

Rocket Lab: Liberating the Small Satellite Market

Jessica Tulp, Peter Beck
 Rocket Lab
 14520 Delta Lane, Suite 101, Huntington Beach, CA 92647; +1 (714) 465 5737
 j.tulp@rocketlabusa.com

ABSTRACT

To provide unrivalled access to space, two important things are needed: a drastic reduction in cost for dedicated launches and increased launch frequency. Currently, the high cost associated with small satellites reaching desired orbits presents a major barrier in the commercialization and exploration of space. This is combined with long lead times to get a satellite on orbit, and with new markets opening, and the potential for drastic growth, it is impossible to be responsive to new opportunities in these timeframes. Rocket Lab has a solution. The Electron launch vehicle is a dedicated small launcher designed to liberate the small satellite market with dedicated, high-frequency launch opportunities. Vertical integration combined with streamlined modular payloads will reduce the lead time to put a satellite on orbit from years to weeks. Electron is a two-stage vehicle capable of delivering payloads of 150 kg to a 500 km sun-synchronous orbit, the target range for the high-growth small satellite market. With a private launch range in Mahia, New Zealand, Rocket Lab can accommodate an increased launch cadence as well as reaching orbital inclinations from sun-synchronous through to 39 degrees from a single site. Rocket Lab’s Electron vehicle is well positioned to disrupt the space industry, opening space up to the burgeoning small satellite market.

INTRODUCTION

Rocket Lab’s mission is to make space accessible by offering small satellite customers a rapid-response orbital service that is frequent and reliable. Since its creation in 2006 by Peter Beck, Rocket Lab has delivered a range of complete rocket systems and technologies. Rocket Lab has entered the launch market with Electron, a launch vehicle featuring revolutionary advancements in turbo-pump technologies, additive manufacturing and carbon composite construction, resulting in true reductions in cost and a high launch frequency.

The small satellite market has seen rapid growth in recent years, and there is more demand than ever before for small satellite launch vehicles which are optimized to deliver small satellites to their desired orbits at a rapid pace. The key to liberating the emerging small satellite industry lies in the pricing, availability, innovation and reliability of Rocket Lab’s Electron launch vehicle.

ELECTRON VEHICLE OVERVIEW

The Electron launch vehicle is a two-stage vehicle (Fig. 1) servicing the emerging small satellite market, and has been designed with a high flight rate in mind. Capable of launching payloads of 150 kg (330 lbs) to a nominal 500 km sun-synchronous orbit from Rocket Lab Launch Complex 1 in New Zealand, as well from U.S. domestic ranges, Electron provides a primary

payload quality launch service at a secondary payload price.



Figure 1: Electron Launch Vehicle Configuration

All flight systems and launch vehicle components are designed, built and tested in-house at Rocket Lab. Electron’s design incorporates a fusion of both conventional and advanced liquid rocket engine technology coupled with innovative use of electrical systems and carbon composite materials. Electron launch vehicle dimensions and specifications are outlined in Table 1.

SPECIFICATION	VALUE
Length	17 m
Diameter	1.2 m
Stages	2
Vehicle Mass (Lift-off)	13,000 kg
Payload Mass	150 kg (Sun-Synchronous Orbit)
Payload Diameter	1.08 m
Standard Orbit	500 km (Sun-Synchronous Orbit)
Propulsion – Stage 1	9 x Rutherford Engines (LOx/Kerosene)
Propulsion – Stage 2	1 x Rutherford Engine (LOx/Kerosene)
Material/Structure	Carbon Fiber Composite
Standard Launch Site	Mahia, New Zealand

Table 1: Electron Launch Vehicle Dimensions and Specifications

Electron makes use of advanced carbon composite materials for a strong and lightweight flight structure, and utilizes advanced carbon composite technologies in the structural elements of the vehicle including propellant tanks. The all-carbon-composite construction of Electron decreases mass by 40 percent resulting in enhanced vehicle performance.

Electron's first stage is powered by nine of Rocket Lab's flagship Rutherford engines, with the second stage powered by a variant of the Rutherford Engine which provides improved performance in vacuum conditions.

The payload fairing on Electron is a split clam shell design and includes environmental control for the payload. The fairing is 2.5 m in length with a 1.2 m diameter and a total mass of 44 kg. It uses a pneumatic locking system and spring separation.

Rocket Lab excels at producing high-performance miniature avionics and flight computer systems. Avionics flight hardware is custom designed by Rocket Lab and includes flight computers and a navigation suite incorporating an initial measurement unit (IMU), GPS receiver and S band transmitter which transmits telemetry and video to ground operations. Guidance and control algorithms are developed with flexibility in mind, and the combination of flight hardware, software and guidance and control algorithms is fully tested and validated using hardware-in-the-loop testing frameworks.

All aspects of the Electron vehicle are designed for ultimate manufacturability to allow for a high launch cadence and provide our customers with an unprecedented frequency of launch opportunities.

RUTHERFORD ENGINE

Rocket Lab's flagship engine, the 4,900 lbf Rutherford, is an electric turbo-pumped LOx/RP-1 engine specifically designed for the Electron launch vehicle.

Rutherford adopts an entirely new electric propulsion cycle, making use of brushless DC electric motors and high-performance lithium polymer batteries to drive its turbo-pumps.

Rutherford is the first oxygen/hydrocarbon engine to use additive manufacturing for all primary components, including the regeneratively cooled thrust chamber, injector pumps, and main propellant valves. Additive manufacturing of engine components allows for ultimate manufacturability and control. All aspects of the engine are designed, developed, tested and manufactured in-house at Rocket Lab.



Figure 2: Rutherford Engine



Figure 3: Testing of 9 Rutherford Engines on Stage One

ELECTRON PERFORMANCE CAPABILITY

Electron missions are customized to suit customer's individual mission requirements, allowing the flexibility to reach a customer's desired orbit when and where required. Rocket Lab can tailor the vehicle to specific mission requirements including a range of sun-synchronous altitudes in circular or elliptical orbits at inclinations between 39 and 98 degrees.

Electron's performance to various orbits can be seen in Figures 4 and 5.

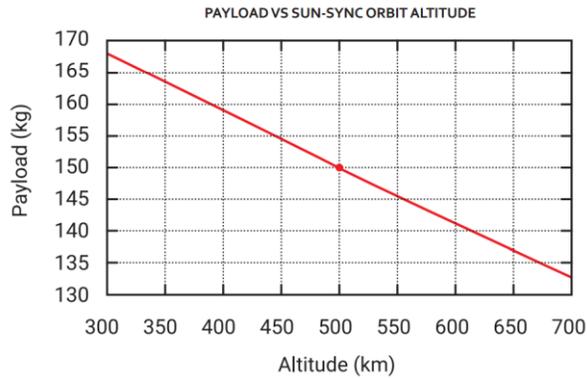


Figure 4: Performance to Circular Sun-Synchronous Orbit

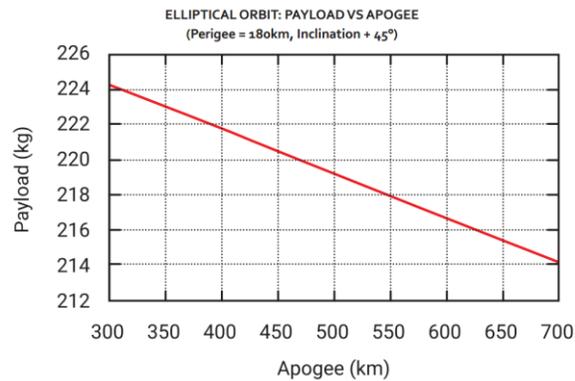


Figure 5: Performance to a 180 km Perigee at 45° Inclination Elliptical Orbit

ROCKET LAB FACILITIES

Rocket Lab is headquartered in Huntington Beach, California, with a subsidiary in Auckland, New Zealand. The facilities in both places employ a talented team of engineers and technicians and continue to grow.



Figure 6: Rocket Lab's Headquarters in Huntington Beach, California



Figure 7: Rocket Lab's Auckland Facilities

The majority of all design, testing and manufacturing is done in-house at Rocket Lab, from the Rutherford engine to the avionics to the carbon composites, enabling rapid, cost-effective fabrication of flight system and vehicle components.

Testing is completed at test cells built by Rocket Lab near the Auckland facilities. Rapid design, build and test schedules are made possible with this conveniently located test cell.



Figure 8: Engine Test Cell in Auckland, New Zealand

Rocket Lab's Mission Control Center is located within its Auckland, New Zealand facilities and houses all necessary equipment to communicate with the launch range and launch vehicle in real-time. Key personnel are located in the Auckland center during a launch.



Figure 9: Mission Control Center in Auckland, New Zealand

Rocket Lab has built a private, orbital launch complex on the Mahia Peninsula, New Zealand, and also has agreements in place for domestic launch capabilities from Cape Canaveral, Florida, and Pacific Spaceport Complex, Alaska, allowing customers a number of opportunities to reach their desired orbit.

LAUNCH COMPLEX 1

Rocket Lab offers the world's first private orbital launch range in Mahia, New Zealand. This FAA compliant site can accommodate a launch rate of 120 flights per year and is licensed for a launch to occur every 72 hours. From the site it is possible to reach orbital inclinations from sun-synchronous through to 39 degrees. This enables a lower-cost launch option with a wide spectrum of orbital inclinations.



Figure 10: Launch Complex 1

New Zealand's remote island location and low volume of marine and air traffic create ideal conditions for frequent launch opportunities.

PROGRAM STATUS AND FUTURE PLANS

In May 2017, Rocket Lab's first test flight of the Electron vehicle lifted off from Rocket Lab Launch Complex 1 on the Mahia Peninsula, New Zealand, becoming the first orbital-class rocket launched from a private launch site in the world.



Figure 11: Electron Standing Ready at Rocket Lab Launch Complex 1

Electron made it to space and went through a successful first stage burn, stage separation, second stage ignition and fairing separation. Reaching space, but not quite orbit, the Rocket Lab team is now focused on the second of three test flights, before beginning commercial missions.



Figure 12: Electron Taking Off 05/24/17

At full production, Rocket Lab expects to launch more than 50 times a year, and is regulated to launch up to 120 times a year. Rocket Lab's commercial phase will see Electron fly already-signed customers including NASA, Spire, Planet, Moon Express and Spaceflight.



Figure 13: View of Earth from Electron

CONCLUSION

Rocket Lab's mission is to remove the barriers to commercial space by providing frequent launch opportunities to low Earth orbit. With proven technology and backing from major investors including Khosla Ventures, Bessemer Venture Partners and Data Collective, Rocket Lab is liberating the small satellite market and creating unprecedented opportunities for the small satellite industry.