data to help make the space environment that much safer and that has to cause for celebration

Also this year, the SDA also held an election for our Standard Member Directors this year. **Brian Swinburne** of Airbus extend his term and the addition of **Lorenzo Arona** of Avanti was added to the board. They are both extremely active and welcome additions to the board and are keen to further engagement with the standard members.

The Road Ahead

Looking forward to 2020, the skies are going to get even more crowded, with many more satellites planned to be put into orbit in the next few years.

Managing potential conjunction events are part of operating in space — this is about how these events are managed, e.g., understanding the data involved to allow an accurate risk assessment to be made and then working with fellow operators to employ coordinated action.

www.space-data.org/sda/



Left: Mark Dickinson, SDA Executive Director
Right: Paul Wauthier, SDA Chairman and Executive Director

ST Engineering iDirect

2019 was truly a remarkable year, and each member of our newly expanded team is brimming with focused energy and a deeper commitment to our ambitious customers.

In the satellite industry, we have been talking about change for years—about a bold new chapter in our story where innovation will accelerate, and new markets and applications will redefine opportunity.

To prepare for this era, we have seen the launch of ambitious Low Earth Orbit (LEO) constellations, the strategic planning of 5G working groups, the redesign of satellite antennas for a new range of mobility use cases, the consolidation of key industry players and more.

Clearly, we are crossing a divide. In one sense, it's a divide of scale. Today, we chart opportunity in terms of thousands of network sites and hundreds of megabytes on a remote. We define manageability in terms of provisioning.

We view interoperability in terms of network management and billing systems. As we shift our attention to future growth plans, we need to think in terms of millions of sites, gigabytes of throughput per remote, true service orchestration within an end-to-end telecom network, service that expands across satellite orbits and access technologies that roam across waveforms and third-party networks.

In another sense, we need to cross over into a new spirit of market readiness. Now is the time to make big moves into the future. Players in the industry must be able to face a larger, more dynamic market with higher stakes. To see a sustainable and substantial return on investment, companies will need to capture revenue quickly and on a larger scale than they have before.

We made our big move this year. In October, ST Engineering officially acquired Newtec and integrated the business with ST Engineering iDirect. With this acquisition, two powerful market leaders have come together to evolve into one dynamic team.

For our customers, this means greater value now and into the future. With our combined strengths, we can better lead our clients and the satellite industry to future market opportunities.

The Evolution of Product and People

Although historically ST Engineering iDirect and Newtec have been competitors, both companies have developed complementary strengths that have evolved from a shared focus on innovation and customers. In particular, ST Engineering iDirect brings together Newtec's innovations in performance and efficiency with iDirect's innovations in networking and mobility.

For our customers, this means access to an expanded product portfolio and to a wealth of expertise. With our combined product solutions, we can build pathways into a broader range of markets than either company could serve on its own.

This new scale will also allow us to dive deeper into current markets — such as aero, cellular backhaul and media — and enable emerging markets and applications, such as land mobility and the Internet of Things (IoT). As a result, we will be able to serve our customers as a single partner that provides technology solutions, market strategy, custom consulting and more.

Of course, none of these achievements would be possible without the right people. Our combined world-class engineering team has the knowledge and skill sets necessary to develop solutions for the future. This will greatly accelerate our time to market so we can keep pace with where new market opportunity is heading.

With our new scale and capabilities, backed by a global, high-touch sales force, we can serve customers no matter what their business model, company size, industry or goals.



Image collage from ST Engineering iDirect's participation at the FOKUS FUSECO 5G Forum.

We will continue to work closely with customers to help them evolve with the best technology solutions at the right costs, addressing the unique challenges and opportunities emerging in our industry.

Expanding the iQ Series and Driving Customer Growth

This year, we were also busy with other developments that lay the groundwork for industry change.

2019 saw the introduction of Evolution® 4.1.3 software, our go-to release that rounds out the advanced capabilities of our iQ Series remotes through additional features such as 16QAM and AES encryption.

We are achieving the ultimate balance of speed and efficiency to serve markets that demand a cost-effective and high-performance solution.

Building on this momentum, we launched several new remote solutions:

- *The iDirect iQ LTE, a software-defined hybrid modem that offers high-efficiency connectivity over satellite or LTE*
- *The iQ 200 for enterprise and maritime customers*
- *And the iQ 200 with iDirect SatHaul XE, which provides a cost-effective, high-performance solution for 2G/3G/4G networks within the cellular backhaul market*

In 2019, we also expanded our iQ Series on the iDirect Velocity® platform. With the release of iDirect Velocity 2.0, we brought the iQ 200 and iQ LTE, as well as enhanced features such as Layer 2 over Satellite and advanced beam switching, to satellite operators so they can deploy managed services in enterprise, cellular backhaul and maritime markets.

Several of our customers around the world embraced the iQ Series to launch new networks and capture fast-growing opportunities.

- *STC Solutions (STCS) adopted the iQ Series this year to launch the first iDirect DVB-S2X network in the Middle East.*
- *Castor Marine in the Netherlands upgraded its global maritime Ku-band network to support all of its vessels using iDirect iQ 200 remotes.*
- *Vivacom, the largest telecommunications provider in Bulgaria, also announced it will launch a DVB-S2X maritime service leveraging iQ 200 Series remotes.*
- *AiTelecom debuted the first iDirect DVB-S2X network in Mexico, using iQ Series remotes across a wide range of enterprise markets.*

- *IP Access International, which runs the largest satellite network for emergency responders in the U.S., shared plans to integrate the iDirect iQ 200 Board and Evolution 4.1.3 into its HARRIER terminal, a portable and hybrid communications solution for first responders.*

A Milestone Year for Newtec

For Newtec, 2019 was a year full of innovation and great success.

In May, Newtec extended its partnership with Marlink to future-proof the company's global VSAT network through its Newtec Dialog® platform.

Telenor Satellite also expanded its offerings with Newtec to satisfy rising demand from its customers for higher throughput maritime services on its THOR 7 Ka-band High Throughput Satellite with the Newtec Dialog® platform.

At IBC 2019, Newtec teamed up with DVB-I, an initiative to develop technical standards for delivering television services over IP, to showcase the future of universal over-the-top (OTT) television services.

The DVB-I demonstration utilized Newtec's MCX7000 Multi-Carrier Satellite Gateway as a receiver and revealed the "single hybrid offering" that DVB-I brings. Historically, satellite has been overlooked as an enabler of OTT services, but its synonymy with broadcast and its capability to deliver high-quality, reliable transmissions anywhere makes it ideal to enable universal OTT television services.

Newtec also continued on its mission to connect the unconnected. Newtec deployed a Newtec Dialog® hub for the Bolivian Space Agency (ABE), which will enable the organization to extend access to residential broadband to at least 6,000 users.

Newtec also provided a Newtec Dialog® to SATSOL, a teleport and Internet Service Provider (ISP) on the Solomon Islands, to help connect remote inhabitants.

The platform also was selected by broadband satellite operator Kacific for its new high throughput satellite, Kacific1, to significantly expand broadband service delivery in underserved areas of Southeast Asia, New Zealand and the Pacific Islands.

Newtec was excited to sponsor the Leuven-based Belgian Agoria Solar team this year on their Bridgestone World Solar Challenge, a 3000 km race across Australia powered entirely by the sun. With the help of Newtec and a few other project partners, the team had access to SATCOM-On-The-Move (SOTM) to adjust their navigation and route planning based on the most up-to-date weather patterns.

The team was also able to live stream video interviews and backhaul action video clips to its thousands of followers — sharing every moment of their journey with their online audience.

Driving the Upcoming Era of Innovation

Throughout 2019, both iDirect and Newtec pushed the industry toward a satcom-5G enabled future through involvement with various consortiums and initiatives, with several successful milestone demonstrations providing proof-of-concepts for the integration of satellites into a 5G testbed.

In 2019, ST Engineering iDirect expanded our participation in global initiatives to prove the value that satellite connectivity can bring to a 5G network model.

We teamed up with key SaT5G members at EuCNC 2019 to demo high-speed video streaming over a 5G multi-link satellite and terrestrial network.

At the FOKUS FUSECO Forum, we partnered with key SaTis5 members to bring to life Enhanced Mobile Broadband (eMBB) and IoT applications.

Meanwhile, Newtec played a key role in the world's first demonstration of 5G backhaul over a LEO satellite with global satellite operator, Telesat, Vodafone and the University of Surrey.

Heading into 2020

At ST Engineering iDirect, we are crossing into 2020 ready to take our customers further into the future.

We will set our sights on building our expanded areas of expertise into a converged technology offering to amplify opportunity in our customers' core markets and to enable new applications with a focus on mobility, global defense, IoT and smart nations.

2019 was truly a remarkable year, and each member of our newly expanded team is brimming with focused energy and a deeper commitment to our ambitious customers.

Our goal is to create the world's most advanced satellite ground infrastructure — uniting our technology heritage and passion for innovation — to deliver far more than the company could previously ever have considered possible.

www.idirect.net

W.B. Walton Enterprises

Walton De-Ice delivers the most innovative and effective solutions to help protect critical satellite networks from degradation and outages due to weather.

2019 has been an exciting year for Walton De-Ice, (W.B. Walton Enterprises, Inc.) as the company marks 40 years of satellite industry experience helping to protect SATCOMS terminals, gateways and teleports from the effects of weather.

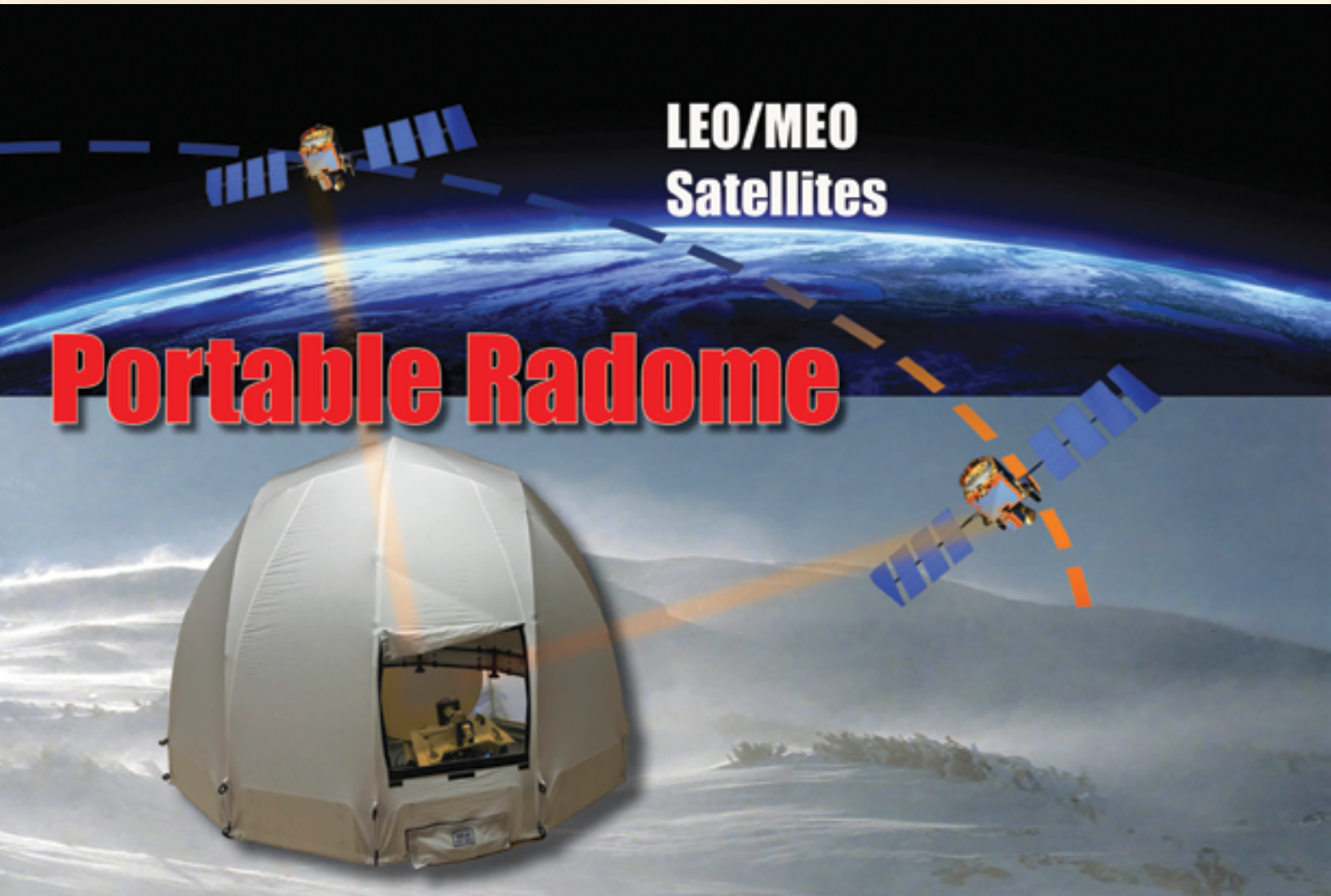
In May, our Chairman, *William Bartlett Walton Jr.*, "Bill Walton" was honored with a Lifetime Achievement Award by the World Teleport Association (WTA) for his leadership and contributions to the industry. In announcing the award, WTA noted that "Today, it is hard to imagine the C-band industry delivering reliable services without de-icing. Walton De-Ice has become synonymous with Earth station antenna De-Icing. Bill Walton was there from the beginning, growing with the industry, and building Walton De-Ice over the last four decades."

Walton De-Ice delivers the most innovative and effective solutions to help protect critical satellite networks from degradation and outages due to weather. The company's main focus has been keeping Earth station antennas snow and ice-free. The original Walton Hot-Air (Plenum) De-Ice design mounts behind antennas from 3.7 to 32 meters. Walton De-Ice's energy-saving Snow Shield, Rain Quake, and Ice Quake systems for 0.6 to 6.3 meter antennas,

Ka-Band Market Leadership and Growth

Market demand from continued HTS and mobility growth has helped to grow the company's 2019 business from satellite operators, service providers and integrators this past year as they continue to invest in new Ka-band ground infrastructure. In 2019, we continued to expand Ka-band leadership in the De-Icing field, with many hundreds of Ka-band large antenna systems now successfully deployed. For Earth station antennas from 3.7 to as large as 32 meters, the Walton Plenum Hot Air De-Icing system maximizes pointing accuracy that is so critical for protecting Ka-Band services.

Unlike competing anti-icing solutions, such as electric pad systems that can cause reflector distortion, Walton Hot Air De-Ice systems heat the entire antenna reflector uniformly, which minimizes reflector distortion that can cause signal problems at the Ku- and Ka-bands. Walton systems also uniquely offer maximum flexibility with electric, natural gas and liquid propane gas heater options. Infrared testing of optimal antenna heating distribution offers precision performance validation for the most demanding Ka-Band customer applications



C-/Ku-Band De-Icing, More Automation, Energy Efficiency in Heating

Customers with C and Ku-band traditional services continued to leverage the firm's new automation and control features, along with the Ice Quake system, a super-low energy consumption solution for shedding snow off antennas from 0.6 to 6.3 meters.

The Ice Quake can deliver up to 100X energy-savings compared to traditional anti-icing solutions, which is why it has been adopted in teleports as well as cable and broadcast facilities.

In the third quarter of 2019, we also announced that a global sports TV leader had tapped Walton De-Ice to protect its satellite broadcast facilities, joining a Walton De-Ice user community of top operators in SATCOMs around the world.

The top global sports media company added Walton's Hot Air De-Ice and Snow Shield systems to maximize uptime for critical satellite signals at major TV broadcast centers.

New Markets: The Portable Radome

Traditional antenna radomes are not built for transportable operation, yet many of today's military and first-responder applications on land require deployable systems where harsh elements demand radome-like protection.

Enter the world's first portable satellite Earth station antenna radome, the Walton Portable Radome, which unleashes a whole new set of possibilities for operating Satellite Transportable Terminals (STT) and micro-VSATs in extreme and mobile conditions to support military requirements for high capacity data, voice and video capabilities worldwide.

It provides a uniquely deployable weather protection solution for applications, such as Military vehicular mount terminals, Comms-On-the-Pause (COTP) or Comms-On-The-Halt (COTH) terminals, VSATs, Transportable uplinks as well as some Enterprise terminals LEO/MEO gateways.

The Walton Portable Radome can protect transportable, trailer and flyaway antennas from high winds, sandstorms, intense heat, snow and ice. Lightweight and airline-shippable for rapid deployment, with easy setup in less than an hour by one person, the Portable Radome goes where no radome has gone before to help live broadcast remotes stay on air.

Complementing protection in harsh winters from snow and ice that the product offers, in burning desert sun heat conditions, an efficient forced air/HVAC system can be added to protect RF and electronics equipment underneath the Radome from overheating damage.

Portable Radome in Remote Broadcast Markets

In September at the IBC 2019 media technology exhibition, Walton showcased the Portable Radome for protecting remote broadcast and sports uplinking applications in extreme weather.

Whether it is for snow at a Winter Olympics, burning sun and dust storms at a Dakar Rally, or heavy winds at a football venue, the Portable Radome protects both on-air signals and satellite equipment from damage.

Portable Radome Traction in Government and Defense Markets

In May, the company announced shipments of the Portable Radome product for U.S.

Government and European Defense agency projects. Units were sold for deployment with a U.S. Government agency and a European defense agency in separate customer projects.

We noted then that growing numbers of large government and military contractor customers acknowledged the unique advantages that the Portable Radome can enable for their end-customer's applications around the world.

New LEO/MEO Design Introduced

In Q3, Walton announced its re-designed Portable Radome for Low Earth Orbit and Medium Earth Orbit (LEO/MEO) satellite Earth station applications, enabling expanded full satellite-arc line-of-sight protection for ground antennas such as LEO gateways and MEO terminals that take advantage of low-latency, high-throughput and next-gen satellite constellations.

The Portable Radome can also be used for fixed site ground networks, and deliver gateway site cost-savings and other advantages

Looking Ahead

Looking to 2020, the company is very excited about opportunities to work with existing and new industry customers, partners, operators and integrators to help deliver the benefits of the firm's latest technologies into LEO/MEO/GEO infrastructure, DoD programs, 5G Earth station systems, and other missions.

www.de-ice.com

David Walton is Vice President of Walton De-Ice (W.B. Walton Enterprises, Inc.), where he is responsible for the Snow Shield, Ice Quake products and new product development. He has over 37 years of satellite industry experience in the design, manufacture, and deployment of earth station technology, and holds several patents for his inventions in this field. He can be contacted at: david@de-ice.com, or visit.

Portable Radome

Protects Antennas & Electronics

**Patent Pending, W.B. Walton Enterprises, Inc.*



Six Satellite Crises

A report by TelAstra, Inc.

By Roger J. Rusch, President, TelAstra, Inc.

Nearly 55 years after the start of commercial satellite projects, the industry remains fascinating to inventors and investors. Many are spellbound by sophisticated projects to build and launch satellites into orbits around the earth. Blending almost magical advances in technology with miniaturized electronics has produced a dazzling array of concepts that would move the Internet into space.

The demand for telecommunications transmission is booming and changing. The satellite industry must now deal with at least six issues that require resolution. These crises can be either a danger or an opportunity. There seems to be a state of confusion due to “disruptive” changes. TelAstra, Inc., decided to issue a major report using 35 years of industry data that the firm has collected. The report addresses each crisis in quantitative terms and explores alternatives that are being considered. It shows that there are relationships and experience that help clarify these matters.

Crisis #1

Terrestrial alternatives are reducing the size of markets that are addressable by satellite and increasing the importance of certain user groups. The terrestrial markets are much larger than those served by satellites. The wireless and fiber providers are more agile at introducing new technology and expanding throughput into more remote regions. They provide service for much lower cost when available in urban regions.

Crisis #2

Satellite operators also have been expanding throughput capacity faster than ever before (Figure 1). In most

There are a number of very clear and obvious mechanisms for government support to the space industry and its contractors that are discussed in the report.

cases the growth in capacity has been faster than the growth in demand. Market forces set the stage for lower transmission prices. Satellites are more competitive, but total revenues have dropped for some.

The report not only looks at past growth of communication capacity, but also estimates the total growth in satellite throughput from 2020 to 2026. The expansion of satellite capacity appears to be headed for even faster growth in the next few years.

TelAstra estimates that GEO, MEO, and LEO satellite systems under construction would each provide about 10 Tbps by 2026 for a total of 30 Tbps. This would be an increase in global satellite throughput by a factor of 7.5, which is equivalent to about 70% CAGR. This would be an unprecedented growth rate in supply for the satellite industry. It also exceeds the growth in demand for terrestrial services.

Crisis #3

Customer preferences have changed along with the associated types of service in demand. Cellular devices are infrequently used for voice telephone calls. Millions of people are abandoning broadcast television and prefer to extract programs directly from the Internet.

Crisis #4

The diverse views on these exciting developments and pricing shocks have caused some established players to pause and reduce capital expenditures. Fewer GEO satellites have been ordered. Fewer satellites are being procured for operation in Geostationary Earth Orbit (GEO). An astonishing array of Low Earth Orbit (LEO) constellations has been proposed with thousands of relatively smaller satellites. The merits and costs of these alternatives are being weighed. Established satellite operators are developing plans that attempt to select or straddle the best alternatives.

Crisis #5

There are several new launch service providers. Current providers are developing next generation launch vehicles to reduce launch costs. The enthusiasm for nanosatellites and LEO Constellations has produced the development of a number of new launch vehicles matched to the needs of small satellites. Users are weighing the risks and rewards of new launch services.

Crisis #6

New satellite solutions typically increase the complexity and cost of user terminals. In the case of LEO constellations, there is a desire for inexpensive electronic satellite-tracking user terminals. Tracking antennas are also needed for terminals on ships and aircraft even when connecting to GEO satellites.

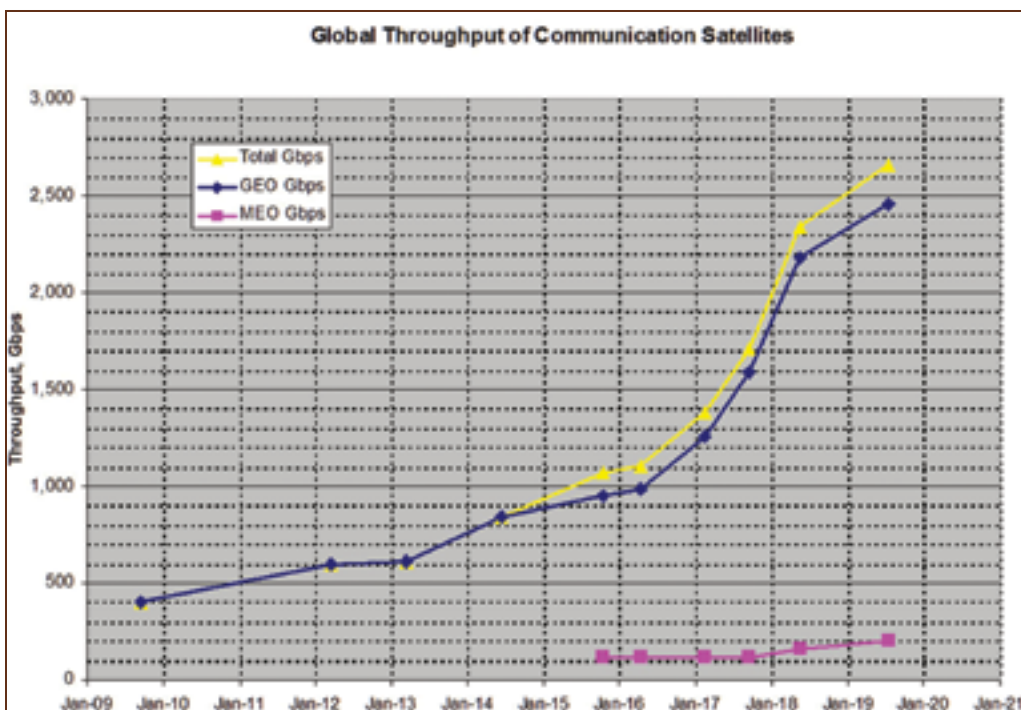


Figure 1. Transmission Throughput of Growth, 2009 to 2019.

The report examines the situation for five satellite communication markets: Fixed Satellite Services (FSS), Mobile Satellite Services (MSS), Television broadcasting, Radio broadcasting, and Broadband Internet access.

Each of the FSS operators has a distinct business and each is developing its own approach to these crises. There are a few common threads. The push to reduce transmission costs has led GEO operators to procure High Throughput Satellites (HTS), a huge increase in theoretical throughput. At the same time, demand for satellite services weakened due to the spread and expansion of terrestrial alternatives. Both production cost and market prices dropped. Capacity is still growing rapidly. The dynamics should not be a surprise since this occurred in the early 21st century. Generally speaking, we have seen that transmission lease prices drop when the cost of providing these services drops. A large expansion of capacity at moderate cost makes large price cuts possible.

The **Mobile Satellite Service (MSS) operators** have a different mixture of issues. MSS was started with the provisions of voice telephone services, a narrow-band service. Over time, users have expected broadband data services from MSS. Only Inmarsat has leaped into the broadband services business for passengers on cruise ships and Internet In-Flight Connections (IFC) for airline passengers. Iridium, Globalstar, Thuraya, and Orbcomm remain committed to low data-rate services. In a few cases they are forming alliances with broadband satellite providers. The number of Machine-to-Machine (M2M) or IOT users is growing rapidly, but the Average Revenue Per User (ARPU) is much lower than for voice or broadband services. The report addresses the situation for each MSS operator.

Television Broadcasting Satellites that provide Direct Broadcasting Service (DBS) or Direct To Home (DTH) must deal with the shift in customer preferences. Subscriber data suggest that fewer people are watching programmed video programs, at least in the developed parts of the world. The report discusses how this has impacted AT&T's DirecTV and DISH. This trend will continue for some time, but there will continue to be an audience for television programs just as there is for radio. These characteristics will require different approaches in each part of the world. There are significant implications for the satellite broadcasting industry as it adapts to the evolving audiences and Higher Definition transmission.

Satellite Radio Broadcasting has been a big success in the US and continues to grow briskly. There are now more subscribers to satellite radio in the US than to the combination of DirecTV and DISH. The ARPU is lower than for television but the total revenue for satellite radio is double the revenue from all the MSS operators.

Echostar Hughes Network Systems, Viasat, and Eutelsat KA-Sat provide **Broadband Satellite Services**. The number of broadband subscriber has been falling for Viasat and Eutelsat, but Echostar HNS has been serving more subscribers. Viasat has been growing revenues by providing

IFC to the airline industry. Revenues are growing in total and are about the same magnitude as for the MSS satellite operators.

At least three operators are funding new **broadband satellite LEO constellations**: OneWeb, SpaceX Starlink and the unnamed Telesat LEO constellation. Excitement about potential "disruptive" technologies led to ambitious plans for these LEO broadband constellations. Although similar ideas were advanced and failed 20 years ago, the lessons from that experience have been shelved as obsolete. "Super Rich" benefactors and Venture Capital have promoted and funded a large number of start-up companies that are based on relatively smaller-than-GEO satellites.

The report also examines other satellite services that are growing rapidly: Earth observation, Internet of Things (IOT), Radio Navigation Systems, and new launch systems. Each of these areas are discussed along with the names of significant new systems.

New GEO HTS have become enormously more capable with individual satellites providing throughput of 1,000 Gbps or more. Satellite operators must deal with variations in demand, both spatially and over time. Service demands are often concentrated in "hot spots," and user demand can shift from one region to another. Consequently, satellite manufacturers have been developing more flexible payload designs that can move capacity and change frequency assignments by ground commands.

New LEO Constellations have been conceived to distribute broadband capacity over the entire surface of the earth while reducing transmission delays (latency). These new solutions require hundreds or thousands of relatively smaller-than-GEO satellites. Past studies have shown that LEO solutions have substantially higher capital and operating costs. New LEO satellite designs are expected to be much less expensive because of new technology.

TelAstra has observed that the cost estimates of LEO constellations tend to grow dramatically over time. **Figure 2** shows the capital cost growth for four prior LEO constellations. The cost growth is partly due to underestimates of the space hardware, but, frequently, a number of important cost elements are not considered. The report identifies eight (8) cost elements that are frequently missing in initial business plans. The report also discusses the high operating cost of LEO systems.

There are a number of very clear and obvious mechanisms for government support to the space industry and its contractors that are discussed in the report. In addition to the topics above, the report provides data on several related matters.

The number of satellites in GEO are increasing steadily. New and replacement GEO satellites are being ordered as fast as satellites are launched.

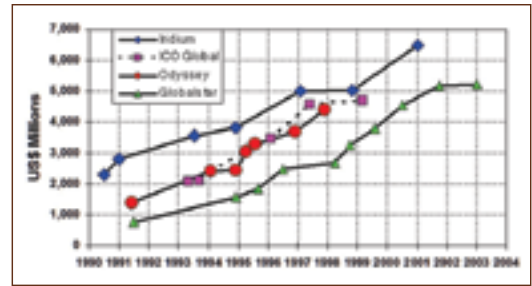


Figure 2. Cost Growth for the Big LEO Constellations.

Every LEO Constellation is inherently global in nature. These LEO Constellations can address users in every country. Consequently, if the LEO constellations wish to reach full utilization, it will be necessary to obtain licensing and approvals in many or most countries. This has been a daunting task.

Developed regions such as Europe, Japan, and North America will have very different needs from many parts of Asia and Africa that have a low per capita GDP.

Not all markets are open to free trade or mass communications. The totalitarian dictatorship in Communist China is extremely zealous about controlling communication. Other dictatorships will have similar issues. Any country that has an established space business will be interested in participation under the right circumstances. There are a growing number of nations that have space aspirations.

Where is the Industry Headed?

This topic has been the subject of a great deal of speculation. On the one hand, we have 55 years of industry experience and data. There have been ups and downs in the past. On the other hand, the world of technology and business is extremely dynamic. The purpose of this essay is to provide clear insights based on historical data, past experience and a carefully reasoned examination of the situation.

The report concludes with 10 bold predictions. If our experience tells us anything, it is that the excitement of space is not about to end. The adventure will continue for many years.

www.telastra.com

Roger Rusch is the president of TelAstra, Inc, a company that consults on the business and financial aspects of satellite communications. The company also publishes Communication Satellite Databases. Contact the author at RogerRusch@telastra.com.



How to Overcome the Biggest Challenges...

... of connected operations

By Obie Johnson, Founder and Chief Executive Officer, CopaSAT

Keeping forward-deployed commercial and military units safe, informed and connected are the difference-makers in remote missions. The best way to accomplish this is to ensure communications and power are available even where neither are available. Traditional solutions cannot achieve this though.

Reliable tactical communications rely on infrastructure and power supplies that work even in the harshest environments. When units operate in places that are completely disconnected from the rest of the world, they need SATCOM hardware that works on-the-move and ruggedized, independent power supplies that can withstand everything nature and people can throw at them.

CopaSAT helps commercial and government organizations turn missions in some of the world's most extreme and remote environments into realized objectives by providing reliable SATCOM-On-The-Move (SOTM) communication and renewable expeditionary power solutions.

CopaSAT has been recognized with the 2019 Mobile Satellite Users Association (MSUA) Mobility Innovation Award for the Top Public Safety Solution for the CopaSAT STORM SOTM terminal. The company also recently acquired the Virideon Intelligent Power and Energy Router (VIP/ER) product line.

The Four Chief Challenges

Constantly changing circumstances

Wherever the commercial and military cooperative efforts of NATO and the U.S. military and businesses may go in the world, situational awareness (SSA) is crucial, particularly in austere environments. The need for quick deployment, tear down and redeployment of communications infrastructure and power means operations can move quickly to adapt to changing and unpredictable circumstances. In addition, clandestine operations led by special operations have even more exacting and extensible requirements for communications and power.

SOTM

NATO and military forces rarely stand still, whether they are operating on land or on the water. This introduces an entirely new set of challenges and requirements. SATCOM on-the-

Ruggedized communications and power considerations are required to support situational awareness for remote, commercial and military mobile operations.

move (SOTM) has always had its limitations, particularly on small military vehicles and vessels like MRZR's, 11-meter ridged hull inflatable boats (RHIBs) and the combatant craft medium — CCM Mk 1. These vehicles and vessels operate at high speeds, and on rough terrain and extreme sea states further exacerbating connectivity challenges.

Remote, hostile environments

Deployments can happen anywhere in the world at a moment's notice. High-risk, dismounted operations often occur where communications and power are not available. The importance of further remaining inconspicuous makes off-the-grid infrastructure necessary. Keeping the location of mission operations concealed is critical. These units also need equipment that can withstand extreme weather, dust and sand, water spray and rough handling.

Sustainable, autonomous operations

Self-reliance is crucial for forward-deployed units. Operations often continue for extended timelines, whether planned or unplanned, requiring sustainable field power and communications. Expeditionary units need autonomy and the discretion to execute in fluid situations.

Addressing Power Requirements

Today, there are means to address each of these challenges. Innovative SOTM and sustainable, ultra-portable field power solutions are supporting commercial concerns and military and NATO forces around the globe.

Powering the mission

Powering sustained, mobilized operations is challenging. Wherever missions are required to deploy in hostile environments, be they commercial or military in nature, operations need rugged, reliable, expeditionary power solutions that are scalable to support a variety of demanding requirements, from simply charging devices to powering full SATCOM communications terminals. There are many environments where trailers and generators are not an option. Eliminating the logistical hassles of transporting, maintaining and supporting traditional power generation sources means missions can go on, even in harsh, isolated locations.

Here is a checklist for SOTM communications.

Reliable tactical SOTM connectivity and communications

These are critical to remote, austere operations. Keeping vehicles and vessels that have never been connected before connected over rough terrain and high sea states is now possible. Even 11-meter RHIBs, MRZR's, CCM Mk 1s can all have on-the-move broadband connectivity.

Mobile hotspot

The best alternative is to have a mobile hotspot that can use SD-WAN and select between cellular, Wi-Fi and satellite networks for optimization, failover and balancing. This offers maximum flexibility.

Connect into communications networks and equipment

In addition to being able to select between cellular, Wi-Fi or satellite networks, integrating other devices like MANET handheld radios provides interoperability between a flexible mobile network and various communications devices.



An installed CopaSAT STORM terminal.

Plug and play

Another important thing to look for is fast deployment and provisioning. Setting up a satellite network can be complicated. However, there are solutions available today that only require a simple push of a button to auto-provision and acquire the satellite.

Anti-spoofing

Identify communications solutions that will protect the networks. SATCOM solutions need to accept external GPS sources such as Defense Advanced GPS Receiver (DAGR) for selective availability and anti-spoofing.

Military-grade

Equipment used in the field needs to be able to withstand rough handling, drops and weather. Look for solutions that have an IP68 rating and protection against water and dust infiltration.

Maximum flexibility and usability

Real estate to install SATCOM terminals is limited on small, fast-moving vehicles and vessels. Solutions that can both transmit and receive on a single terminal, make communications possible to and from vehicles and vessels that would have never been connected in the past.

Low visibility

Keeping a low profile is important. Portable solutions that don't call attention to forward-deployed units make all the difference. Making sure it isn't obvious that a vehicle or vessel has satellite communications capabilities is also useful for clandestine missions.

Capacity flexibility

Predicting satellite usage and purchasing satellite capacity typically means commissioning capacity that

may never get used. Getting access to flexible satellite services that are designed to have the connectivity follow the terminal means only paying for the satellite capacity that is actually used.

Here's a checklist for what to look for in reliable, field-deployable power.

Portability

Getting power to remote locations means the lighter the better when it comes to making power available. Today, there are expeditionary power solutions that are easily portable. The ability to provide power at nearly any location without a logistics trail can make a critical difference in many missions.

Sustainable and renewable

Look for power that is autonomous and renewable, particularly when missions can end up stretching out past the normal 72-hour window.

Military-grade

Field power needs to meet military-grade requirements. Solutions that are designed to MIL-SPEC standards will ensure power continues to flow even after being exposed to inclement weather and unexpected drops or rough handling and transport.

Water and dust infiltration

Working in remote environments often means equipment is exposed to the elements such as dust and rain. Ensuring your power generation equipment is designed to withstand the elements is crucial. Look for passively cooled devices that do not rely on fans or filters. This will reduce maintenance and increase reliability.

Flexibility and usability

Systems should provide scalable field power designed to meet fluid requirements and extended operations. Support for regulated, unregulated output power and MPPT solar charging is also important. While protection against overvoltage, undervoltage, over current and short circuit are a requirement.

Modular

Specifying modular systems that can support multiple power sources including AC, DC, battery and solar is vital. Having multiple input and output types provides maximum flexibility and adaptability to a variety of environments, situations and requirements.

Fast set up and tear down

With units constantly on the move and situations being fluid, easy set up and tear down of power systems helps keep forward-deployed units powered while allowing maximum transportability.

Keeping the Lines of Communication Open

There are so many places, vehicles and vessels where you can't use Commercial-Off-The-Shelf (COTS) SATCOM solutions.

On-the-move communications and SATCOM for MRZR's, 11 meter rigid hull inflatable boats (RHIBs) and other special operations craft have not been available. Legacy solutions don't fit and cannot track fast enough to remain connected with a satellite while the vehicle or vessel is moving at high speeds. This has always been a challenge. However, now there are solutions addressing the challenge, making all of these applications possible for the first time.

Expeditionary Power and SOTM

Ultimately, a number of commercial as well as military and NATO operations require low visibility, standalone expeditionary power and SOTM solutions that can withstand remote and unforgiving environments and use. Combining these solutions into a single package helps maintain communications so every deployed unit can remain vigilant while remaining situationally aware at all times.

CopaSAT professional services and AxialOne managed services employ professionals that understand mission critical because they have been deployed in some of the world's most demanding missions. We partner with leading satellite operators, satellite service providers and satellite hardware manufacturers to deliver reliable communications on a global scale.

When COTS, one-size-fits-all SATCOM services and solutions don't meet mission requirements and require a custom-engineered solution, CopaSAT brings on-the-ground, real-world field experience to every engagement. CopaSAT knows mission critical because the company has lived mission critical.

www.copasat.com

Obie J. E. Johnson is a technology entrepreneur and Auburn University electrical engineer that has worked with military satellite communications systems for nearly 40 years and is the owner of CopaSAT.

In 2008, Mr. Johnson assembled a small team to develop successful X-/Ku-/Ka-band manpacks and fly-away terminals while a co-owner at Tampa Microwave.

In 2017, CopaSAT acquired Eclipse Composites Engineering, which provides carbon fiber composite antennas used in WGS certified satellite terminals. In 2019, CopaSAT completed the acquisition of Virideon's intelligent power management product solutions.



Making Complex Problems Simple

User-friendly geospatial data processing tools

By Max Polyakov, Managing Partner,
Noosphere Ventures Investment Fund

Nowadays, one observes a number of technology and market trends that have a significant impact on the remote sensing industry. One key trend is reducing the size and weight of satellites in low-earth orbit. Improved technology, including deployable antennas and miniaturized propulsion systems, enables satellite operators to avoid using large, expensive satellites for many applications. Instead they replace them with groups of small satellites that can be launched together with tens of other satellites, or launched individually using a small-lift launch vehicle.

In addition to reducing cost, the increased number of Earth Observation (EO) satellites in orbit creates new capabilities. For example when the same surface area is imaged from many different orbital positions, one can use stereo image processing techniques to generate 3D height measurements of that area.

Other important technological factors include the Big Data revolution and the maturity of cloud computing. These technologies combined with tools like machine learning and data analytics make it possible to obtain previously unknowable information about our world on a persistent, global, and high-resolution basis.

Another trend is miniaturization of satellite sensors such as synthetic aperture radar (SAR). Thus, commercial satellite-based radar monitoring services are becoming more available. SAR technologies have already been practically applied in many industries, but due to high satellite cost and power consumption, access to high-quality commercial SAR data is limited to that provided by a small number of non-US, government-built, dual-use satellites (which always give priority to government users).



At present, many of the traditional differences between space companies and IT companies persist. This distinction will become more and more invisible in the near future.

Data Analytics Becomes the Industry Standard

As of this writing, most industries have experienced digital transformation. This transition will continue to take place in nearly all industries and the processes governed by them. Industry leaders need detailed and up-to-date industry-specific information in order to optimize their management processes for the digital era. In fact, many industries increasingly demand processing and work-flows managed, in part, by geospatial information systems.

At the same time, geospatial information systems are unfamiliar to most industrial enterprises. Therefore, it is important to provide them with fast and easy access to open and proprietary data sets, and to equip them with user-friendly geospatial data processing tools.

On the other hand, increased data availability inspires development of new applications thereby increasing market demand. However, despite its availability only 5 percent of the imagery collected by EO satellites ends up being used. Why? Because there are still many barriers preventing the industry from making remote sensing tools useful for everyone.

EOS' mission is to completely remove these barriers as soon as possible. EOS is simplifying access to geospatial data and developing new data processing tools in an effort to accelerate growth of this nascent industry.

EOS makes complex problems simple, so that anyone can access remote sensing services that were once available to only the most wealthy and sophisticated governments and corporations.

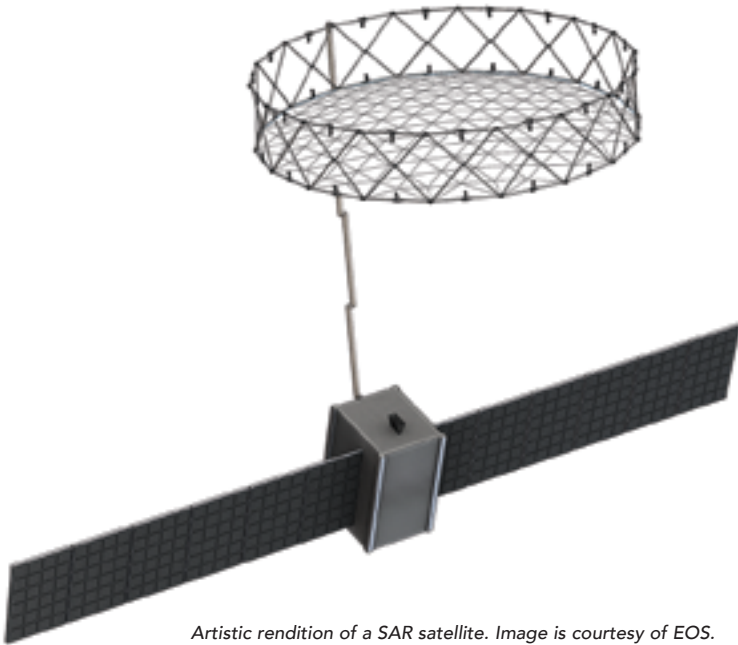
From Analytics to Data

Since 2015, EOS has offered cloud-based services to manage large volumes of geo-information data, as well as specific analytical solutions which apply satellite remote sensing data to a wide range of industries. Customers use EOS solutions for security, ecological health monitoring, environmental management, agriculture, etc. EOS clients and partners are world-leading companies in data analysis, agriculture, and insurance sectors — as well as governments and other state and non-commercial organizations.

Integration of different technologies is key. All EOS-developed algorithms and methods use advanced data processing and analysis technologies, including data combination methods known as Data Fusion. EOS' experience proves that the most accurate and useful result can be achieved by synergistically combining data from different sensors: optical images, radar data, LIDAR point clouds, etc. to enhance both the quality of the individual data sets as well as the accuracy of higher level analytical results such as object detection, crop classification, height estimation, etc.

During all these years, EOS has strived to carefully study each industry vertical and suggest intelligent solutions based on the available data. Each industry vertical represents new data set(s), new task(s) from the end user, and new challenges. Each step forward in this regard is a positive contribution to the industry of data analytics. EOS creates an ecosystem which transforms the science of remote sensing into practical business cases.

EOS is a vertically integrated company working on multiple remote sensing projects, including the development of its own satellite constellation designed to meet current and future market needs. Using more persistent and versatile data sources will further enhance EOS analysis results.



Artistic rendition of a SAR satellite. Image is courtesy of EOS.

In 2019, EOS announced the launch of a new division — EOS SAR — whose mission is to develop low-cost high-performance synthetic aperture radar (SAR) sensors intended for deployment in a constellation of small satellites.

In addition, EOS began production of optical satellites in 2018. The first phase of EOS satellite constellation consists of 12 satellites providing 2-3 hours revisit time for a given area. The first SAR satellite launch is expected in 2022, with commercial constellation operations beginning in 2023.

EOS decided to develop its own constellation of remote sensing satellites after researching practical business cases in commercial and government EO markets. Despite a great amount of open satellite data, the markets still lack persistent, high-quality, high-resolution data sources.

New Horizons — SAR constellation

EOS satellite constellation reduces system latency, enabling delivery of analytical results to the end user in just a few hours. Using multiple satellites compared to one satellite dramatically reduces the time between consecutive passes over the same area. Satellites with optical sensors are widely used in commercial constellations today. As of now, optical sensors have mostly adapted to the small satellite paradigm and their technology is readily available.

However, satellite-based optical sensors cannot function in cloudy weather or at night. Accounting for these and other limiting factors, information from satellites with optical sensors can only be used four months out of a year - and the satellites are essentially useless during the rest of the time.

development of a low-cost high-performance SAR payload for small satellites with ultra-high ground resolution down to 25 cm.

EOS SAR satellites will operate in Stripmap and Spotlight modes (including interferometry) and will cover a wide range of applications. EOS is also considering dual-frequency SAR in X-band and S-band on a single satellite. Dual-band operation increases versatility for all weather imaging and improves object-ground contrast. A special configuration of the radar front end allows for imaging of selected areas in both bands in a single orbit.

EOS SAR payload incorporates a deployable reflector antenna developed in-house at EOS. This proprietary antenna technology enables EOS SAR instrument to improve satellite efficiency and offer superior image quality. Moreover, the antenna itself has low mass and dimensional characteristics, making it more favorable and less costly to launch the SAR satellite into orbit.

2020 and Beyond

EOS SAR is the last logical division within the geospatial branch of Noosphere Ventures. Noosphere’s investment portfolio currently includes Firefly Aerospace, which offers satellite launch services from its fleet of small and medium-sized launch vehicles, SETS, a supplier of electric satellite propulsion systems for small satellites, and EOS, an industry leader in data storage and analytics services for remote sensing.

The first operational debut of Firefly’s Alpha rocket is scheduled for a February 2020 launch from Vandenberg Air Force Base. Later on in 2022, the Alpha rocket will start launching EOS remote sensing satellites into precise, dedicated orbits designed for optimum constellation performance.

Traditionally, SAR satellites are rarely used for commercial applications due to their large size, technical complexity, and high costs. As of now, however, EOS has significantly reduced the size and complexity of SAR sensors and antennas, and opened a huge opportunity for growth in the EO market.

All these factors, as well as the market demand for analytic results 24/7, contributed to EOS choice of SAR technology for its remote sensing constellation.

EOS’ engineers have already designed a radar prototype and are moving ahead with the

Meanwhile, EOS as a company will maintain its focus on data storage and processing services. In fact, EOS is already developing combined analytical solutions designed to ingest data from various sensors and formats, including EOS SAR data. Additionally, mutual integration of services for processing, storing, visualizing and analyzing this data will allow EOS to capitalize on all potential synergies.

Finally, EOS is planning to expand its portfolio of cloud services to include monitoring of agricultural areas — Crop Monitoring. Crop Monitoring services help farmers make optimal decisions for efficient farm management by analyzing satellite data in near real time. Crop Monitoring services are widely used by agricultural producers and traders as well as insurance companies and banks.

On the macro scale, EOS’ strategy is shifting toward both vertical integration in the economic value chain and horizontal integration in terms of strategic partnerships and implementation of joint projects.

At present, many of the traditional differences between space companies and IT companies persist. This distinction will become more and more invisible in the near future. Observers will begin to see various industry branches merge, becoming “new space” companies comparable to IT companies in terms of speed and growth.

EOS currently plays an active role in the digital transformation of industry by developing advanced cloud-based technologies and expanding and strengthening its portfolio of internal and external services. Thus, EOS is now driving development of its own remote sensing infrastructure that will enable it to play a more important role in the future.

eossar.com/sar-technology.html

eos.com

noosphereventures.com

firefly.com

sets.space

Max Polyakov is the Managing Partner at Noosphere Ventures Investment Fund.



Why Mobile Satellite Services are...

...ready for mainstream consumers in 2020

By Michael Capocchi, CEO of Beam Communications Holdings Limited

Consumers have, for many years, regarded mobile satellite services (MSS) as a niche and often expensive solution that haven't always appealed to mainstream markets. This perception isn't helped by the fact that satellite devices have missed the mark in terms of how most consumers expect to interact with the technology and apps.

However, the digital age has changed what people regard as a basic human need and staying connected is now a necessity, no matter where you are located on the planet. This is why the market is ready for a new and innovative product that makes it easy and seamless to send messages from anywhere on Earth, and in a way that wasn't previously possible.

Australian satellite device developer Beam Communications Holdings Limited (ASX: BCC) has teamed with established North American satellite solutions provider Roadpost Inc. to launch ZOLEO, the first ubiquitous messaging device of its kind in the world.

ZOLEO is a wearable device, easily clipped onto a belt or backpack, and delivers satellite messaging capabilities to any Android or Apple smartphone. Users can seamlessly send messages from their phone, or, at the push of a button, generate an SOS or check-in to tell someone they're OK as they move in and out of mobile or Wi-Fi coverage.

There is currently an unmet demand for an easy to use, affordable and portable pole-to-pole communications device; however, this will change in 2020.

The MSS market is a relatively elastic market. If prices fall, there will be an exponential increase in demand for the service. This is why improving affordability is such a big driver for the mass adoption of such solutions.

Think about services that are taken for granted today but ones that used to be only accessible by the few, such as air travel and cellular service. The tipping point was falling prices and the MSS market is reaching a similar inflection point.

What Consumers Want

ZOLEO is the result of a global collaboration between Beam Communications and Roadpost Inc.

Beam has a 20 year track record in developing portable satellite equipment and is the OEM partner behind the successful Iridium GO! hotspot device and the Thuraya WE dual mode (satellite and 4G) hotspot unit.

Beam has received orders from Iridium for 45,000 Iridium GO! @ units and will be among the first companies in the world to develop products using the upgraded Iridium Certus@ 9770 transceiver after the firm was selected by Iridium to become a beta partner.

Roadpost, which is headquartered in Toronto, Canada, with an office in Seattle, Washington, is the lone worker safety and mobile satellite solutions provider of choice for more than 45,000 individuals, businesses and government organizations. The company has been in operation for nearly three decades.





Iridium GO!

Unique Seamless Messaging Solution

What makes ZOLEO unique from other portable MSS devices is that it is specifically built for pole-to-pole global messaging. The clip-on device automatically switches between Wi-Fi, cellular and the Iridium NEXT satellite network to provide uninterrupted and seamless access to messages and email through the free ZOLEO app.

The service also includes a local mobile number so that users can send and receive SMS messages as well.

ZOLEO provides a familiar smartphone messaging experience with emoticons and access to the phone's contacts.

The development of the new solution was based on in-depth market research of target users with 96 percent of surveyed respondents rating communications and SOS alert features as the biggest reason to purchase an MSS device.

Increase in Globetrotting Adventurers

It's easy to see why there is pent up demand for a cost-effective global messaging solution. As air and land travel have become more affordable, an increase in people traveling and crisscrossing the globe in search of their next adventure is on the increase.

In fact, the global Adventure Tourism market is forecast to grow at 17.4 percent per year from 2017 to 2023, to reach US\$1.3 trillion annually, according to a 2018 report by Allied Market Research — Asia Pacific is the fastest growing region due to the wide variety of destinations on offer — most of which is outside cellular coverage.

Adventure tourism typically takes travelers off-the-grid and includes activities such as caving, climbing, cycling, hiking and rafting. However, it isn't only adventurous tourists that are on the rise — there is a growing domestic traveler market, including the caravaner and cruise markets.

Cruise goers are always keen to remain in constant contact with friends and family without having to pay for expensive internet time.

Don't forget anxious parents whose teenagers might be embarking on a backpacking adventure on another continent.

A low-cost MSS solution can be the key to keeping travelers and their loved ones connected, even at the most remote ends of the planet.

Making Communication Available for Rural Residents

Those living in rural communities often bemoan the lack of reliable coverage as they often have to travel in and out of mobile coverage.

Despite the trend toward urbanization, World Bank data shows rural populations are growing with 3.4 billion people living in such communities in 2018 compared with 3.2 billion a decade ago — and the numbers continue to grow. This is a significant market, as close to half of the world's population live outside metropolitan cities.

Communication in rural communities is especially crucial when emergencies and natural disasters, such as bush fires, earthquakes and hurricanes strike. A lack of communication can result in a life or death situation.

Supporting Lone Workers

Then there is the lone and remote worker sector. These include single-person or small crews from the oil and gas, mining, healthcare and utilities industry.

These workers often have to work extended periods in the field and organizations are increasingly turning to global communications solutions to improve safety, increase productivity and control rising employee insurance costs. The Lone Worker Safety market in Europe and North America is forecast to double in size to €260 million in 2022, according to analyst firm Berg Insight.

While no data is available for Asia Pacific, it is likely that the region would experience stronger growth.

The ruggedized device is IP68 rated, which makes it suitable for maritime use, has a built-in GPS for location sharing, DarkSky™ weather forecasts, separate SOS and "I am OK" buttons and as much as 200 hours of battery life.

Conclusion

There is currently an unmet demand for an easy to use, affordable and portable pole-to-pole communications device; however, this will change in 2020.

Consumers will increasingly be drawn to satellite solutions, particularly those that offer dual- and multi-mode capabilities.

While ZOLEO is designed as a personal communication tool, the concept can be adapted to enterprise and government applications as well. After all, more than 70 percent of the planet's surface does not receive a mobile or Wi-Fi signal.

Cost and simplicity of use has been a key factor in preventing the mainstream adoption of satellite services, but that's about to change. ZOLEO will be launched before the end of December 2019.

For more information, please visit www.zoleo.com.

You can find out more about Beam Communications Holdings Limited at www.beamcommunications.com and Roadpost Inc. at www.roadpost.com.

Michael Capocchi is the CEO of Beam Communications Limited.



On the Horizon

New lithium-based technology for satellite batteries improving mission performance

By Dr. Chengsong Ma, Chief Scientist, Saft

Lithium battery technology for satellites has been deployed for more than 20 years, improving the calendar life of missions, reducing weight and resulting in total cost of ownership reduction for satellite manufacturers and operators.

The technology has been field-proven, safe and reliable with little change to the basic design and chemistry of the battery. Now, a new battery technology is emerging that will enable even better performance, especially in the growing Low Earth Orbit (LEO) radar satellite market: lithium titanate oxide, or LTO.

A key advantage that traditional lithium-ion (Li-ion) technology brings to satellites is significant weight savings due to its high specific energy. This has contributed to the ability for satellite manufacturers to make smaller satellites that operate in LEO, such as constellations. These satellites are less expensive and easier to launch into orbit position, and are becoming increasingly prevalent for use in radar, telecommunications, internet, and surveillance applications.

With reduced size and costs always a priority, satellite manufacturers are constantly asking 'what's next?' when it comes to new battery technology that will reduce system weight, last longer and provide enhanced safety — all contributors to efficiency and overall cost savings.

In the 1990's lithium-ion technology emerged as a lighter replacement (3x lighter) for nickel-hydrogen batteries. Now, advancements in technology have brought LTO into the space battery market as an even lighter, higher-power, safer and longer-lasting option.

What is LTO?

Lithium titanate oxide chemistry offers several key benefits for space applications. The lithium titanate-based anode in LTO batteries, compared to the graphite or carbon-based anode found in traditional lithium-ion batteries, allows them to achieve very high charge and discharge rates, meaning they are capable of re-charging much faster than traditional lithium-ion (Li-ion) technology.

As the satellite market moves toward smaller satellites in LEO, battery technology must also evolve to meet the demands for size, weight and performance.

LTO operates in a potential range far from lithium plating, unlike graphite based-anodes, providing cycle life and safety advantages. They are capable of tens of thousands of high rate charge/discharge cycles with very low heat generation, which eliminates the need for thermal management, and reduces system size and complexity.

The main advantages of LTO compared to Li-ion are:

- Potential for extremely long cycle life, even at 100 percent Depth of Discharge (DoD)
- Very safe
- High rate charge and discharge
- Fast charge capabilities
- Storage and shipment at 0V
- Excellent low temperature performance

Of course, as with any technology, trade-offs do exist. For LTO, high temperature operation has challenges and there is a 30 to 50 percent reduction in energy density when compared to Li-ion. For this reason, chemistry choice is often the deciding factor for satellite manufacturers when selecting the correct battery for the mission profile.

Saft, a manufacturer of batteries for space and numerous other niche industrial applications, is an expert in developing all battery chemistries used in space, including lithium-ion, primary lithium as well as nickel-based chemistries and has been working on developing LTO technology specifically for space and other demanding applications.

LTO Comparisons

Not only is chemistry choice important, but so is cell construction and overall battery design. Space applications — especially in LEO with its aggressive cycling requirements — need robust, reliable and safe battery technologies that maintain performance in harsh environments.

Saft has developed LTO prototype batteries in pouch cell format that have demonstrated better overall performance than commercially available 18650 Li-ion cells that are a common power source found in many smallsats.

In terms of DoD, or the percentage of capacity left after discharge relative to the overall capacity of the battery, LTO cells can use up to 90 percent DoD compared to 20 percent DoD for currently -used space Li-ion cells. A typical best 18650 space cell at 250 Wh/Kg is limited to cycling at 10 percent DoD usage to achieve 50,000 LEO cycles.



The 18650 space cells have a narrow operating temperature window with usable energy output of 25 Wh/kg. In contrast, a Saft LTO LEO prototype cell at 100 Wh/Kg can discharge to 80 percent DOD while providing a much longer LEO cycle life. Saft LTO cells require no thermal management and the usable energy output is 80 Wh/kg. In addition, Saft's cells have demonstrated excellent cold temperature performance with no capacity loss.

Technology Comparison

Commercial 18650s	Saft LTO cells
Energy density = 250Wh/Kg cell level	Energy density = 110Wh/Kg cell level
Limited to 10-20% DOD LEO cycle	80% DOD LEO with longer cycle life
Small operating temperature window	Requires minimal thermal management
Energy output = 25Wh/Kg -50Wh/Kg	Energy output = 88 Wh/Kg

While they are inexpensive and suitable for smallsats with less demanding missions, commercial 18650 Li-ion cells have poor cycle life and are not designed to withstand the extreme environments of outer space that include wide ranging temperature changes, shock, vibration, abuse and demanding cycling.

Space application 18650s must limit the depth of discharge to 10 to 20 percent, otherwise the cell performance will fade dramatically.

While they can be considered for short and medium durations with very low DoD, they are not suitable for long-term missions. Furthermore, many of these cells have no flight heritage or are still under qualification, further limiting their usefulness in critical space missions.

LTO Benefits for the LEO Space Market?

LTO batteries have several advantages for smallsats that operate in LEO, the main one being reduced weight. Due to their extended operating range (-30°C to +70°C), there is no need for heaters to maintain the optimum temperature for space conditions, thereby simplifying the system and increasing usable energy.

In addition, they are capable of higher cycling (up to 10x more) than graphite-based technology

and the voltage can be dropped down to 0V for storage and shipping without any loss of capacity. Plus, LEO cycling demands are highly specialized. They are very aggressive, long, and have very high charge rate requirements with no rest periods. LTO has demonstrated the ability to sustain high charge/discharge rate without rest.

This is extremely advantageous for radar/agile LEO satellites, where only a short time is available for recharge when the battery is used during sunlight periods. They have also demonstrated greater usable energy in LEO cycling conditions despite lower energy density of LTO than graphite-based chemistry.

An example of the type of performance that could be expected of LTO-based batteries for LEO satellites looks like:

- Orbit duration: 90-110min
- Eclipse duration: 30 to 35 min
- Discharge peak up to 7-10C
- Available charge time: 30 to 40 minutes when battery is used in sunlight periods
- Cycle number: 12 to 16 per day
- Life time: up to 12 years, 70,000 cycles

As the satellite market moves toward smaller satellites in LEO, battery technology must also evolve to meet the demands for size, weight and performance. Chemistry choice should be the first consideration and different pairings are appropriate for different applications.

Saft is working to develop/optimize a suite of LTO-based cells with different positive electrode chemistries for material optimization. The company currently has a patent in place and is working to continuously improve batteries performance for satellite customers.

www.saftbatteries.com

Dr. Chongsong Ma is the Chief Scientist for Saft's Space and Defense Division where he leads the development of next-generation space battery technology for Saft in the U.S. He has worked in a variety of technical roles at Saft since 2008, also serving as technical advisor for commercial lithium-ion battery programs where he pursues new funding opportunities. He has 20 years of experience in new product development and commercialization for batteries and fuel cells, over 40 publications in peer reviewed journals, and is a frequent invited speaker at various international technical conferences. He holds a Ph.D. in Physical Chemistry and a M.S. in Analytical Chemistry.



Space Report 2019–Q3

An Executive Summary

A guide to global space activity

By Space Foundation

Highlighting a range of space industry activities, **The Space Report Quarter 3** conveys the most pertinent and interesting findings of Space Foundation research and analysis conducted during the quarter.

These perspectives on commercial space revenue, STEM education, and emerging jobs provide key insights into trends that continue to shape the larger space industry and how it will continue to grow and evolve.

The global space economy crossed the \$400 billion mark for the first time this year with revenues of \$414.75 billion. Commercial space activity fueled much of that growth, with the largest single-sector gain coming from value-added services, which posted a single-year 20.5 percent increase in revenues.

Strong economic news in the space industry also was reflected in the second-quarter results of the The S-Network Space Indexsm. Of the 30 space-related companies it tracks, seven showed growth of 20 percent or more in Q2 2019. Overall, the index showed an increase of 8.7 percent and outperformed the two comparison indexes.

The full version of *The Space Report Quarter 3* provides more detail regarding 2018 activities. For more in-depth and up-to-date information, The Space Report Online captures the latest and most accurate space industry data.

Both the report and database subscription are available for purchase. To join major aerospace companies, universities, research firms, and government organizations that are serious about gaining in-depth knowledge about the global space industry, see the end of this summary for purchasing details.

The Space Report serves as a resource for government and business leaders, educators, financial analysts, students, and space-related businesses.

Global Commercial Space Activity

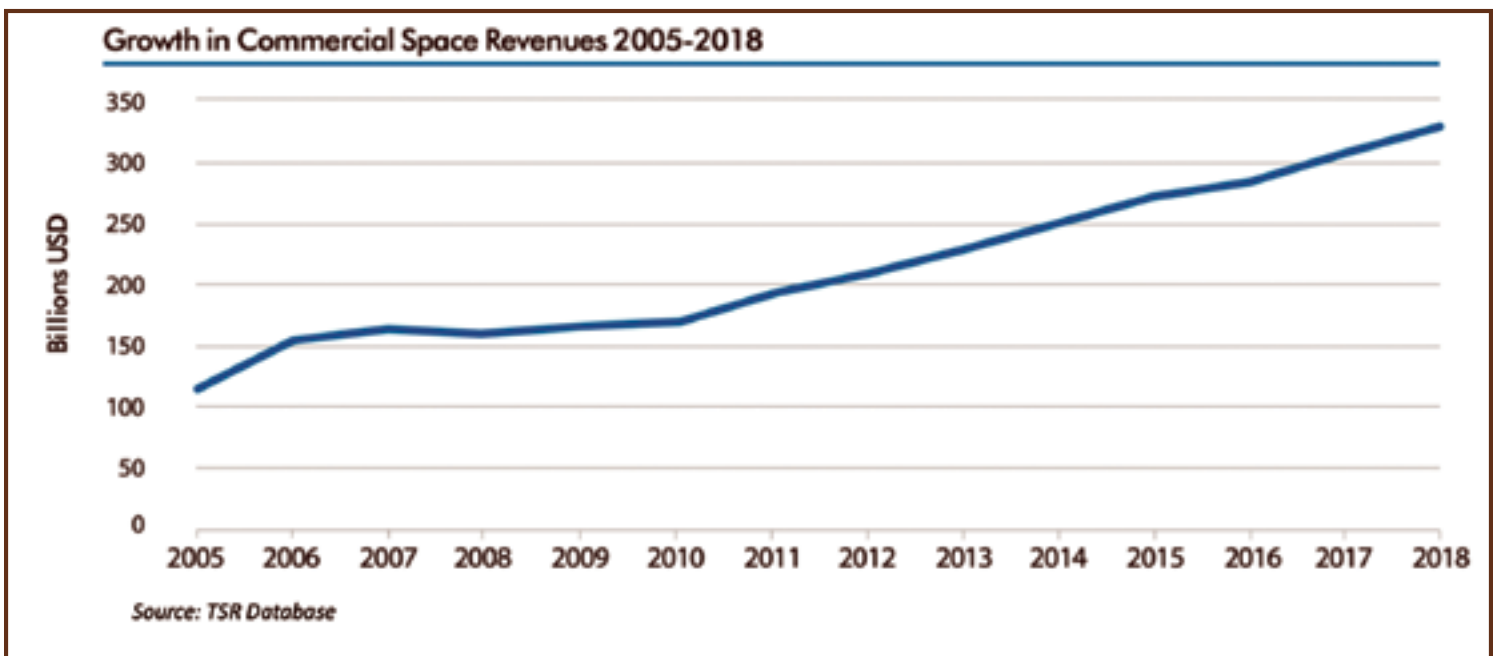
- Revenues from global commercial space activity in 2018 reached their highest levels ever, totaling \$328.86 billion, an increase of 6.6 percent from 2017. Commercial revenue accounted for 79.2 percent of total global economic activity in space.
- Starting in 2004, legislative mandates and private enterprise fueled a new era dedicated to space exploration and the involvement of private enterprises. From 2005 to 2018, those new efforts triggered a 13-year period of growth that resulted in a 162 percent increase in commercial space revenue.

Commercial Space Products and Services

Commercial space products and services accounted for 69.7 percent, or \$229.17 billion, of total commercial revenue, during 2018.

Category	Revenue	Source
Ground Stations and Equipment	\$92.47 B	Satellite Industry Association, European GNSS Agency (GSA)
Satellite Manufacturing (Commercial)	\$5.28 B	Eurospace
Launch Industry (Commercial)	\$1.49 B	Eurospace
Insurance Premiums	\$0.46 B	XL Catlin
Commercial Human Spaceflight (Deposits)	\$0.00 B	News Reports; Public Statements
Total	\$99.69 B	

- In 2018, value-added services, companies that receive and use satellite signals for a range of businesses including logistics and smartphone apps, contributed the largest portion of revenue in this sector, 43.1 percent, with \$98.67 billion.



- Revenues from Direct-To-Home(DTH) television were close behind, providing 42.0 percent of total revenue in this sector in 2018, with \$96.31 billion.

Broadcasting

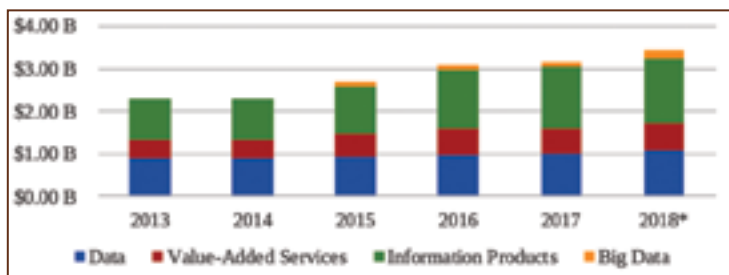
- Satellite television revenues were estimated to be \$96.31 billion in 2018, based on data from the Satellite Industry Association, public filings, and industry reports.
- Revenue has been relatively steady in this area, decreasing less than 1 percent from the estimated total of \$97 billion in 2017. Satellite TV providers are losing customers primarily to over-the-top services that provide on-demand content, like Netflix, Amazon Prime Video, and Hulu
- In the area of satellite radio, provider Sirius XM increased revenue by 6.4 percent over the past year, from \$5.43 billion in 2017 to \$5.77 billion in 2018.

Communications

Global revenue in 2018 was estimated to be \$24.97 billion, 4.1 percent more than the estimated revenue of \$24 billion in 2017.

Earth Observation

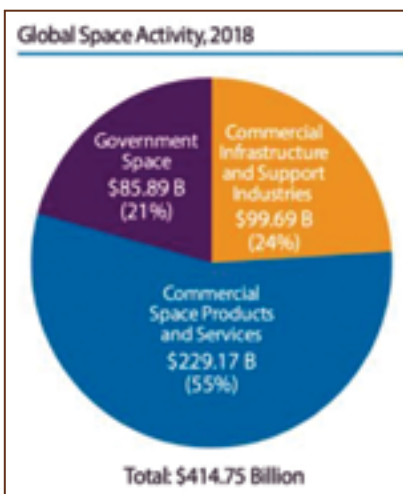
Total global revenues for this sector were estimated at \$3.45 billion in 2018, an increase of 9.4 percent from the total revenues of \$3.15 billion in 2017.



*Estimated Revenue: Source: Northern Sky Research, Public Filing

Commercial Infrastructure and Support Industry

Commercial infrastructure and support industries accounted for \$99.69 billion in revenue in 2018, which represented 30.3 percent of total commercial space revenue. This is 2.6 percent more than the \$97.16 billion in revenue during 2017. The largest source of revenue in this area in 2018 was from ground stations and equipment, which accounted for \$92.47 billion, or 92.8 percent, of total revenue in this category.

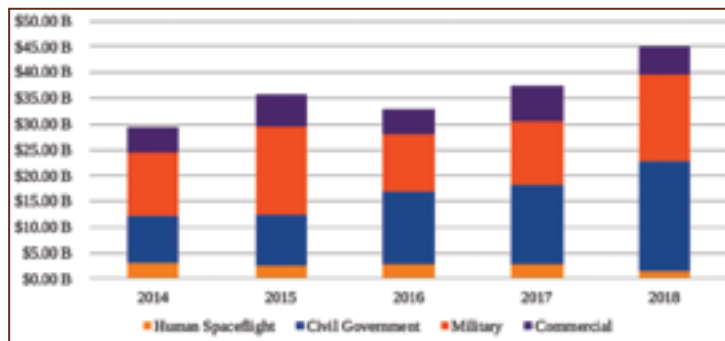


Satellite Manufacturing

- From 2014 to 2018, the total manufacturing value of spacecraft/satellites launched each year increased almost 50 percent from just under \$30 billion to \$45 billion.

- The majority of that value in 2018 came from civil government and military sectors, but U.S. companies launched 167 spacecraft/satellites and earned \$5.28 billion in revenue.

- Revenue from commercial spacecraft accounted for 11.7 percent of the estimated \$45 billion total value of the spacecraft market in 2018. The remaining 88.3 percent, or \$39.75 billion, was related to civil and military spacecraft, including cargo launched to the International Space Station as part of NASA's commercial resupply services.



Source: Eurospace

Launch

- Estimated global market value for commercial launch services in 2018 was \$1.49 billion, according to Eurospace, the European space industry association. This is a decrease of 40.3 percent from the estimated total of \$2.49 billion in 2017.
- Commercial launches accounted for 21 percent of the estimated total global market value for orbital launches in 2018.
- Launches for government customers accounted for the remaining 79 percent, or \$5.60 billion of estimated market value.

STEM Education

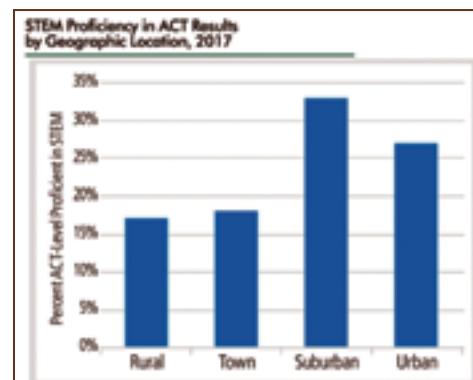
This analysis of the future of the space industry examines STEM proficiency rates of primary and secondary students, subsequent STEM postsecondary graduation rates, and the familial and educational background of STEM degree recipients.

STEM Proficiency in Primary and Secondary School

U.S.

Significant differences in STEM education can be found across public and private schools, and throughout grade levels.

In science, eighth grade proficiency in private schools is 10 percent of that in public schools. Similarly, eighth grade technology and engineering literacy proficiency



Source: STEM Education in the U.S.: Where We ARE and What We Can Do — 2017, ACT

in private schools is also 10 percent higher. There's an additional disparity between all public and big-city public schools, namely, mathematics proficiency is 8 percent lower in big cities and science proficiency is 19 percent lower.

No school location produced a STEM-interested and STEM-proficient student base greater than one-third.

International

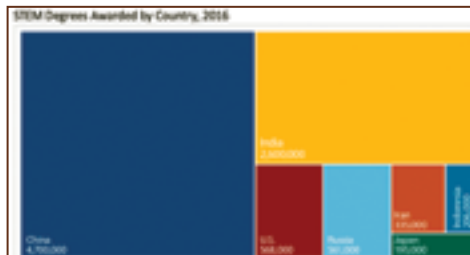
The Organisation for Economic Co-operation and Development (OECD) surveys 15-year-olds across the world in the Program for International Student Assessment (PISA). The 2015 survey included over half a million students in 72 participating countries, creating a baseline of STEM proficiency on a global scale

On a regional scale, Asia outperformed other continents, containing three of the top five nations in science proficiency, and all five of the top five nations in mathematics proficiency

On the other end of the spectrum, 46 percent of students surveyed scored an average of Level 2 or below on mathematics and in science. Of these, about 25 percent scored a Level 1 in science and over 30 percent scored a Level 1 in mathematics.

Postsecondary Degrees in STEM

The U.S. awarded only 6 percent of all STEM degrees awarded globally in 2016—approximately 568,000.



Source: World Economic Forum.

China produced eight times as many — 4.7 million — and more than half of all STEM graduates in 2016, followed by India (28 percent). Taking national population into account, Iran produced the greatest number of STEM graduates per capita (1:238), followed by Russia (1:258), and China (1:294). For comparison, the U.S. STEM graduate rate per capita landed at 1:569.

Emerging Jobs

According to Pew Research, U.S. STEM employment has grown 79 percent since 1990. The Bureau of Labor Statistics tracked a 10.5 percent increase in employment (approximately 800,000 jobs) across all U.S. STEM occupations between May 2009 and May 2015. U.S. STEM employment in May 2015 reached 8.6 million, accounting for 6.2 percent of total U.S. employment. The Bureau of Labor statistics predicts 2.6 million U.S. STEM job openings between 2014 and 2024, with the most dramatic growth projected in mathematical science occupations.

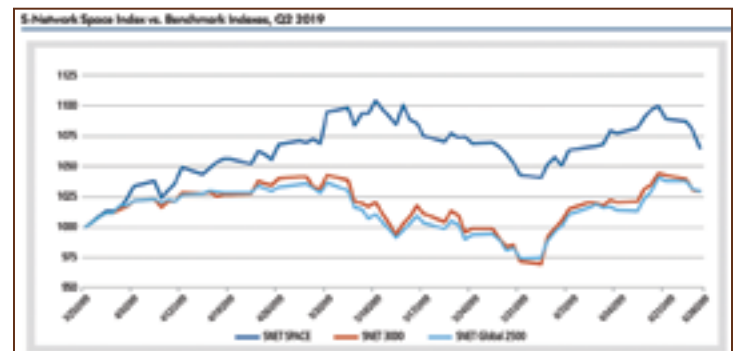
- With the sub-baccalaureate workers included, STEM jobs represent 20 percent of all U.S. jobs. By this metric, as many as 26 million jobs in the United States require significant STEM knowledge and skills in at least one STEM-related field.
- A 2014 Business RoundTable survey projected that during the next five years, major American companies will need to add a total of nearly 1.6 million employees to their workforce: 945,000 who possess basic STEM literacy and 635,000 who demonstrate advanced STEM knowledge.

- One in three workers ages 25 and older that have at least a bachelor's degree in a STEM field of study, but only about half (52 percent) of these STEM-trained workers are employed in a STEM occupation.
- The U.S. Census Bureau even reported in 2014 that 74 percent of those who have a bachelor's degree in a STEM major are not employed in STEM occupations.

S-Network Space Indexsm

The S-Network Space Indexsm tracks a global portfolio of publicly traded companies that are active in space-related businesses and compares their performance against two other indexes. The S-Network 3000 tracks the 3,000 largest U.S. stocks by market capitalization, and the SNET Global 2500 tracks a combination of the 1,000 largest U.S. stocks, 500 largest European stocks, 500 largest Pacific basin stocks (developed), and the 500 largest liquid Emerging Market stocks.

In Q2 2019, the 30 space companies the met the financial requirements for inclusion in the Space Index significantly outperformed the S-Network US Equity 3000 Index (SNET 3000) and the S-Network Global 2500 Index (SNET Global 2500).



Note: Performance shown for each index is for the gross total return, assuming all dividends are reinvested.

Report Purchasing Options

The Space Report serves as a resource for government and business leaders, educators, financial analysts, students, and space-related businesses. For more than a decade, *The Space Report* has chronicled the growth of the space community from around the world.

The Space Foundation's Research & Analysis team produces *The Space Report*, and earlier this year transitioned its annual summary into quarterly updates of global space activity. This new format makes it possible to provide the most up-to-date information on space infrastructure, facilities, launches, and programs. Similar to other major economy-measuring indicators that inform our awareness of what is happening around the world, the quarterly installments of *The Space Report* are designed to improve our discussions and understanding of the reach, impact, and health of the space community.

To purchase *The Space Report* 2019, or to subscribe to *The Space Report Online*, go to thespacereport.org/pricing.

For more information about the availability, pricing, and delivery of *The Space Report*, please contact TheSpaceReport@SpaceFoundation.org.

For questions related to *The Space Report* content, or the space industry in general, or a request for customized research by the organization's Research & Analysis team, please contact Research@SpaceFoundation.org.

