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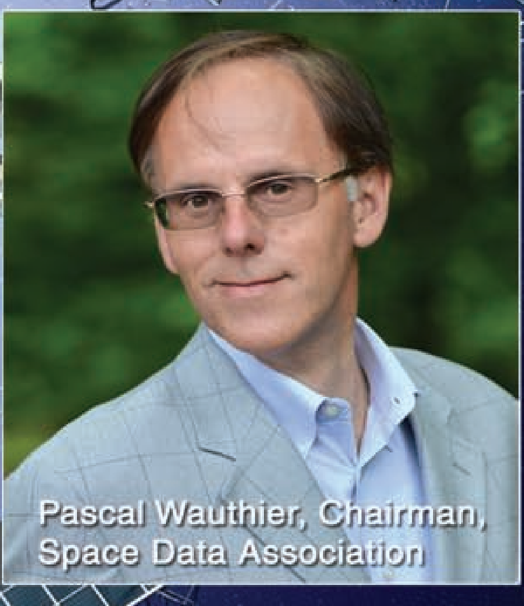

Pascal Wauthier, Chairman, Space Data Association


We have taken Summit to new heights

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Front cover photo courtesy of Space Data Association

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Teledyne CCD image sensors integrated into remote sensing instruments on board NASA's Mars Rover Perseverance

Teledyne e2v has provided its CCD42-10 image sensor to drive two of the instruments, SuperCam and SHERLOC, on board NASA's Mars Rover Perseverance.

The Mars 2020 mission is part of a long-term effort of robotic exploration of the Red Planet. The 2020 mission addresses high-priority science goals including questions about the potential for life on Mars. The mission will look for signs of past microbial life itself.

The mission also provides opportunities to gather knowledge and demonstrate technologies that address the challenges of future human expeditions to Mars. These include testing a method for producing oxygen from the Martian atmosphere, identifying other resources (such as subsurface water), improving landing techniques, and characterizing weather, dust, and other potential environmental conditions that could affect future astronauts living and working on Mars.

Teledyne's CCD42-10 sensor has proven its worth for the task, performing a similar role on Mars since 2012 within the ChemCam instrument onboard NASA's Curiosity Rover. The SuperCam and SHERLOC instruments of Perseverance will advance this capability and be used to search for organic compounds and minerals, looking to see if they have been altered by watery environments, proving signs of past microbial life on the Red Planet.

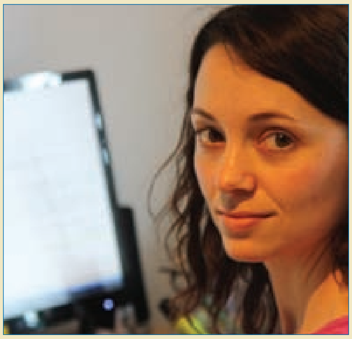
This version of the CCD42 family of CCD sensors has a full frame architecture. Back illumination technology, in combination with an extremely low noise amplifier, make the device well-suited to the most demanding applications, including spectroscopy as performed by the SuperCam and SHERLOC instruments on the Mars 2020 Perseverance Rover.

In addition to SuperCam and SHERLOC, Teledyne DALSA's Bromont semiconductor foundry built the JPL-designed CCD image sensor that powers SkyCam, part of the Mars Environmental Dynamics Analyzer (MEDA), a meteorological suite for the Mars 2020 rover.

Building on technology from the previous Curiosity rover, SkyCam is one of the Radiation and Dust Sensor (RDS) instruments that will monitor sky brightness over time in a variety of wavelengths and geometries in order to characterize Martian dust and the solar and thermal radiation environment. SkyCam will image the sky at varying times as part of the dust study, for cloud tracking, and for astronomical imaging.

In yet another Teledyne connection, all of the electricity needed to operate these sensors and everything else on the Perseverance rover is provided by a power system called a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) developed by Teledyne Energy Systems, Maryland, US.

EDITOR'S VIEW



The best laid plans

Welcome to the second issue, and a Technologies Special Issue at that, of Satellite Evolution Americas! When we were planning this issue back at the start of the year, we had in mind that its release would coincide with the SmallSat 2020 conference, making a technology/small satellite theme especially appropriate.

Of course, even the best laid plans go awry… The full extent of the COVID-19 pandemic had yet to be revealed, but now it looks like this will go on far longer than anyone expected. This 'new normal,' first expected to last a few months only, may actually become a very real new normal, with no vaccine on the horizon and no end in sight. Indeed, a significant number of people believe that we'll be living like this for years – working from home, attending events virtually, seeing loved ones at a distance. It makes for sad reading, further bolstered by the discovery of a new type of Swine Flu (G4) in China which also has the potential to trigger a new global pandemic. A reported 10 percent of industry workers are already infected, although there's no evidence of human to human infection at the time of writing.

Happily, SmallSat 2020 is going ahead virtually, with registration free of charge. Accordingly, in this special issue, we take a look at current projects and developments within the launch sector, small satellites, and the antennas used to communicate with them. The International Telecommunication Union (ITU) reports on the use of satellite communications to bridge the digital divide in small island developing states, while the Space Data Association (SDA) outlines the satellite industry's changing attitude towards space situational awareness (SSA). Exclusive interviews with technology specialists Mission Microwave and Comtech Xicom round out the issue.

We hope you enjoy the issue and stay positive in the months to come!

Photo courtesy of Shutterstock ●●●

Sateliot allies with Danish Gatehouse to its LEO nano-satellites to offer a global 5G connection

Sateliot, the first satellite telecommunications operator to provide continuous global connectivity to the Internet of Things (IoT) universe under a 5G architecture, has sealed an agreement with the Danish Gatehouse Group to develop the world's first NB-IoT network, which will enable it to offer global 5G connectivity once its LEO nanosatellite constellation is deployed.

This agreement with Gatehouse, one of the most experienced companies in the development of satellite communication systems, is part of the 4.6 million investment plan in R&D of Sateliot and is one of the three projects that the Spanish company will carry out in the next two years.

Specifically, this work will consist of adapting the NB-IoT Slack Protocol and the NB-IoT waveform so that IoT terminals can be connected to Sateliot's LEO satellite network whenever they do not have land coverage or are deployed in areas where there is no classic mobile communication infrastructure, such as remote regions of the Arctic or the Australian outback, for example.

Within this framework, both companies will develop a 'laboratory environment' where they will simulate the connection using configurable hardware and test the commercial Sateliot services that are expected to start operating in the third quarter of 2022.

Sateliot's research and work with Gatehouse will contribute to the implementation of the 5G NB-IoT international standard for small and low altitude satellite networks promoted by the 3GPP association, responsible for the 3G/4G and 5G standard, of which Sateliot is an active member. This innovative standard will also be patentable for Sateliot's exclusive use.

Nevertheless, and according to these implementations and developments, the company will deploy from the last part of the year a constellation composed of up to 100 of these devices.

With the size of a microwave, they will orbit some 500km from the Earth, rising as telecommunications towers from space that will provide an extension of coverage to traditional operators so that they can connect objects anywhere terrestrial networks do not reach.

For Michael Bondo Andersen, CEO of Gatehouse, "Considering the potential of the New Space or data as 2.7 million IOT devices are connected today through satellites, it is necessary to develop a solution that moves the NB-IOT protocols into space".

According to Marco Guadalupi, technical director of Sateliot, "Our agreement with Gatehouse is strategic and fundamental for the implementation of our services. And a differentiating step since it will allow us to put our expertise in the main organizations of the sector of which we are members such as 3GPP, GSMA, ETSI or 5G IA."

Staying at the cutting edge

Comtech Xicom Technology is a Silicon Valley based division of Comtech Telecommunications Corp leading the global satcom amplifier industry across commercial and military markets. Vice President of Business Development, Heidi Thelander talks about some of the company's most exciting new technologies and business strategies which have ensured success, and how Comtech Xicom will stay at the cutting edge in the world of tomorrow.

Laurence Russell, News & Social Editor, Satellite Evolution Group

Heidi Thelander, Vice President of Business Development, Comtech Xicom Technology

Question: What makes Comtech Xicom's BUCs and SSPAs unique? Who are the target customers?

Heidi Thelander: Xicom's emphasis for our Block Upconverters (BUCs) and Solid State Power Amplifiers (SSPAs) is in attaining high-performance while also prioritising a very compact, rugged, and efficient design.

The new lines we've been promoting include the Bobcats, which are small but powerful. These address the compact, mobile and man-portable terminals where weight really matters. The Ka and Ku-band models weigh in at about 4.5lb, while the X-band models are 5.3lb, boasting a lot of power for their weight.

We also have the larger Pumas which are higher power-density, AC-powered amplifiers or BUCs intended to be part of a compact terminal. The higher-powered models at the 100W linear and up level are more for fixed and transportable case-based platforms. They range from 20-50 lb depending on the power level and are available in X, Ku, or Ka-bands. They also feature built-in redundancy switching to support high availability satcom links.

Bobcats, which are small but powerful. These address the compact, mobile and man-portable terminals where weight really matters.

The Bobcat and Pumas are both optimised for commercial and military customers that are prioritising size, weight, and power (SWaP) to speed up their links.

In addition, we've introduced the Falcon Ka and Ku-band systems which are in-cabin airborne products providing satellite communications from an aircraft for inflight communications for a variety of sectors. These units are DO-160 certified for commercial aviation, and we started shipping the Ku-band Falcon several years ago. We now have it in an Aeronautical Radio, Incorporated (ARINC) form factor.

We've received great feedback across all these models, and we're extending our capacity to serve demand including high-quality technology capable of working with MEO/LEO applications.

Our team has also shown remarkable ingenuity in customising products. We have the capability to do almost any Ka-band frequency translation that a customer needs. For instance, we've delivered a 27.5-30GHz tri-band switchable BUC with overlapping bands which handles all the calibrations and supports Inmarsat's Open BMIP standard. Whatever your frequency scheme within Ka-band, we can support it with conversion.

Question: Comtech Xicom is the world leader in millimetre **wave Traveling Wave Tube Amplifiers (TWTAs). How did Comtech Xicom assume that edge?**

Heidi Thelander: What's really giving us the edge in millimetre wave TWTAs is twofold. We committed fully to millimetre wave; every one of our test sets works up to 50GHz and we are increasing from there. And we've been on the cutting edge in increasing both power level and frequency at every chance with TWTAs.

We were the first to have the Ka-band 250W, the first to

ship the Ka-band 500W, the industry leader in Q-band, and the first to develop a 250W Q/V-band, so we've always been pushing the envelope. We're also ready to deliver our technology in high volume when needed.

Question: How would you describe the competitive landscape for faster delivery?

Heidi Thelander: Fast delivery can be challenging but is easier if you communicate well with your customers to know what's coming. Maybe you need items with a long lead time, or models which we don't sell very frequently.

For the most common commercial products, we're able to get lead times down by understanding the market and maintaining strong communication with customers to forecast demand accurately. We certainly devote resources to getting our delivery times down and offering quick delivery where possible.

Question: You've recently made strategic investments to see quality and reliability increased across your product line. What did that entail, and did it pay off?

Heidi Thelander: I would say it's more than a set of investments and more of an effort to adapt our own internal culture. One of the things Mark Schmeichel, Xicom's President, likes to say is that "nothing is below the radar."

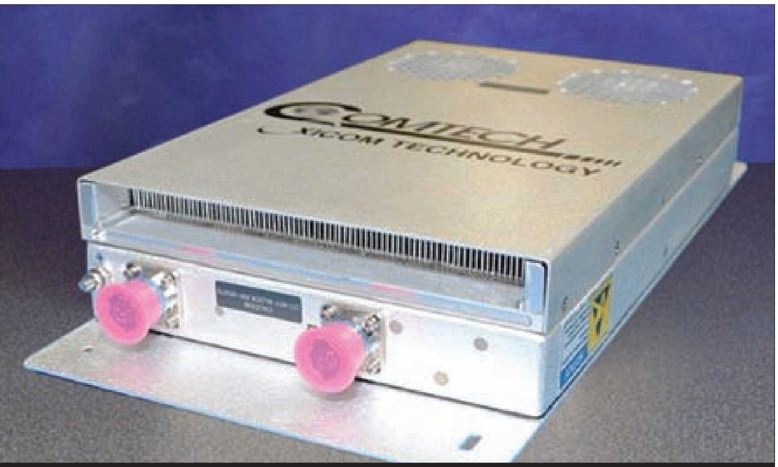
We've gone to a quality and reliability model where every single failure is addressed, even if it seems like a one-time affair, including things at very early stages, during manufacture.

In addition, we've implemented a lot of screening processes, taking us to an Aerospace Basic Quality System Standard (AS9000) quality level, which was driven by our airborne activity but spread across our entire manufacturing group. Ultimately that drove up the quality of all our products.

Question: How do your products compare with others in our industry?

Heidi Thelander: The new Bobcats are industry-leading in size and weight, and also in efficiency, which is why so many integrators are requesting quotes on these.

On the Puma side, we're even more feature-rich. There are people out there producing similar power levels, or comparable size and weight, but a lot of them are barebones.



Falcon Ka-band system

"Fast delivery can be challenging but is easier if you communicate well with your customers to know what's coming. Maybe you need items with a long lead time, or models which we don't sell very frequently."

The Pumas support a wide range of systems, including redundant and power combined, such as our proprietary Variable Phase Combined (VPC) system that offers soft-fail and hot-swapping at a very reasonable cost.

We have a lot of experience working with integrators of these larger systems from our TWTA products, which has all gone into our process in designing the new higher power SSPA products. Competitors experienced in SSPAs who started using Gallium nitride (GaN) to get to higher power levels don't have the same experience with the more complex larger terminals that we have.

We also have specific expertise in X-band in reducing and eliminating leakage, which is extremely important for multi-carrier terminals. Any leakage from the units can result in problems when they're amplified by the antennas. That's always been a hard problem, but we've developed a series of techniques in manufacture and design that reduce and eliminate a lot of leakage, which has eliminated that particular problem.

Question: What are some of the new developments in your multi-amp redundancy systems and controllers?

Heidi Thelander: One of the developments with our multi-amp systems is the Continuous-Phase System (CPS), where we're combining the outputs of multiple amplifiers that all normally operate below their maximum linear power level so that if you have a unit go out, the system automatically increases the remaining units power levels to make up for the loss in output power form the failed unit, over a very short transition period.

So, you're buying a little bit more power than you need, but you don't need redundancy switching, you're just running economically in a safer method. It's like an alternative to those big racks which have high maintenance costs, which often require replacement modules every month.

This is more for highly reliable amplifiers, in which you get to keep operating at your desired linear power level with just a short drop in the case of a unit shutdown. That's pretty appealing for some of the larger ground stations where availability is everything. Usually, you can mount this system right up on the hub of an antenna, which allows you to buy a lower power amplifier by eliminating a long cable run from a rackmount location. For those reasons and more we think this solution is very competitive.

We've also developed liquid-cooled systems. We've had quite a few customers wanting liquid-cooled amplifiers for various reasons, including reduced acoustic noise, elimination of high-maintenance hub-mount air conditioners, and improved long-term performance and lifetime. Some of the locations where our amplifiers are installed are in urban environments where this is a huge issue. Liquid cooling eliminates the need for fans, which can be a major source of acoustic noise.

Another advantage to liquid-cooling over air-cooled is that air-cooled amplifiers in antenna hubs usually require air

"But we also see demand in the future for V-band LEO systems for some of their links. That's a little bit further out, and it'll take some time for the cost structure to adapt as volume and costs stabilise to the point where it makes sense to invest in them, but we do see it as an eventuality. It'll be just like the way the Ka-band transitioned from use in the first military satellites to the commercialisation point."

conditioners which are typically your number one maintenance item. If you can get rid of that, you can make it a lot easier to maintain overall, and therefore reduce operating costs. There's also the matter of tight temperature control provided by liquid-cooling which reduces variation in output power and gain and can extend the life of the amplifier. The benefits are quite numerous.

Question: Where do you see the future or Q-band and V-band going?

Heidi Thelander: We're really excited about Q and V-band. People look at it different ways; there's phase one, which is sort of a replacement for Ka-band feeder links, which is the most urgent application and what's being addressed first. We think that's going to generate plenty of additional business for V-band amplifiers.

But we also see demand in the future for V-band LEO systems for some of their links. That's a little bit further out, and it'll take some time for the cost structure to adapt as volume and costs stabilise to the point where it makes sense to invest in them, but we do see it as an eventuality. It'll be just like the way the Ka-band transitioned from use in the first military satellites to the commercialisation point.

Larger Pumas which are higher power-density, AC-powered amplifiers or BUCs intended to be part of a compact terminal

Comtech is right there at the forefront with all the millimetre wave products. We have the first V-band 250W peak TWTA shipped last year and which we're continuing to supply. We're going to continue innovating with higher power, lower power, and solid-state technology.

So, we're well aware of what is happening with this technology, and we're working hard to stay at the forefront of an exciting new market

A few customers want liquid-cooled amplifiers for certain applications

Next generation antennas for NGSO satellites

With small satellite constellations becoming increasingly commonplace, the terrestrial antennas used to track these 'fast-moving' NGSO satellites are coming under increasing scrutiny. Innovative new designs far removed from traditional parabolic antennas and VSATs are coming to fruition.

Amy Saunders, Editor, Satellite Evolution Group

We're halfway through 2020, the year of the small satellite constellation. With new small satellites being launched in abundance despite the ongoing coronavirus pandemic, a massive influx of new capacity will soon be upon us. Whether bridging the digital divide with low-latency high-speed Internets services or enabling massive Internet of Things (IoT) networks across the globe, antenna technology is well and truly in the forefront of peoples' minds.

While a good number of ground segment companies have already exampled the use of traditional parabolic antennas and VSATs, which have been proven to track 'fast-moving' satellites in medium Earth orbit (MEO and low Earth orbit (LEO) entirely satisfactorily, several innovative companies are looking beyond existing technologies to produce a more agile, streamlined antenna product capable of performing the same function with additional size, weight and (in some cases) power (SWaP) advantages, among others.

Amidst the non-geostationary orbit (NGSO) satellite boom, newcomer and existing antenna companies are further exploring phased array and meta material designs to track any and all satellites in orbit. Such manufacturers purport that these electronically steered antennas (ESAs) will be able to better track NGSO satellites, which move faster across the sky in relation to Earth, as well as achieving more seamless switching rates between satellites when compared with mechanically steered antennas.

It's true that ESAs will, by and large, be smaller and more discreet, and thus more easily fitted to mobile sites such as aircraft, trains, buses and cars. They also hold the advantage that, being electronically rather than mechanically steered, there is less wear and tear and therefore more inherent durability. However, naysayers have highlighted that ESAs are (for the most part) much more expensive and consume much greater amounts of power. Questions have also been raised as to whether they're suitable for all mobility applications, particularly onboard maritime vessels which are prone to rolling and pitching. Finally, there's also some uncertainty whether the current wave of innovative ESAs will be launched in time to be widely utilised for the upcoming NGSO constellations. Nevertheless, with NGSO booming, several ground segment equipment suppliers are exploring innovative new technologies with phased array and meta materials technologies. NSR expects cumulative revenues from flat panel antenna sales to reach US$12 billion by 2029, with mobile applications, particularly government and commercial aviation, to drive opportunity, accounting for 98 percent of the market value over the next decade.

Steve Collar, CEO, SES and Isotropic Systems CEO - John Finney with new terminal designed for SES O3b mPOWER

Kymeta launches u8 ESA

Arguably the world's best-known flat panel ESA entity, Kymeta is working towards unlocking the potential of satellite connectivity combined with cellular networks to meet booming demand for mobile connectivity. The company's u7 flat panel ESA is the first commercially available product of its kind, which, when combined with the Kymeta Connect connectivity services, is delivering revolutionary mobile connectivity across the globe to land-mobile, aeronautical and maritime end users. Kymeta is also working with LEO satellite operators on technology and service collaborations.

March saw the latest addition to Kymeta's product line with the commercial launch of its next generation flat panel ESA, the Kymeta u8. The Kymeta u8 is the world's only commercially available flat panel electronically steered antenna built specifically for mobility and designed for the needs of both military and commercial customers. The Kymeta u8 antenna enables complete coverage of the Ku-band with highly reliable electronic beam steering and no moving parts. It is available as an antenna, as a terminal, or in flyaway configurations.


MISSION
MICROWAVE
Efficient, Compact and Reliable GaN BUCs
X, Ku and Ka-Band 12-400 Watts
STINGER
JAVELIN
TITAN
25 W Ka-Band
50/100 W Ka-Band
200 W Ka-Band
55 W Ku-Band
100/125 W Ku-Band
200 W Ku-Band
50/80/100 W X-Band
150 W X-Band
The New Shape of Solid State

Kymeta has amassed a significant number of partnerships, including with; Türksat to bring connectivity solutions for Türksat's voice, data, Internet, TV and radio broadcasting customers; Intelsat, Cubic Telecom and Cradlepoint for the delivery of the SmartBus project, connectivity on board TEPSA's bus line in Peru; Viasat's government-focused terminal modification kit programme enabling Kymeta's u7 terminals to interoperate with Viasat's satcom networks; the City of Redmond for a full-scale emergency management exercise designed to assess disaster response and recovery preparedness, dubbed Cascadia Rising Solutions.

Most recently in March, Kymeta teamed up with Cubic Telecom to bring a hybrid satellite-cellular package combining LTE and satellite delivering secure, hyper-efficient, and highly-optimized connectivity to industries such as the military, emergency response, transportation, recreational and overland adventure vehicles. The network connectivity occurs seamlessly to ensure that users remain connected anywhere in the world, even at sea, in the midst of a mountain rescue, or in the middle of a desert. Kymeta's network software leverages the best of satellite and cellular networks to deliver cost savings and increased reliability to the user.

Photo courtesy of Shutterstock ●●●

Phasor readies for commercialisation

Another major player in the GEO and NGSO satellite antenna segment is Phasor, which is developing high throughput digital phased array electronically steerable antennas (ESAs) based on patented dynamic beam-forming technologies and system architecture. The company is focusing on enabling high bandwidth communications-on-the-move for maritime, aeronautical, and land-mobile end users faster, cheaper, more reliable, and available anywhere. This innovative technology enables incredible connectivity from an extremely small form

March saw the latest addition to Kymeta's product line with the commercial launch of its next generation flat panel ESA, the Kymeta u8 ●●●

factor, while the use of electronic phased array technology allows beam direction to be controlled instantaneously in any direction, making it ideally suited to 'fast-moving' satellites in MEO and LEO.

On June 5th, 2020, Hanwha Systems (HSC) acquired the business and assets of Phasor Solutions, the UK-based satellite communication antenna developer. Hanwha Systems is Korea's No. 1 MFR technology company developing high tech communications and radar technologies, and it is planning to enter into the satellite communication antenna business, through its acquisition of Phasor.

Hanwha Systems and Phasor are committed to developing and launching market leading ESAs to serve the broadband mobility, satellite communications, IoT and Non-Geosynchronous Satellite Operator (NGSO) markets.

Isotropic Systems cracks the code on next-gen connectivity

Relative newcomer Isotropic Systems is already having a major impact on the connectivity world with the world's first multi-beam, high-bandwidth and low power, fully-integrated high throughput terminal, and an end goal of enabling the satellite industry to break through to new markets. Isotropic Systems' terminals feature patented beamforming lens technologies that provide the high throughput ground infrastructure required to unleash the full potential and capacity from multi-orbit constellations in GEO, LEO and MEO. That ability to leverage capacity across multiple orbits and bands is exactly what government, defence, aero, maritime and telco markets need to meet the burgeoning and evolving demand for high-powered connectivity.

"Hanwha Systems and Phasor are committed to developing and launching market leading ESAs to serve the broadband mobility, satellite communications, IoT and Non-Geosynchronous Satellite Operator (NGSO) markets."

Isotropic's unique antennas, which are flexible and customisable to meet specific performance, cost and power consumption requirements, have garnered serious interest and contracts in the discerning defence market. The company announced a major antenna evaluation and development contract with the Defence Innovation Unit (DIU) of the US Department of Defence to test the ability of its multi-beam antennas aboard next-gen Navy ships at sea. The DIU is reviewing Isotropic's antennas and circuits as an enabler to fuse multi-band, multi-orbit commercial and military capacity to deliver intelligence data at the tactical edge over a single platform. "This is essentially the holy grail – the ability to arbitrage commercial and military capacity across multiple orbits and bands to enable a whole new level of connectivity," explained John Finney, Isotropic Systems CEO. "We've cracked the code for next-gen connectivity capabilities that government and commercial engineers have tried to solve for years."

March saw the latest development stage of Isotropic's partnership with SES – first announced in 2018 with the goal

Isotropic Systems terminal featuring optical beamforming modules. Photo courtesy of Isotropic of producing scalable, cost-effective multi-beam terminals for the O3b mPOWER constellation – which will see the teams review, refine and test key components of the full line of customised digital software-defined terminals throughout the rest of this year. Isotropic Systems' terminals are set to be commercially available late next year, as the SES O3b mPOWER constellation satellites are due for launch.

Isotropic also announced that it is licensing patented core components of its antennas to leading aeronautical and defence system integrators in order to accelerate customised designs, certifications and deployments of its terminals across commercial, business and government aircraft around the world. Isotropic's flexible platform conforms to the fuselage or radome for a tailored terminal and is fully customisable to the size of the aircraft.

Aeronautical and defence system integrators that license Isotropic's technologies will be working towards the integration of patented lens modules and chipsets into their terminal platforms throughout the year, with trials expected in the first half of 2021 and a commercial launch timeframe of 2021-2022.

C-COM Satellite Systems anticipates successful tests in coming months

C-COM Satellites Systems Inc., a pioneer in mobile satellite antenna systems, has made a world-renowned name for itself and its long history of providing innovative products for a wide variety of satellite applications. The company successfully used its iNetVu antennas last year to track small satellites in LEO in partnership with Kepler Communications and NSLComm.

Now, in partnership with a research team at the University of Waterloo's Centre for Intelligent Antenna and Radio Systems (CIARS), C-COM has been developing a next generation Ka-band flat panel antennas based on phased array technology for enabling high-throughput mobility applications over satellite: Land, airborne and maritime. The company is aiming to open up tracking capabilities for the new generation of small satellite constellations and High-Altitude Platform Stations (HAPS) with its new modular conformal design antenna. The lightweight solution is expected to begin trials this year to test its LEO tracking capabilities, with a working product expected to be available as early as next year.

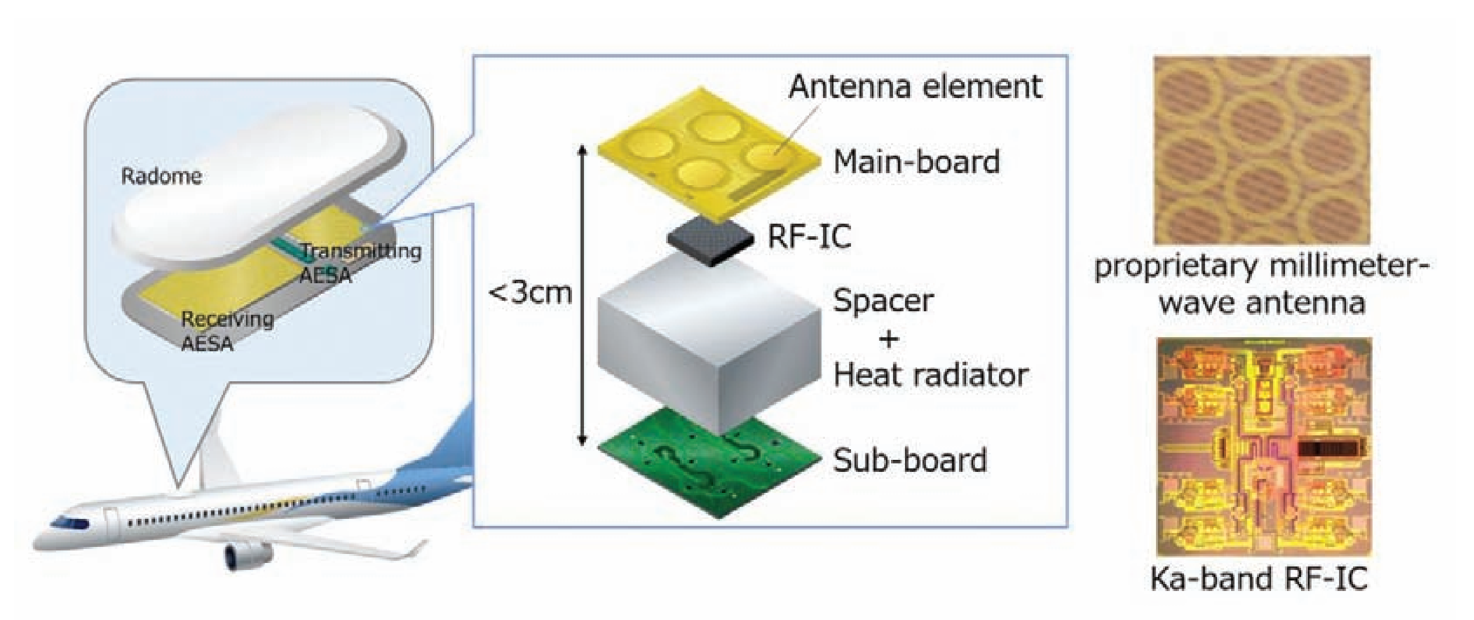
C-COM has been granted two patents for its phased array antenna technology, the most recent in 2019 for its invention of a phased array antenna calibration method and apparatus. A unique process for calibration of a phased array antenna is used to adjust internal phase shifters and amplifiers, making it possible to recalibrate the antenna on-the-fly, potentially mitigating service interruptions.

Mitsubishi Electric Corporation announces first AESA

Mitsubishi Electric Corporation, a longstanding player in the global satellite and space sectors offering SSPAs and VSATs in the ground segment, has also entered the field.

Back in February, Mitsubishi Electric announced that, in collaboration with Japan's National Institute of Information and Communications Technology (NICT), it had developed technology for an extra-thin Ka-band active electronically steered array antenna (AESA) featuring the world's thinnest profile at less than 3cm, to deliver high-speed inflight connectivity services at data rates beyond 100Mbps. The company also announced that it had developed the antenna elements and, in collaboration with Tohoku University and Tohoku MicroTec Co., developed a radio-frequency integrated circuit (RF-IC) for an envisioned millimetre-wave V-band AESA that will be capable of delivering inflight connectivity at even faster speeds.

Mitsubishi Electric's Ka-band AESA is thin and small enough to be installed in any current aircraft and it can operate even at high latitudes, which will allow passengers to enjoy on-demand streaming and other high-speed Internet services on flights worldwide. Following further testing and demonstrations, the company plans to commercialize its Ka-band AESA after 2023 and a V-band AESA after 2027.



Mitsubishi Electric's Ka-band AESA is thin and small enough to be installed in any current aircraft and it can operate even at high latitudes. Image courtesy of Mitsubishi Electric

Ka family - Titan, Javelin and Stinger. Photo courtesy of Mission Microwave

Tactical customer base

Mission Microwave is a satcom component developer specialising in Solid-State Power Amplifiers (SSPAs) and Block Up Converters (BUCs) based on Gallium Nitride (GaN) semiconductors supplying high-performance high-reliability products to military, mobility and mission critical SATCOM terminal customers. Following their recent successes and future investments, we caught up with Steve Richeson, VP Sales & Marketing, to recap the company's efforts and speculate on their future.

Laurence Russell, News & Social Editor, Satellite Evolution Group

Question: Could you share some milestones you've achieved over the past year?

Steve Richeson: We've made some further advances with our tactical customer base. As of a year ago, we had established a reputation in the tactical terminal market that was such that antenna and terminal providers in that market had to be able to explain to their customers why they *weren't* using Mission Microwave technology.

The awareness we'd earned as an obvious category leader with the end-users meant that they weren't interested in using anything less than our hardware. We're willing to claim victory in the terminal BUCs market now because of that success which was led by our customers delivering better terminals to end-users.

One other milestone that we announced at Satellite 2020 is the release of our new high-power, 400W Ka-band gateway amplifier.

We've also seen a few major customer wins recently, such as Envistacom, besides a few other large public companies we can't speak about.

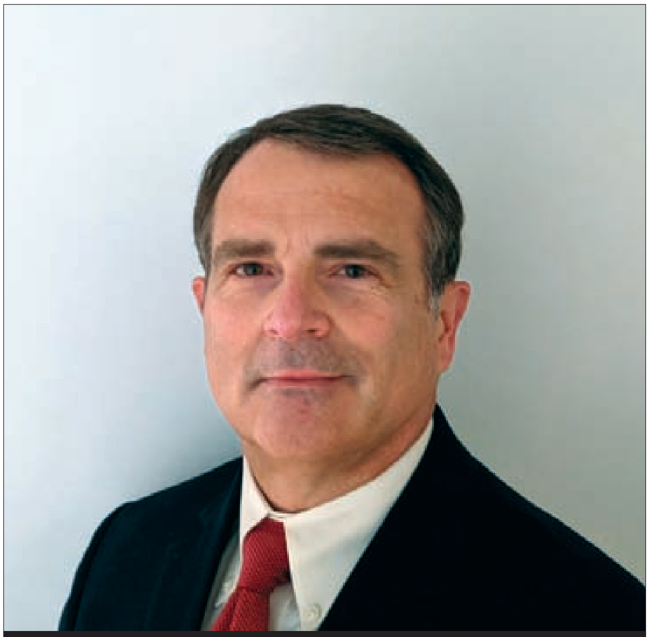
We've seen some fairly steep revenue growth for the company, which is always a challenge to keep up with, and so far we've been able to do that.

Question: You've delivered for Intellian by optimising their Ka-band terminals for high throughput satellite (HTS) and LEO applications. How are you continuing to innovate in the world of satcom terminals?

Steve Richeson: Intellian was really instrumental in learning what was required to bring wideband products to market, which we achieved through communication with their customer base.

They would work with geosynchronous and medium Earth orbit (MEO) satellites, as well as the new LEO constellations. Intellian was a leader in innovation there, and they relied on us to be able to create the wideband BUCs to be able to support that range.

What's next is a continuation of that arrangement, with



Steve Richeson, VP Sales & Marketing, Mission Microwave

greater flexibility and optimised control interfaces for unique applications – particularly in the maritime industry. We also want to extend the power range that the wideband product offers.

We went up to 400W recently, but we've yet to extend provision down to the lower end because lower-end customers are more likely to need purpose-built terminals as opposed to combination platforms that can switch between LEO/MEO/GEO which are really appropriate for large maritime stations. These combination terminals are our wheelhouse; we tend to invest in high-power high-performance technology, and that's what all the customers are clamouring for.

We're very aware of our competitive markets. Sometimes when we interact with customers in need of lower end solutions, we'll even identify the providers best suited to help them, because that's simply not us. Our technology is at the high-end of the performance and price curve, and it always will be.

Question: You've seen some noteworthy growth as a result of delivering such solid solutions. Do you think that's come about as a result of out competing rival developers, or have you been creating entirely new solutions to open new markets?

Steve Richeson: It's a mixture of both. The part that we're

"We're very aware of our competitive markets. Sometimes when we interact with customers in need of lower end solutions, we'll even identify the providers best suited to help them, because that's simply not us."

happiest about is the new segments. Of course, the incumbents in the industry see us as a threat because we are certainly claiming more of the share.

We're offering a superior product, which has broken up some old relationships as buyers have moved over to us. It's not that dramatic of a transition, but we've absolutely eroded share from our competitors.

But as I said, the growth that we're most excited about is in the new categories in our work with wideband and multi-constellation technology. An example would be some of the disruptive terminal developers like Get SAT. We're an enabler for those kinds of designs.

That hardware is a new category. Small, flexible, high-performance terminals that work exceptionally well with high throughput satellites (HTS). Both these technologies and the satellites they talk to are a still emerging revolution creeping onto the market, and the uniquely high-power BUCs or amplifiers they need to be fit into a very small form factor to suit their builds are something we've consistently been able to provide.

Mission Microwave's 400 Watt Ka-Band MOAB SSPA/BUC. Photo courtesy of Mission Microwave

A few years ago a 25W Ka-band amplifier would be the size of a briefcase and weighed 30lb. Our work has allowed us to produce better hardware at a smaller size to allow for entirely new applications, enabling a new class of mobile terminals. That's opened up entirely new markets which we're closely related to, and that we're excited about, not least because it's powering the future of satcom.

Question: Now that you're gaining ground, is there a particular application you'd like to capitalise on across mobility, maritime or airborne systems?

Steve Richeson: We see growth in all of those segments, of course, but in terms of application, maritime is demanding more and more bandwidth, with the flexibility of being able to tap into multiple constellations. Most importantly, they want higher power and better throughput wherever they can get it. We see a lot of growth there.

When it comes to specific opportunities, I believe Mission Microwave still has a generalised market focus. On the mobility side, there are certain programs in the military area of the business we're involved in that we can see growing, which includes some of America's leading defence contractors.

In the aviation space, we introduced products last year for which we have initial customers this year. Aviation is a very closed industry that doesn't require particularly heavy advertisement, but we're active in the business, and I think 2020 will be the first year where we'll be able to show substantial revenue in the aviation sphere.

Question: Your new product, the Wideband Ka Solid State Amplifier replaces the legacy 500W Traveling Wave Tube design. Could you introduce it to us?

Steve Richeson: That's a very exciting product. It'll take a little time for the industry to get used to a new normal though. The gateway side of the business across Earth stations have been asking for years now for a solid-state replacement for travelling wave tube amplifiers.

Higher power level and frequency are hard to do with any amplifier, including travelling wave tubes. They're known for their limited reliability and life expectancy, but solid-state is associated with energy efficiency and performance coupled with greater reliability. We think we can circle the square and provide a product which delivers strong results whilst maintaining strong longevity.

This product marks our entry into the gateway market, so we designed it to be a drop-in replacement for travelling wave tube amplifiers on the market now. Again, we expect this to ultimately take share, as we've already been doing, but we'd like to clarify our strategy isn't competitively driven, but rather customer driven. We've introduced this product because it's been demanded for years, and since no one answered it for so long, we decided to simply leverage our resources to deliver what was needed.

Solid-state technology in the hands of our engineers has now reached the point where we can offer not only viability for the gateway industry, but also compelling performance. I expect it'll be another 24 months for that to become a big part of our business, but we believe this is a very large potential market which is actively growing right now.

As the travelling wave tubes age out of service, which does occur relatively quickly, we could see ourselves becoming an even bigger name as our replacements find footing, potentially becoming a majority aspect of what we do in about four years.

Question: Do you have any predictions for how the world will change in the wake of the NewSpace boom we're seeing gaining steam, and if so, how does Mission Microwave fit into that new paradigm?

Steve Richeson: To voice an easy prediction, all this is going to take a lot longer than one might think. Business people enjoy terminally optimistic claims that rarely line up with any kind of reality.

It's easy to be a naysayer, of course there are some fundamental changes on the table right now, but the fact is not all of them will happen. It's just that when people in this business see growth they get pretty vocal about it, no matter how thin or fragile it is.

That said, we're a participant in this revolution. Among the universal and incumbent entities in the amplifier and BUC business, Mission Microwave is recognised and aligned with some of the most innovative customers out there. We're enabling the work being done in and around constellation and combination networks, which we're very excited to nurture.

But it's early days in the NewSpace environment. At present, it's a small part of our business, which is of course going to change. We've been growing by following the wave of new technologies and claiming market share where we can excel, but it's a mature industry with a long way to go.

Today a lot of the money in satcoms come from traditional satellites architectures, the majority of which look more or less the same as they did twenty years ago, that's just the business.

Ultimately it all comes back to our customers we're aiding in evolving to serve a new kind of industry, whatever it'll be, and we're very happy to be there.

It's early days in the NewSpace environment. Photo courtesy of Shutterstock ●●●

Connecting the unconnected

Bridging the digital divide, connecting the unconnected or underconnected – these are the hot topics of the moment. With connectivity providing essential services for health, education, finance, government and so much more, the development of satellite communications capacity for the small island developing states during natural emergencies is of the utmost importance.

Doreen Bogdan-Martin, Director, ITU Telecommunication Development Bureau

Digital skills and entrepreneurship training at the e-Rezeki training centre, Melaka, Malaysia. Photo courtesy ITU/J. Marchand

On 6th April, while most of the world was connected through advanced ICT applications and services during COVID-19, far in the South-East Pacific, on the Small Island state of Vanuatu, people in Malekula were relying on emergency telecommunications to access vital services. The South Malekula Junior Secondary School was one of the very few links that survived the devastation of Typhoon Harold, the fourth-strongest storm on record. This remote connectivity solution took years of collaborative partnership.

The 20,000-30,000 islands in the Pacific Ocean pose a challenge. The vastly-distributed remote islands, with relatively low populations, coupled with the region's constant vulnerability to natural disasters, as well as the lack of access to a stable electricity supply, means that providing reliable telecommunications infrastructure as a foundation for economic development, remains an uphill battle.

To the ordinary people - farmers, fishermen, students, etc. - ICT connectivity is critical to economic and personal wellbeing as well as to access government services during emergencies. Strategies were needed to address these challenges and implement low-cost and reliable network configurations to minimize disruptions that can be caused by both terrestrial and satellite failures, particularly when disasters strike. To realize this, ITU with its partners, Inmarsat, Intelsat, Kacific and International Telecommunications Satellite Organization (ITSO) worked with the beneficiary administrations in the Pacific islands to develop remote satellite connectivity capacity.

Photo courtesy of ITU

Previously, the satellite-based ICT Infrastructure in place in the Pacific utilized a limited number of satellite service providers and mainly used C-band and Ku-band connectivity. In 2014, following the 2011 Special Pacific ICT Ministerial Forum in Noumea-New Caledonia, ITU, along with its partners, initiated a project to develop low-cost, reliable, diverse satellite communications capacity for the socio-economic development of the Pacific islands region, utilizing un-used satellite capacity.

Each partner had a distinct contribution to the project. ITU provided over 80 units of satellite ground terminal equipment, several hybrid solar power solutions for remote sites with no electricity, and computing equipment to develop labs. The satellite providers offered free satellite bandwidth during the project period, while ITSO provided funds for training on the remote installation of the equipment. The administration prioritized connectivity of remote islands, managing national coordination, logistics and installation.

A connectivity solution

The joint effort was successful in providing a connectivity solution on a large breadth of radio spectrum giving a good mix of high speeds, proven connectivity and ease of transportability through C, Ku and Ka-band satellite connectivity equipment, even though this region faces constant rainy conditions. The connected countries are now reaping the benefits of the ICT infrastructure; and have the


Photo courtesy of ITU

peace of mind that emergency telecommunications are in place to ensure public safety when disaster strikes.

In Tonga, engineers from the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC) installed Ku-band satellite connectivity equipment at the Niuatoputapu High School. Extensive planning went into this challenging installation due to the extreme remoteness of the Island which required long journeys by boat from the main Tongatapu Island.

In Samoa, five Ku-band satellite terminals connected remote schools to develop functional computer labs which were inaugurated by the Minister of Communications and Information Technology in 2019.

In Papua New Guinea, the ICT regulator, National Information and Communications Technology Authority (NICTA), installed Ku-band terminals in rural secondary high schools, using solar-powered solutions to counter the lack of a stable electricity supply. The systems are now being used by the respective schools and surrounding communities, creating a rural e-community centre.

Typhoon Harold devastated infrastructure in Malekula Island, the second-largest island of Vanuatu. However, the satellite connectivity solution that had been installed by the Office of the Government Chief Information Officer (OGCIO) at South Malekula Junior Secondary School successfully linked the community to the rest of the country and enabled the early disaster relief operation.

It is hoped that the installed capacity in Pacific countries will continue serving the previously unconnected islands and bringing the social and economic benefits of digital transformation to the Pacific. Each country will have its own unique success story made possible by each remote e-centre.

Big plans for small satellite launches

The small satellite sector has positively boomed in recent years, with everything from single R&D CubeSats to massive tens-of-thousands-strong satellite constellations being embarked on. With so many more satellites due for launch than ever before in history, dedicated small satellite launchers are rapidly gaining in numbers and deploying some exciting new technologies.

Amy Saunders, Editor, Satellite Evolution Group

Back in the days before all we could talk about was the new plague – COVID-19 – the year 2020 was set to be a spectacular success for the satellite sector, with small satellite projects and dedicated launch companies really benefiting from the start of a fresh new decade.

Indeed, the influx of small satellite projects has created fantastic opportunities for launch providers. Existing providers have developed new launch vehicles with a much greater emphasis on rideshare capabilities, while more than a handful of start-ups have been created solely dedicated to small satellite launch technologies.

Frost & Sullivan expects a total of 20,425 satellites to be launched in 2019-2033, with high demand taking the small satellite launch market beyond US$28 billion by 2030.

"Serial production and rapid manufacturing will play a pivotal role in meeting market demands. To ensure the success of the industry, it's imperative that launch frequency, inventory and manufacturing capability are optimized," said Prachi Kawade, Research Analyst, Space, Frost & Sullivan.

Enter coronavirus

Then came the new coronavirus, COVID-19, to play havoc with the world.

NSR has reported that the satcoms sector had suffered tremendously, with a 35-50 percent decline in stock prices for SES, Intelsat, Eutelsat and ViaSat in just over one month in February. NSR believes that the overreaction by the financial markets calls into question the long-term strategy adopted by several publicly listed operators; consistently reducing contract backlog, higher commoditization and low product differentiation seems to have left investors searching for unique business cases. The impact of COVID-19 is expected to be felt through to the year end.

Similarly, the ACCESS.SPACE Alliance, which represents the small satellite sector and its stakeholders, has also expressed its concerns on the effects of the crisis for its members and the wider NewSpace ecosystem. The alliance has highlighted the following challenges:

- Cash flow constrains, lack of resources to fund operations, difficulties in accessing finance, reduction of customer orders, revenue losses and/or lack of visibility about the consequences of the crisis, with a disproportionate impact for start-ups and SMEs, which are at risk of business interruption or even bankruptcy due to the new crisis.
- Delays or difficulties in terms of workforce availability, supply chain disruptions, manufacturing, launches, with sometimes risks of financial penalties.
- Delays in research, development, and innovation (RD&I) projects and operational problems to join, participate or continue such projects.
- Delays or difficulties in terms of networking, contract acquisition and business development due to restrictions in terms of mobility, flight cancellations, travel restrictions and prohibitions of conferences and other events.

Rocket Lab's 10th launch. Photo courtesy of Sam Toms

While the business environment remains uncertain, ACCESS.SPACE has reported that global telecommunications networks have been facing unprecedented strain leading to data speed disruption and service level degradation at a time when connectivity is critical to keep the economy running, inform and educate the public and coordinate the battle against the virus. The risk of major outages, whether by congestion or unavailability of workforce or spare parts, is growing, calling for more disaster-resilient communication networks.

Satellite-based communication networks are of course largely independent from terrestrial infrastructure and should play a greater role in disaster communication strategies supporting mitigation, preparedness, response, and recovery. You'd think this fact would play in favour of satellite operators, however, market uncertainties have seen the downfall of many entities since COVID-19 hit the streets, not the least of which includes OneWeb, which earlier in the year cut many jobs and faced bankruptcy. The latest reports indicate that a new consortium of private investors, as well as £400 million from the UK Governments, will enable OneWeb to continue operations. Nonetheless, the dedicated small satellite launch sector marches on. How many players will be left standing by the end of the COVID-19 outbreak remains open for bets, however, we can be assured that we won't lose everyone.

Rocket Lab opens Launch Complex 2 for business

Rocket Lab remains one of the few dedicated small satellite launch providers already successfully completing launch campaigns today.

In addition, the company has also developed its own in-house small satellite platform, the Photon, meaning that the company now offers an all-inclusive spacecraft build and launch service.

Rocket Lab's Electron vehicle features two stages – the first is powered by nine Rutherford engines (the first oxygen/kerosene engine to use 3D printing for all primary components), and a second stage featuring one Rutherford engine variant – and an optional apogee kick stage that can execute multiple burns for different orbit placements powered by the company's 3D printed liquid propellant Curie engine. The Electron vehicle, comprising carbon composite materials affording impressive weight savings, can lift a 225kg payload into SSO. Rocket Lab is also presently exploring the reusability of its Electron launch vehicle.

Rocket Lab closed out 2019 with the official opening of its new US launch site, Launch Complex 2, at the Mid-Atlantic Regional Spaceport. Rocket Lab's Launch Complex 1 on the Mahia Peninsula of New Zealand had achieved 10 flights of the Electron launcher by this time, including six in 2019. Launch Complex 2 is expected to open up new markets, including government customers and national security applications, with up to 12 missions per year. Following up this news in January, Rocket Lab announced the opening of a new manufacturing site and headquarters which will bring Mission Control Centre capabilities to the new Long Beach Complex, which also hosts Launch Complex 2. Designed to produce more than 12 Electron vehicles each year and expand Rutherford engine production to more than 150 this year alone, the new complex was completed in the second quarter of the year.

In February it was announced the Rocket Lab had been selected by NASA as the 2021 launch provider for a small satellite mission to the same lunar orbit targeted for Gateway (NASA's upcoming orbiting outpost for astronauts to visit before travelling on to the Moon, part of the ARTEMIS program). The Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) is expected to be the first spacecraft to operate in a near rectilinear halo orbit around the Moon. CAPSTONE will rotate together with the Moon as it orbits the Earth, coming as close as 1,000 miles and as far as 43,500 miles from the lunar surface. Following the launch from Launch Complex 2, Rocket Lab's Photon platform will deliver CAPSTONE on a ballistic lunar transfer; the Photon's Curie propulsion system will enable the satellite to escape Earth's gravity. NASA also certified the Rocket Lab Electron launch vehicle later in March, lending further confidence in the small satellite launcher.

Meanwhile, Rocket Lab is also set to perform a dedicated launch of the first ever synthetic aperture radar (SAR) satellite, expected to optimize hotspot monitoring of key regions in the world, for Capella Space, later this year from Launch Complex 1. Part of Capella Space's Whitney constellation,

LauncherOne. Photo courtesy Virgin Orbit the new SAR satellite will maximise coverage over areas in the Middle East, Korea, Japan, Southeast Asia, Africa, and the US, delivering sub-0.5m changes on the Earth's surface.

Nanoracks rocks in-space launches

Another active dedicated small satellite launcher, and with a unique approach, is Nanoracks, which has opened up the International Space Station (ISS) for business. Launched in 2009, Nanoracks combines three key concepts in its workflow – low-cost, hardware standardisation and understanding the customer – to help launch small satellites to LEO from on board the ISS.

Nanoracks operates three distinct deployers from the ISS – as well as offering rideshare capabilities via SpaceX and India's Polar Satellite Launch Vehicle – which target CubeSats and MicroSats:

- The Nanoracks CubeSat Deployer (NRCSD) is a self-contained CubeSat deployer that mechanically and electrically isolates CubeSats from the ISS, cargo resupply vehicles, and ISS crew. The NRCSD is a rectangular tube that consists of anodized aluminium plates, base plate assembly, access panels and deployer doors. For deployment, the platform is moved outside via the Kibo Module's Airlock and slide table that allows the Japanese Experimental Module Remote Manipulator System (JEMRMS) to move the deployers to the correct orientation for the satellite release and also provides command and control to the deployers. Each NRCSD can hold six CubeSat Units – allowing it to launch 1U, 2U, 3U, 4U, 5U, and 6U CubeSats.
- The Nanoracks Kaber Microsat Deployer (Kaber) is a reusable system that provides command and control for satellite deployments from the ISS. Kaber enables Nanoracks to support the deployment of microsatellites up to about 82kg and with a 24U form factor from the JEM Airlock Slide Table. Kaber promotes ISS utilization by enabling deployment into orbit for a class of payload developers normally relying on expendable launch vehicles for space access. Microsatellites that are compatible with the Nanoracks Kaber Deployer have additional power, volume and communications resources enabling missions in LEO of more scope and sophistication.
- The External Cygnus Deployment Program is part of the first-ever program in which an ISS Commercial Resupply Vehicle is able to deploy satellites at an altitude higher than the ISS after completing its primary cargo delivery mission. Flying at 500km provides an open door for new technology development as well as an extended life for CubeSats deployed in LEO. The lifespan of CubeSat deployed from the Cygnus vehicle at 500km adds approximately two-years additional lifetime compared to Nanoracks' ISS NRCSD deployment program. Cygnus can deploy CubeSats of 36U volume, 1U-6U linear form factors.

Times must be good at Nanoracks as the company is hoping to recruit a whole host of new engineers and technicians. Back in February, the company completed its 17th CubeSat deployment mission from the ISS, which featured seven CubeSats from a variety of research and educational institutions. To date, Nanoracks has deployed 263 small satellites.

Taiwan Innovative Space (TiSpace) has ambitious plans to provide innovative and cost-effect launch services for microsatellites and nanosatellites destined for LEO and SSO

Virgin Orbit nears flight demonstration

Taking an altogether unique approach to small satellite launches is one of my personal favourites dedicated small satellite launch providers, Richard Branson's Virgin Orbit, which is on a mission to 'open space for everyone.'

Virgin Orbit launched an orbital rocket for the first time in May. Launch vehicle LauncherOne was carried into high altitude onboard the Cosmic Girl aircraft prior to successful in-air separation at around 35,000 feet; the plan, in which LauncherOne was to enter freefall for four seconds before the NewtonThree first stage engine fires up and continues on towards the target orbit, failed at this stage, with LauncherOne never reaching its target orbit.

Virgin Orbit plans to enable high frequency launches from a selection of global runways, by manufacturing 24 rockets each year from its Long Beach production facility. The company will enable full vehicle launches and rideshare missions alike. Virgin Orbit is also looking for new launch sites and destinations this year, with the UK Space Agency having recently awarded the company £7.35 million to enable LauncherOne missions from Spaceport Cornwall, with the first launch expected not before 2022. Virgin Orbit is also collaborating with SatRevolution and Polish universities for up to three launches delivering small spacecraft to Mars, with the first launch due no earlier than 2022.

FireFly Aerospace readies for inaugural launch

Newcomer Firefly Aerospace is also gearing up to enter the dedicated small satellite launch market. Committed to providing economical and convenient access to space for small payloads, Firefly is on track to start delivering 1,000-4,000kg class payloads to LEO this year with a starting price of US$15 million. The company intends to launch from SLC-2 at Vandenberg Air Force Base, where it has a long-term lease in place, and SLC-20 at Cape Canaveral.

The company is beginning with the Firefly Alpha launch vehicle, which combines the highest payload performance with the lowest cost per kg to orbit in its vehicle class. Alpha can deliver one metric ton to LEO and 630kg to 500km SSO and will offer full vehicle and rideshare services via two monthly launches. The carbon fibre composite Alpha features a first stage with four Reaver engines and a second stage with one Lightning 1 engine.

Firefly is also developing its carbon composite Beta launcher, a 2.5-stage vehicle capable of lifting 4,000kg to 200km LEO with Geosynchronous Transfer Orbit capabilities. The first stage features three Alpha Stage 1 cores comprising a total of 12 Reaver engines, while the second stage features one Lightning 1 engine. The company also has the vision for Gamma, a futuristic reusable launch vehicle rocket plane, which utilises aspects from both its Alpha and Beta vehicles, and offers air or ground launches, as well as the potential for hypersonic transport on Earth.

FireFly has partnered with Aerojet Rocketdyne to gain expertise on 3D printing for its Reaver engine production, as well as collaborating on its upcoming Orbital Transfer Vehicle and the Beta launch vehicle. The company has also partnered with Israel Aerospace Industries to cooperate on lunar landing technology, Genesis, which will be used for mission contracts under NASA's Commercial Lunar Payload Services program; the first flight is expected at the end of 2021. Meanwhile, back in January, Firefly announced the execution of a Launch Services Agreement with Innovative Space Logistics BV (ISILAUNCH), which will see ISILAUNCH offer multiple dedicated and rideshare launch opportunities on Firefly Alpha starting this year. The inaugural Firefly Alpha launch is due this year, with plans to launch a collection of rideshare payloads resulting from the Dedicated Research and Education Accelerator Mission (DREAM) competition. A total of 26 DREAM payloads from seven countries will be launched.

Orbex progresses with new contracts and spaceport plans

UK-based Orbex was founded in 2015 in order to provide low-cost orbital launch services for the small satellite sector. The company has gone on to develop one of the most advanced low-carbon high performance micro-launch vehicles in the world, which, according to the company, 'means higher reliability, more flexible mission profile types and a regular, scheduled launch service.' Since its launch, Orbex has raised more than £38 million in public and private funding, including from two of Europe's largest venture capital funds (Sunstone Technology Ventures, now Heartcore, and the HighTech Gründerfonds), the UK Space Agency, the European Space Agency and the European Commission Horizon 2020 programme.

A wide range of advanced materials and techniques are used to create each Orbex Prime launch vehicle, including the use of additive manufacturing for almost the entire propulsion subsystem and carbon fibre/graphene composites for the main structures and tanks. With a 150kg to Sun Synchronous Orbit (SSO) payload capacity, Prime utilises bio-propane, a clean-burning renewable fuel that cuts carbon emissions by 90 percent compared with traditional hydrocarbon fuels. Prime features a novel architecture that saves around 30 percent of inert mass, increasing efficiency by 20 percent.

Orbex 3D-printed engine. Photo courtesy of Orbex

Orbex has secured launch contracts with TriSept Corporation (rideshare contract launch due in autumn 2022), In-Space Missions (Faraday-2b satellite due in 2022), Deimos (formed a strategic partnership for launches), Innovative Space Logistics (wide-ranging cooperation agreement including technical launch services and orbital space launches), Astrocast (10 satellites of a 64 CubeSat IoT constellation due by 2023), and SSTL (experimental payload due for launch on Prime's maiden launch in 2021) already from the UK's first spaceport in Sutherland, Scotland. Orbex's Prime is expected to be the first rocket to launch from the Sutherland spaceport in 2021. In August 2019, Orbex's partner, Highlands, and Islands Enterprise (HIE) confirmed that it had signed a 75-year lease option with landowners to build and operate a spaceport on its land. Meanwhile, in February, a planning application for the launch site was submitted, with construction due to commence later this year. Up to 12 launches are planned for the site annually.

TiSPACE on track for 2020 launch

Established in 2016, Taiwan Innovative Space (TiSpace) has ambitious plans to provide innovative and cost-effect launch services for microsatellites and nanosatellites destined for LEO and SSO. TiSPACE aims to offer global coverage and 24-hour services to enable on-demand launches to meet orbit deployments and scheduling requirements.

The company spent 2019 increasing the efficiency of its non-explosive hybrid rocket engines to meet NASA's Class-

“Secretive US start-up company Astra plans to reshape how the space industry works, starting with access to space. Offering smaller more frequent launches, Astra envisages enabling a wave of innovation in LEO and improving life on Earth through greater connectivity and more regular observation.”

I rocket propulsion status while also keeping costs lower than competitors. The HAPITH V launcher can lift a 390kg payload to LEO and 350kg payload to SSO, and features a single hybrid rocket engine upper stage, a four-hybrid engine second stage, and a five-hybrid engine first stage.

Bad weather meant that the planned first launch in February at the Taitung launchpad was aborted. TiSPACE remains on track for its first small satellite launch later this year. Interestingly, the Taitung County Government has reported that TiSPACE did not file the required application before building the launchpad on private property, which is Aboriginal domain, and has been fined NT$400,000. The company is required to demolish the launch site or apply to legally alter its land use.

Astra aborts DARPA Launch Challenge

Secretive US start-up company Astra plans to reshape how the space industry works, starting with access to space. Offering smaller more frequent launches, Astra envisages enabling a wave of innovation in LEO and improving life on Earth through greater connectivity and more regular observation. Launched in 2016, Astra built its first rocket test facility in California in 2017, launched Rocket 1.0 and Rocket 2.0 in 2018 (both initially believed to be failures, but were later reported as successes, although Rocket 2.0’s flight was shorter than planned) from the Pacific Spaceport Complex – Alaska (PSCA), and in 2019, built a new rocket factory and spaceport. This year, the company has embarked on the production of Rocket 3.0.

Very little was known about the company’s rocket technologies, tests or launch attempts until earlier this year. Rocket 3.0 has been revealed as a two-stage, five-engine kerosene, and liquid oxygen powered rocket. The first stage ‘Delphin’ engines feature electric motor pumps arranged in a pentagon shape, unique from other five-engine rocket designs. Rocket 3.0 can lift a 150kg payload to 500km SSO. The aluminium tanks are easier and cheaper to work with, although heavier than carbon fibre alternatives. In addition to the PSCA, Astra plans to launch from a second site in the Marshall Islands in order to access low-inclination orbits. The company reportedly has more than 12 signed launch contracts, but for who and when, remains a mystery.

In 2019, Astra was selected as a finalist in the Defense Advanced Research Projects Agency’s (DARPA) Launch Challenge (the other two finalists later dropped out). Astra was charged with integrating and lifting four small payloads into 445km orbit, although 150km would also be accepted. However, in March this year, Astra was forced to scrub the launch demonstration from the PSCA, pushing it beyond the challenge’s US$12 million prize fund window. According to Astra’s website: “Our team decided to hold the launch at T-53 seconds after a sensor reported unexpected data that could have impacted the success of the flight. Out of our commitment to safety, and to increase the probability of overall success of the three-launch campaign, we have decided to prioritize fully investigating the issue over attempting to win the DARPA challenge today….We remain determined to reach orbit and plan to attempt another launch attempt as soon as possible.”

Interestingly, the DARPA Launch Challenge seems to carry with it something of a curse. Vector Launch was also due to have entered the challenge with its carbon composite Vector R launch vehicle, having performed two subscale Vector R test flights in 2017, but the company dropped out from the competition last year after losing large amounts of funding and has since filed for bankruptcy.

LEO is already the most debris-filled orbit; any collision with even small debris in this orbit could increase this significantly. Photo courtesy of Space Data Association ●●●

Changing the industry's approach to SSA

Space situational awareness (SSA) has gone from a fringe interest to a matter of global importance over the last 20 years. As growing numbers of spacecraft enter various orbits, space has become more cluttered than ever before, increasing the risk of collisions and debris incidents.

Pascal Wauthier, Chairman, Space Data Association

Space situational awareness (SSA) was given very little thought in the early 2000s. Even in cases where operators considered the risk of collision in space to be of concern, it was accepted that there was very little that could be done to avoid them. Services like JSpOC and SpaceTracks were used by some, but even then notifications of close approaches were considered more of a 'heads up' and collision avoidance manoeuvres were rarely undertaken. The main reason being that the data provided by legacy SSA services was highly inconsistent and so not actionable. ---

The satellite industry itself has changed hugely in the past decade, moving away from traditional markets such as broadcast, with a new focus on opportunities in non-geostationary orbiting satellites (NGSOs). Since the SDA's inception in 2009 and the birth of the SDC 10 years ago, we have been working hard to change the industry's approach to SSA and have made significant steps to this end. Now, new innovations look to create new opportunities for satellite, whilst at the same time presenting another challenge to the safety of flight.

With this in mind, it seems like a good time to consider how far we've come in SSA and how far we still have to go.

Future of LEO

The satellite industry is notoriously competitive. Particularly in the last decade, the pressure to provide a quality service at a low cost has been solidified by a consumer expectation. Similarly, the satellite industry has always been quick to innovate to maintain its competitiveness and to capitalise upon new consumer demands.

Demand for low-latency services like broadband, particularly in rural areas which traditionally lack fibre connections, has been a driving force behind the boom in launches into the NGSO Orbit. The cost to build and launch smallsats in the LEO orbit has also dropped significantly, arousing even more interest from commercial entities. The issue of SSA in GEO and MEO is of course equally important, but LEO poses a particular challenge due to the size of the constellations required to maintain coverage. Not to mention that the usability of GEO and MEO orbits relies upon safe passage through LEO first.

If we consider that there are already 1,300 active satellites in LEO, it's difficult to see how planned launches (which is expected to see that number rise by ten times in just a few years) won't be a challenge to those of us concerned with collision, and of course debris.

LEO is already the most debris-filled orbit; any collision with even small debris in this orbit could increase this significantly.

Lax end-of-life de-orbit regulations are not helping matters, whilst a lack of onboard propulsion within new satellites in LEO means that many are unable to even attempt collision avoidance manoeuvres.

Pascal Wauthier, Chairman, Space Data Association ●●●

Regulating at end-of-life

In response to this, it's key that we consider the viability of developing measurement systems that might allow us to better track objects in LEO, particularly those smaller than 10cm. Even in GEO (which is less debris-filled than other orbits) if we were able to track objects between 20cm and 1m in size, this would account for a potential 50 percent increase in the number of objects being tracked. By doing so, data about these objects could help operators to avoid collisions and keep space cleaner for future use.

Of around the 5,000 satellites currently in space, only a staggering 1,950 are still functioning. Currently, for LEO, the guidelines require de-orbit into the Earth's atmosphere within 25 years. In GEO, we currently have around 85 to 100 percent of all payloads which reach end-of-life attempting to comply with space debris mitigation measures (which usually involves raising the orbit enough to create a separation from other active satellites, to reduce the probability of collision). Between 60-80 percent do so successfully, and happily this has been increasingly steadily over recent years. In LEO, however, the situation is very different with only between 15-25 percent of payloads reaching end-of-life in the current decade attempting to comply with these same measures. And even then, only between around 5-15 percent manage to do so successfully.

To this end, increased regulation could be a significant help in improving de-orbiting numbers and decreasing the amount of space junk above us over time. At present, there is very little significant regulation in SSA whilst current laws also differ nationally, which means there are inconsistencies across operators. We should be mindful, however, that any regulations that do come into force do not cause a detrimental effect of adding to the commercial cost for operators, nor hold back innovation.

Getting the national agencies on- board

At the same time, it's important to consider that even small steps and any effort taken by operators towards de-orbiting represents a change in thinking since the past decade. The success of the SDA over these last 10 years just shows that space operators recognise the importance and are ready and willing to invest in maintaining the safety of flight.

The SDA has, in particular, highlighted the critical nature of data sharing towards the ability to coordinate and achieve safety of flight. SSA relies on the best available data, without which collision avoidance manoeuvres would be ineffective. The SDA has also fostered important cooperation between operators, something which up until 2009 was mainly occurring on an individual level between those operators who had their own personal agreements. Now, using the SDC (Space Data Center), the biggest operators across the world share their date safely and work together to keep space safe.

We are beginning to make ground towards the goal of making SSA a national concern. For example, the plan to transfer SSA services from 18SPCS to the Department of Commerce in the US, and the emergence of EUSST for Europe shows that the concept of Space Traffic Management is being adopted by the national agencies.

The SDA would, however, like to see SSA transferred from the sole responsibility of operators to that of the state. SSA is a real environmental issue. Without the ability to safely operate in space, many of the everyday services and those of a more complex nature across the world could become impossible. That is a real threat to the world and as such should be treated as an international, governmental issue.

Conclusion

I believe I speak for the rest of the SDA's directors when I express my hope that the collaborative effort of our members is truly helping to ensure the future of satellite. We have worked hard over the last 10 years to show that cooperation is key towards our goal of a safe space environment. Now more than ever, as new challenges present themselves, it's important that our innovative industry continues to bring about new technology and strategies for effective SSA. By having the national agencies taking over SSA services, we also hope to alleviate some of the burden on operators which they have largely shouldered this past decade. Space is becoming more congested and the problem of debris grows every passing day. But as the sustainability of space is brought more and more to the forefront, I'm confident that we can maintain the safety of flight and a positive future for satellite.

Of around the 5,000 satellites currently in space, only a staggering 1,950 are still functioning. Photo courtesy of Space Data Association ●●●

Photo courtesy of Shutterstock

A critical year for small satellites

Small satellites are everywhere these days; in the commercial segment, government and military, scientific exploration, and even among academic institutions such as schools. With the miniaturisation of satellite technology, access to space has never been more achievable.

Amy Saunders, Editor, Satellite Evolution Group

As an industry with less than 100 years of history, the satellite sector continues to innovate. Moving on from massive, multi-million-dollar communications satellites, each one carefully crafted over years of planning, construction, and testing, we're now entering an era where smaller, assembly-line satellites are all the rage.

Mini (100kg-500kg), micro (10kg-100kg), nano (1kg-10kg), pico (0.1kg-1kg) and femto (<100g) satellites are attracting consumers from all walks of life, with benefits including cost effective payloads and launches, rapid production and launch cycles, lower latencies as a result of lower orbits, and a much lower overall barrier to entry.

The potential marketplace for space and satellite technology is wide open for anyone bold enough to make a move.

Technology is good, but demand is better

It's all well and good having this incredible new technology in place, but technology for the sake of technology, without demand and solid well-thought out applications is doomed to failure (remember the 3D TVs of the noughties, anyone?). Fortunately, that's not the case where small satellites are concerned, with market research companies across the globe – as well as a simple Google search which divulges success stories aplenty – all in fervent agreement on the booming future for small satellites.

ResearchAndMarket.com's *'Small Satellite Market – Growth, Trends, and Forecast (2019-2024)'* report expects a small satellite market CAGR of more than 17 percent in 2019-2024, with massive investments by venture companies, growing demand for low-cost satellites and Earth observation applications all propelling the growth of the sector. The company highlights power-related limitations and launch regulations as potential barriers for the market growth during the forecast period. However, technological advancements, particularly the miniaturization of electronic components, 3D printing, advanced material technology, artificial intelligence and machine learning are expected to help manufacturers overcome some of the barriers and develop advanced small systems capable of performing multiple missions. On a similar note, Mart Research expects the US3.53 billion small satellite segment of 2018 to grow at a CAGR of 20.83 percent in 2019-2026, citing that small satellites are 'more useful than their larger counterparts in purposes like gathering scientific data and radio relay.' Vastly reduced mission costs are also highlighted as a key demand driver.

Notably, ResearchAndMarkets.com reports that the military held the largest share of the end user of small satellites in 2018, utilising the satellites to augment communications capabilities. The draw of small satellites reportedly stems from the risk to large communications satellites from newly developed anti-satellite weaponry. However, the commercial segment is expected to experience the highest CAGR during 2019-2024, with heavy investments and many start-ups being launched.

ResearchAndMarkets.com and Mart Research, among others, both reported that North America held the largest market share in the small satellite segment in 2018, mainly

SpaceX, which launched its first demonstration satellites Tintin A and Tintin B back in 2018, is making huge strides towards its Starlink constellation. Photo courtesy of SpaceX

due to the number of small satellite launches by the USA for both commercial companies and NASA. However, the Asia Pacific region is expected to grow at the largest CAGR during 2019-2024, with China, Japan and South Korea actively developing and launching their own small satellites.

Interestingly, while much of the space sector is currently undergoing market consolidation, the small satellite segment is in fact becoming quite fragmented due to the aforementioned start-up companies as well as existing satellite manufacturing companies branching out into small satellites. Additionally, due to the simpler designs, quite a number of schools and universities are also producing their own small satellites for launch.

Small satellites = Big business

The applications of small satellites are so varied that educations and research institutions, small businesses, militaries, governments, and commercial entities alike want in on the action. Naturally, it's the big-name constellations which are drawing the most attention, as the race to stay ahead of the curve is well and truly underway.

O3b Networks has continued to build out its O3b network of MEO satellites, completing its first-generation small satellite constellation in April 2019, bringing the total to 20 satellites. Now the company is working on its O3b mPOWER constellation in cooperation with Isotropic Systems, ALCAN and Viasat. The new constellation will be based around seven 'super-powered' MEO satellites, with more than 30,000 dynamic, electronically generated fully-shapeable and steerable beams that can be shifted and switched in real time. Delivering multiple Terabits of throughput globally, the Boeing-built fleet is scheduled for launch next year via SpaceX and is scalable to multiple terabits of throughput globally, providing coverage to an area of nearly 400 million square kilometres. A total of 22 O3b mPOWER satellites have been approved.

SpaceX, which launched its first demonstration satellites Tintin A and Tintin B back in 2018, is making huge strides towards its Starlink constellation, which will ultimately feature 12,000 small satellites utilizing inter-satellite links and operating in Ka and Ku-bands. The company kicked off 2020 with the January launch of another 60 Starlink satellites, and combined with subsequent launches this year, has brought the current Starlink constellation total to 360 (or 362 including the demonstrator satellites) at the time of writing. This latest launch makes SpaceX the owner of the largest commercial fleet in orbit; indeed, one of the significant benefits of operating your own launch company seems to be a much speedier than usual constellation build-out. As many as 18 more missions are planned for this year.

Another constellation contender, OneWeb Satellites, has been in the news for all the wrong reasons this year. Things were moving along quite nicely, with the first major launch of 34 of its LEO satellites successfully launched in February. Prior to this, an initial six satellites were launched back in February 2019, and provided examples of impressive capabilities in the following months. However, in March the company announced it had filed for Chapter 11 after several investors pulled out due to the pandemic. However, it is not all bad news as on July 3rd it was announced that a consortium of the UK Government and Bharti Global Limited had committed to provide more than US$1 billion to acquire OneWeb and fund the full restart of its business operations.

Canada's Telesat is also gearing up for a not too distant small satellite constellation launch. The LEO constellation has 300 planned satellites, although may ultimately grow to 500, and will be launched on board Blue Origin's New Glenn rocket, which has its maiden flight planned for next year. Following highly successful prototype satellite tests in orbit and a lucrative partnership with the Government of Canada – expected to generate CAD$1.2 billion for Telesat over 10 years, and an additional CAD$85 million contribution through the Government's Strategic Innovation Fund - the future is looking bright indeed.

July 2018 saw the announcement that Facebook is planning its own constellation of LEO satellites. Indeed, the planned Athena constellation is designed to provide broadband Internet connectivity, particularly to rural regions. The FCC has approved the Facebook subsidiary PointView's constellation plans; however, more details are few and far between.

In more recent news, Amazon has decided to get in on the action, with a planned 3,236 strong constellation of small satellites in LEO for broadband Internet connectivity. Kuiper Systems will call for three layers of satellites, 784 at 590km, 1,156 at 630km and 1,296 at 610km. The news makes sense given that Amazon owner Jeff Bezos also owns launch company Blue Origin, making the operational ideals more and more similar to SpaceX's Elon Musk.

Elsewhere, LeoSat Enterprises had planned a unique constellation of 78 small satellites featuring inter-satellite links, comprising 13 satellites (12 functioning and one spare) in six polar orbits. However, in November 2019 it was announced that operations had been suspended and all employees laid off after Hispasat and SKY Perfect JSAT failed to complete LeoSat's US$50 million Series A investments as pledged.

2020: A big year for small launchers

The influx of small satellite projects has created fantastic opportunities for launch providers. Existing providers have developed new launch vehicles with a much greater emphasis on rideshare capabilities, while more than a handful of start-ups have been created solely dedicated to small satellite launch technologies. Indeed, Frost & Sullivan expects a total of 20,425 satellites to be launched in 2019-2033, with high demand taking the small satellite launch market beyond US$28 billion by 2030.

"Serial production and rapid manufacturing will play a pivotal role in meeting market demands. To ensure the success of the industry, it's imperative that launch frequency, inventory and manufacturing capability are optimized," said Prachi Kawade, Research Analyst, Space, Frost & Sullivan.

Small satellite launch provider Rocket Lab closed out 2019 with the official opening of its new US launch site, Launch Complex 2, at the Mid-Atlantic Regional Spaceport. Rocket Lab's Launch Complex 1 on the Mahia Peninsula of New Zealand had achieved 10 flights of the Electron launcher by this time, including six in 2019. Launch Complex 2 is expected to open up new markets, including government customers and national security applications, with up to 12 missions per year. The first mission will deliver the US Air Force's Space Test Program 27RM, which will deliver the Monolith microsatellite into orbit, in the spring of this year. This is the latest in a long line of impressive 2019 news for Rocket Lab, which also announced its new Photon spacecraft for missions to the Moon and beyond and began testing its Electron rocket boosters for reusability.

Looking ahead, 2020 is expected to be huge for small satellite launch specialists. One of my personal favourite small satellite launchers Virgin Orbit launched an orbital rocket for the first time in May. LauncherOne was carried into high altitude onboard the Cosmic Girl aircraft prior to successful in-air separation; however, while details remain murky, LauncherOne failed to continue to its target orbit. Virgin Orbit is also looking for new launch sites and destinations this year, with the UK Space Agency having recently awarded the company £7.35 million to enable LauncherOne missions from Spaceport Cornwall, with the first launch expected not before 2022. Virgin Orbit is also collaborating with SatRevolution and Polish universities for up to three launches delivering small spacecraft to Mars, with the first launch due no earlier than 2022.

Meanwhile, newcomer FireFly Aerospace is preparing for the inaugural launch of its Alpha rocket in the first quarter of the year from Vandenberg Air Force Base in California. FireFly has partnered with Aerojet Rocketdyne to gain expertise on 3D printing for its Reaver engine production (each Alpha launcher contains four Reaver engines), as well as collaborating on its upcoming Orbital Transfer Vehicle and a larger Beta launch vehicle. FireFly has also partnered with Israel Aerospace Industries to cooperate on lunar landing technology, Genesis, which will be used for mission contracts under NASA's Commercial Lunar Payload Services program; the first flight is expected at the end of 2021.

Beyond the US, Taiwan Innovative Space Inc. (TiSPACE) is looking forward to achieving its first small satellite launch on board its Hapith launcher at the end of the year. The company spent 2019 increasing the efficiency of its hybrid rocket engines to meet NASA's Class-I rocket propulsion status while also keeping costs lower than competitors. TiSPACE is presently negotiating leasing launch facilities in other countries, plans to create a California office to access US commercial space, and ultimately build a satellite technology industrial park.

Photo courtesy of Shutterstock

Space Flight Laboratory announces new line of cost-effective cubesats

Photo courtesy of Space Flight Laboratory

Space Flight Laboratory (SFL) has announced a new line of high-performance, low-cost CubeSat buses. The 3U (THUNDER), 6U (SPARTAN) and 12U/16U (JAEGER) CubeSats complement SFL's legacy suite of space-heritage nano- and microsatellites, fulfilling mission size requirements from 3 kg to 500 kg.

SFL will discuss its new CubeSats and legacy buses at the virtual Small Satellite Conference (SmallSat 2020) being held online Aug. 1-6, 2020.

SFL was among the first in the world to launch CubeSats including the CanX-1 CubeSat in 2003 and CanX-2 in 2008, with capabilities that exceeded the state-of-the-art at that time. Since then SFL focused on somewhat larger, more capable satellites for more challenging missions, garnering a reputation for "quality at low cost." As SFL delivered high-performance, high-quality microsatellites for more than two decades, the CubeSat market matured, and the number of commercial opportunities increased.

The new product line of high performance CubeSats leverages SFL's quality platform technologies while addressing the need for aggressive, disruptive missions and satellites that are as small as possible to meet highly constrained business demands. This represents a return to CubeSats for SFL but with the ability to leverage more than 22 years of experience and technological advancements.

Bringing to bear the accumulated power of SFL know-how and technologies will satisfy the now mature demand for platforms that perform well and are compatible with commercial-off-the-shelf CubeSat deployers and aggregated launches.

"SFL can accommodate the budget and performance objectives of any microspace mission," said SFL Director Dr. Robert E. Zee. "And we are positioned to meet the evolving spacecraft development and business model requirements of different organizations - from disruptive demonstration missions to fully operational constellations."

Zee continued, "The new line of high-performance CubeSats will allow us to offer something for everyone, from market disruption to long-term operational stability. The spectrum of SFL platform offerings will enable staged roadmaps to larger missions for some customers. Having platforms that cover the full range of capability will make transitioning and forward compatibility easier for our most demanding clients."

With demonstration and operational programs in mind, SFL has also announced Newspace (accelerated) and Microspace (standard) development options for the new CubeSat line. The accelerated procedures are designed to move demonstration satellites quickly through the development process and into orbit for short-term proof-of-concept performance. They can also be used operationally in scenarios where rapid replenishment is planned. Microspace, or SFL's standard development approach, which has been perfected at SFL for more than two decades, ensures the reliability of operational spacecraft built for long-duration missions in orbit.

"Every satellite we build – whether CubeSat, nanosat, or microsat – incorporates the same flight heritage, avionics, and attitude control that we have developed and refined after developing 52 distinct satellites – either launched or launching soon – the Microspace Way," said Zee. "Regardless of the demands of the mission, we use the same generic core and scale the platform as necessary to meet specific mission objectives."

SFL satellites have achieved more than 121 cumulative years of operation in orbit. These microspace missions have included SFL's trusted attitude control and, in some cases, formation-flying capabilities. Other core SFL-developed components include modular (scalable) power systems, onboard radios, flight computers, and control software.

The new SFL CubeSats will be ideal for NewSpace programs that are intended to either disrupt commercial markets or operate from a long-term rapid replenishment strategy. The industry-accepted form factors of CubeSats make them attractive for proof-of-concept programs or programs that involve repetitive quick replenishment where cost constraints are critical. They fit the cost models of some businesses because they are built for orbital deployment from, and aggregation of relatively inexpensive, standardized dispensers being mass produced on the market today.

"Once a demonstration CubeSat is launched and successfully commissioned, SFL is able to trigger mass production for rapid deployment and replenishment or leverage the success to take our client's business model to the next step. This may involve transitioning to longer lifetime CubeSats and/or our legacy microspace platforms which can be done with relative ease," said Zee.

SFL's heritage of on-orbit successes includes missions related to Earth observation, atmospheric monitoring, ship tracking and communication, radio frequency signal geolocation, technology demonstration, space astronomy, solar physics, space plasma, and other scientific research.