First Firefly engine test

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

Orbex headquarters, Scotland

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.

While the business environment remains uncertain, ACCESS.SPACE has reported that global tele-communications 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, 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

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

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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.

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

LauncherOne. Photo courtesy Virgin Orbit

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The New Shape of Solid State

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 spacepor t 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 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

HAPITH V launcher can lift a 390kg payload to LEO and 350kg payload to SSO

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-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.

Astra's small satellite launcher stands vertical at Pacific Spaceport Complex on Kodiak Island, Alaska. Photo courtesy John Kraus/Astra