

ORBIT

Astro Space Stamp Society

October 2021 - ISSUE 130



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1947 - 2021**

Space flights: little companies grow up

The development of Rocket Lab *by Pietro Della Maddalena*

"ROCKET LAB IS REDEFINING HOW WE ACCESS SPACE", is the thunderous announcement to those who access the institutional website of this company, which is the first private company dedicated to small satellites, which can be everything, from the small CubeSats weighing 3 pounds, to spacecraft sized like a washing machine.

The potential market is huge. It is estimated that 200 small satellites are launched per year; Swedish space technology company AAC Microtec estimates that by 2023 the number will rise to over 500. CubeSats, which have become much more sophisticated over the past decade, will account for a large percentage of the increase and are a "target market, but not the only one", according to New Zealand-born Peter Beck, founder and CEO of Rocket Lab.

The rocket, named Electron, is a mere sliver if compared to the giant rockets used by Elon Musk's SpaceX, and Jeff Bezos' Blue Origin, to send people into the solar system. It is only 56 feet tall and can carry only 500 pounds into space.

But Rocket Lab is aiming at markets closer to home. "We're the space FedEx", Peter Beck says, "We're a little man that delivers a parcel to your door".



Rocket Lab will charge a base price of \$ 5.7 million for a dedicated launch into orbit, but if several CubeSats share the journey, the cost for the little ones could be hundreds of thousands of dollars.

However the cost is not the only factor. For Beck, the most important thing in rocket business is the launch frequency. The company plans to launch once a month by the end of this year, twice a month next year, aiming at launching "every 72 hours", he says. The Rocket Lab manifest is booked for the next two years and has "a nice backlog" of customers waiting to fly. Payloads include a dozen NASA-sponsored CubeSats.

According to Carlos Niederstrasser, an Orbital ATK engineer who has been following small rocket development for several years, more than three dozen small satellite launch projects are underway around the world. Not all of them will survive, but many are ready to begin operations. Just behind Rocket Lab there is Virgin Orbit, based in Long Beach, California, spun off in 2017 from Virgin Galactic, the Richard Branson's space tourism company.

Reading the website spurs the imagination to gallop towards what, until a few years ago, was science fiction, but now,



they tell, is reality; you may press a button: "BOOK MY LAUNCH". Actually, it's difficult to believe that a few clicks on a web page are enough to send something into space (besides, of course, a large balance on your credit card), but you realize however that here the mentality has already crossed the thresholds of future. The web site describes in detail the rocket Electron, arguing that it is an optimal mode for frequent and reliable access to Space for small satellites; Electron's payload fairing is made entirely of carbon and is designed and manufactured in-house at Rocket Lab.

An optional stage can perform multiple ignitions to place numerous payloads in different circular orbits. It offers many more orbital options, particularly for rideshare customers who have traditionally been limited to the designated orbit of the primary payload. Equipped with a liquid propellant Curie engine, 3D-printed by Rocket Lab, capable of 120N of thrust and multiple ignitions, with a total thrust of 22 kN (5.000 pounds).

Through an extensive research programme, Rocket Lab has developed carbon composite tanks compatible with liquid oxygen, guaranteeing significant weight savings. Custom cryogenic valves and helium pressurization systems have been developed by Rocket Lab for maximum efficiency and reliability.

Rocket Lab excels in manufacturing miniature avionics systems and high performance flight computers. The processing nodes make use of a state-of-the-art FPGA architecture, which allows for enormous customization of functions while maintaining hardware compatibility. Electron's first stage is powered by nine Rutherford engines. Rutherford is an oxygen / kerosene pump powered engine specially designed in-house for Electron, using an entirely new propulsion cycle. Its unique high-performance electric propellant pumps reduce mass and replace hardware with software. Rutherford is the first oxygen / kerosene engine to use 3D printing for all primary components.

Rocket Lab stands out for the originality of the names assigned to the missions carried out so far. (See table p 19).

"It's a Test" was the first launch of Rocket Lab's Electron launch vehicle. When Electron lifted-off at 16:20 NZT from Rocket Lab Launch Complex 1 on the Mahia



Peninsula in New Zealand, it became the first orbital-class rocket launched from from a private launch site.

The mission saw Electron complete a perfect first stage burn, stage separation, second stage ignition and fairing separation and successfully reached the space.



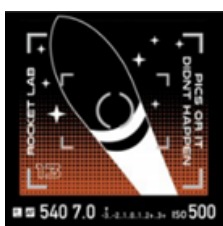
The "Still Testing" mission was Rocket Lab's first orbital launch of the Electron vehicle. Electron lifted-off at 14:43 NZDT on 21 January 2018. The launch marked the beginning of a new era in commercial access to space.

Still Testing carried a Dove Pioneer Earth-imaging satellite for Planet, as well as two Lemur-2 satellites for the weather and ship tracking company Spire.



The "ELaNa-19" mission for NASA (Educational Launch of Nanosatellites 19) was Rocket Lab's fourth Electron launch and the company's first mission for NASA. The launch was significant for the small satellite industry as it was

the first time NASA CubeSats used a commercial launch vehicle.

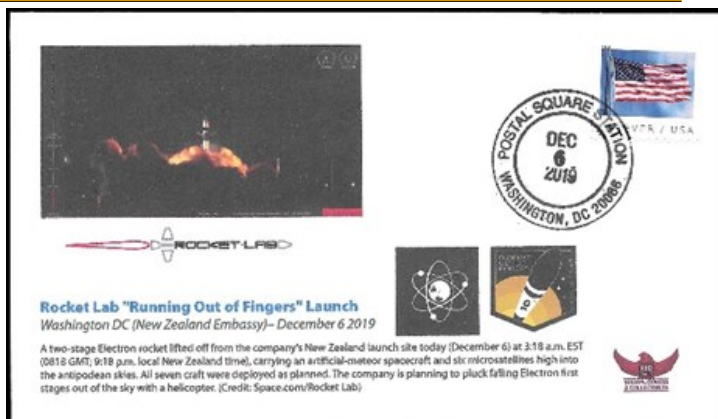


March 28, 2019 - The mission launched the R3D2 (Radio Frequency Risk Reduction Deployment Demonstration) payload for DARPA. R3D2 was a prototype reflect array antenna designed to improve radio communications in small spacecraft. The antenna, made of a thin Kapton

membrane, was packed tightly inside a small satellite for stowage during launch and was then deployed to its full size of 2.25 metres in diameter once it reached low Earth orbit. Compacting a large antenna into a small satellite provides significant advantages, overcoming the need to build large satellites that only can be launched as a ride-share payload on big rockets with significant price tags and time delays

December 6, 2019 - Onboard this rideshare mission were six 5 cm PocketQube microsattellites from satellite manufacturer Alba Orbital.

"Running Out Of Fingers" also included the first full-guided



telemetry re-entry of the Electron launch vehicle's first stage, as part of Rocket Lab's plans to re-use and re-fly rocket boosters in future missions.

"Pics or It Didn't Happen" was a rideshare mission for seven small satellites for a range of customers including Spaceflight Inc.'s customer Canon Electronics, as well as Planet and In-Space Missions. The primary payload aboard this mission was the Canon Electronics Inc.'s CE-SAT-IB with high-resolution and wide-angle cameras. The next five spacecraft manifested for this mission are the latest generation of SuperDove satellites manufactured by Planet, operator of the world's largest constellation of Earth-observation satellites. Planet's satellites are capable of



shooting the Earth's entire landmass on a near-daily basis.

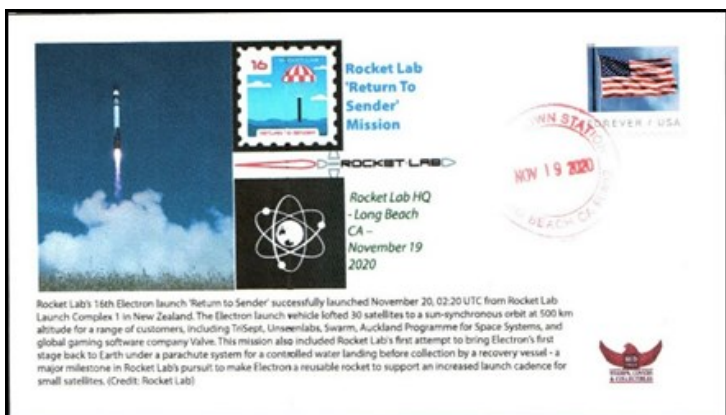
On July 4, 2020, the Electron launch vehicle successfully lifted-off from Launch Complex 1 and proceeded through Stage 2 ignition, and fairing jettison as planned. Several minutes into the second stage burn, the engine performed an emergency shutdown resulting in a failure to reach orbit.

After carrying out extensive testing, Rocket Lab's Accident Investigation Board was able to identify the issue originated by an anomalous electrical connection which was intermittently operated through flight, and created increasing resistance that potted and liquefied the surrounding compounds and led to the disconnection of the electrical system and subsequent engine shutdown.

August 31, 2020 – "I Can't Believe It's Not Optical". The satellite, named "First Light", was launched as a stage of the Electron rocket that put into orbit the Capella Space's



Sequoia radar imaging satellite. Once Sequoia was released, the controllers sent commands to place the stadium in "Photon satellite mode", turning it into an operational satellite. This was the first satellite built and designed by



Rocket Lab.
 Rocket Lab's 16th Electron launch "Return to Sender" successfully launched on November 20, 2020. The Electron launch vehicle lofted 30 satellites to a sun-synchronous orbit at 500 km altitude for a range of customers, including TriSept, Unseenlabs, Swarm, Auckland Programme for Space Systems, and global gaming software company Valve. This mission also included Rocket Lab's first attempt to bring Electron's first stage back to Earth under a parachute system for a controlled water landing and subsequent collection by a recovery vessel. The future goal will be to try a mid-air recovery: SpaceX may soon not be the only private company capable of launching, recovering and relaunching its own rockets. A major milestone in Rocket Lab's research to make Electron a reusable rocket supporting an increased launch cadence for small satellites.

Rocket Lab, established in Auckland, New Zealand in 2006, first moved its headquarters to Huntington Beach in California in 2013, and then moved in 2020 to Long Beach, where it now has its HQ and from which it announced the first launch from the company's Launch Complex 2 in Wallops Island, Virginia, with a U.S. Air Force payload. The Electron rocket of that mission is already on the launch site, with the new pad which having passed a set of tests last spring now waiting for NASA to certify the Autonomous Flight Termination System (AFTS) that will be used on the rocket to ensure the safety of the range. Rocket Lab is also

building a second launch pad in New Zealand, which will be ready later this year; Beck also announced the construction of a new HQ and factory in Long Beach, California, which will be capable of producing 12 or more Electron rockets per year, and will add a second mission control centre.

In addition to its launch vehicle efforts, the Company is working on a satellite bus called "Photon" based on the thrust stage of the Electron rocket. Beck also said he believes the company is now well positioned to take advantage of growing demand for small launches as many competitors have been sidelined by the pandemic. "The small launch around the world is largely paralyzed due to COVID-19", he said. "We see ourselves playing a really pivotal role in this period, bringing customer payloads into orbit while everyone else is tackling the pandemic".

In 2021 Rocket Lab will launch a CubeSat in lunar orbit for NASA. This historic mission will support NASA's Artemis programme which will land the first woman and next man on the moon by 2024.

Using the Electron rocket and Photon Lunar spacecraft, Rocket Lab will launch NASA's Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) CubeSat on a dedicated lunar orbit. CAPSTONE's primary goal is to test and verify the calculated orbital stability of a nearly straight halo orbit around the Moon, the same orbit planned for the Lunar Gateway, the Gateway being a small planned space station that will orbit the Moon to provide astronauts with access to the lunar surface. It will contain accommodation for astronauts, a laboratory for science and research and access for the visits of spacecraft. CAPSTONE will also test a navigation system that will measure its position using NASA's Lunar Reconnaissance Orbiter (LRO) without relying on ground stations.

CAPSTONE is one of the first steps in learning how to manage more robust missions in this orbit: a milestone for future exploration of our solar system.

(A version of this article first appeared in an edition of *AdAstra*—in Italian and English— earlier this Summer and is reproduced with permission by Pietro, our Italy based member and Umberto Cavallaro, editor of *Ad Astra*.) [Reference www.rocketlabusa.com](http://www.rocketlabusa.com)

Launch date	Mission	Customers
25-May-17	It's a Test	Lancio di prova
21-Jun-18	Still Testing	Rideshare
11-Nov-18	It's Business Time	Rideshare
16-Dec-18	NASA ELaNu-19	NASA
28-Mar-19	DARPA R3D2	DARPA
5-May-19	STP-27RD	U.S. Air Force Space Test Program
29-Jun-19	Make It Rain	Spaceflight
19-Aug-19	Look Ma, No Hands	Rideshare
17-Oct-19	As The Crow Flies	Astro Digital
6-Dec-19	Running Out Of Fingers	Rideshare
31-gen-20	Birds of a Feather	National Reconnaissance Office
13-Jun-20	Don't Stop Me Now	Rideshare
4-Jul-20	Pics Or It Didn't Happen	Rideshare
31-Aug-20	I Can't Believe It's Not Optical	Capella Space
28-Oct-20	In Focus	Rideshare
20-Nov-20	Return to Sender	Rideshare
15-Dec-20	The Owl's Night Begins	Synspec
20-Jan-21	Another One Leaves The Crust	OHB Group
22-Mar-21	They go up so fast	Rideshare