Small Commercial Launch Vehicle Industry Analysis
An Insight into Representative Companies

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ABSTRACT
In recent years, technology improvement has enabled small satellite commercial demand surge. Many emerging enterprises are developing commercial small launch vehicles. It is necessary to pay attention to this industry that is likely to have disruptive innovations in the next decade. In the commercial satellite launching service's demand side, remote sensing and communication uses an innovative business model, which will be the main growth part. BlackSky is a perfect example of new business model stimulated by small satellites. Its goal is to provide a real time image information of earth, which is considered too expensive without small satellites. From the supply side, a large number of small launch vehicle providers are developing their launch vehicles with a much lower cost per launch, but few of them succeed. They also have to transform to solve the future demand of greater payload. In general, smaller satellite demand stimulated the development of small launch vehicles, and small launch vehicles will stimulate space economy with lower cost

Keywords: *Small Satellite, CubeSat, Small Launch Vehicles, Market Growth, Industry Analysis*

1. INTRODUCTION

As the performance of small satellites improved, the trend of increasing small satellites' demand became more certain. Such demand drives a surge in the number of new entrants in the commercial launch vehicle industry. Many of them specially focused on developing small launch vehicles to match such demand.

These small launch vehicles (50kg to 1000kg to the LEO) have advantages that large launch vehicles cannot provide, such as launch frequency. For example, Rocket Lab's electron rocket directly targets the small-set market and has at least 140 million order backlogs. This investment and development in rockets, in turn, stimulate small-set demand.

Niederstrasser studied the small satellite launch vehicles in development in the aspects of market demand, capabilities, stated performance goals, cost, and funding sources. Niederstrasser concluded that as new entrants increase fast, the market may not support all the new competitors, but the capital market thinks there will be room for some new entrants [1]. Hertzfeld studied the supply, demand, price, and opportunity costs of the commercial space industry. Hertzfeld concluded that the demand for the commercial space industry is uncertain in fields other than government and telecommunications satellites. Telecommunications satellites' demand won't increase as fast as before [2]. Canis studied the development and new changes of the commercial space industry. Canis concluded that new entrants and the use of small satellites are increasing—the U.S. government shifts to using more fixed-price contracts [3].

Weinzierl studied managing and improving and space economy from the government perspective. Weinzierl concluded that Complementarities such as resource extraction and in-space manufacturing would stimulate investment [4]. Kim studied the potential speculative economic bubble of the launch industry from the supply side. Kim concluded that the launch industry is overheated, and investors are too optimistic about future demand growth. Then government regulation is necessary for industry development [5]. Nervold. et al. studied the potential of OPEN framework CubeSat in stimulating the small satellites industry with lower cost. They concluded that a beneficial spiral of price reduction might be created in both small satellites and the launch industry [6].

Buchen studied the latest trend in the small satellites market. Buchen concluded that reduced cost of spacecraft components increases the ability of small satellites and

the commercial sector gradually has more influence in the space industry [7]. Reed studied the demands in the commercial satellite market and development in space launch vehicles. Reed concluded that the commercial launch market would drive by demand for commercial GEO and LEO communication satellites [8]. George studied the projected economic impact of yearly growth in commercial space on the U.S. and Florida economies and industries, especially in the labor area. George concluded that the government should help the industry development with policy [9]. Peter studies the ability of electron rockets to lower the cost of small satellite launching. Peter concluded that electron rockets could provide high-frequency launch services with low costs. The rocket will satisfy the drastic growing market demand and expand the number of their launch complexes [10].

This article analysed the commercial launch vehicle industry from the demand and supply side. Demand side is analysed first by four main growth areas and growth trend. The second part is supply side. In this part I collected data of main stream competitors. I also analysed a representative company based on technology about how it meets the demand of small satellite launch and its future plans.

2. DEMAND

The demand for the commercial launch industry is mainly composed of commercial communications satellites, commercial remote sensing or Earth observation satellites, and commercial crew and cargo missions. The detail of demand composition is in Figure 1.

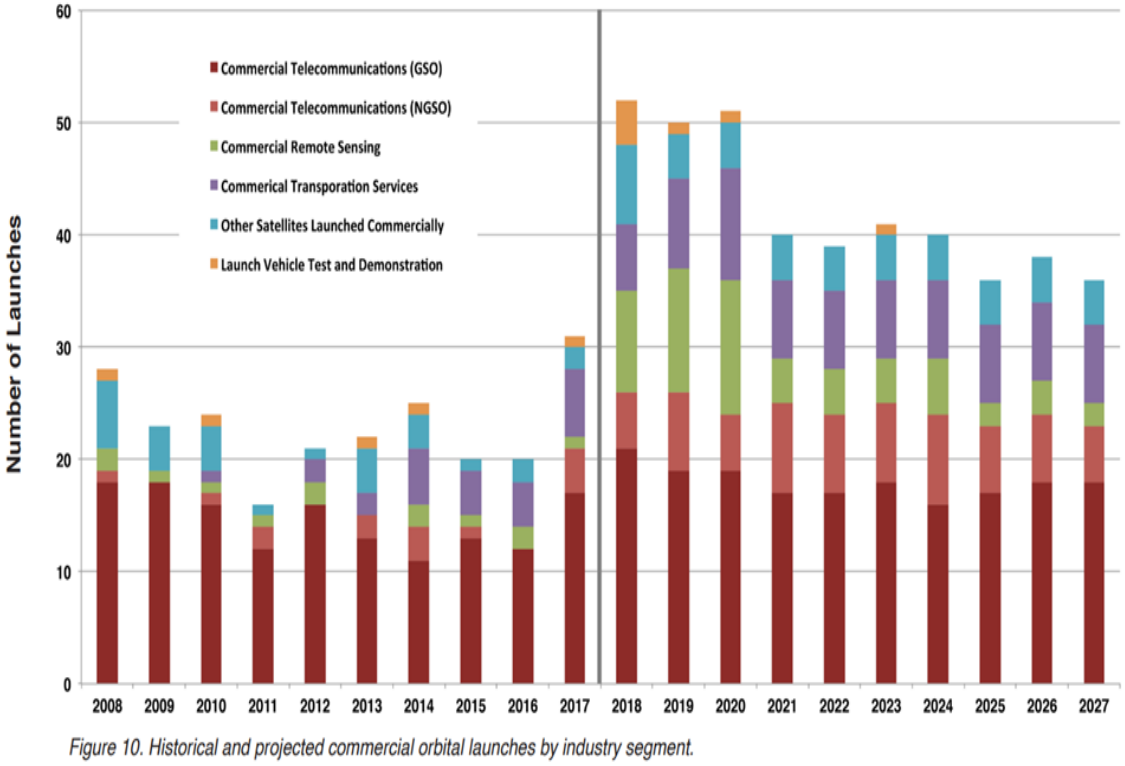

Figure 1 Historical and projected commercial orbital launches by industry segment [11]

The demand for small satellites has the greatest growth potential (Figure 2). The development of new technologies made satellites lighter and smaller, and new launch vehicles lowered the cost of launch. These signs of progress enable academic institutions and companies to access space with much lower costs than before and stimulate innovation of new commercial use of space. While there will be little or no growth in the number of space stations in the next decade (except China)

The main commercial use of small satellites is generated by remote sensing or Earth observation, while communication uses peak in 2018 and drop fast in 2019. Data analytics and satellite remote sensing companies always launch their satellites into the LEO (low earth orbit). The number of remote sensing satellites launched has been increased substantially in recent years. By 2025, most small satellites will be launched in constellations into orbit. It will significantly shorten the time needed for satellites companies to deploy their payload and make profits. Small satellite constellations will account for ~83% of all satellites launched by 2028. The potential market of real-time data collecting such images is massive, and to achieve this goal, a much larger constellation will be required to launch into orbit.

The property of the LEO orbit is that satellites on this low orbit always generate friction with the atmosphere

and will return to the atmosphere after its life ends. This means that small satellites should be replaced regularly and generate sustained demand in the future. In addition, the low-cost characteristic of small satellites also facilitates technology demonstration satellites for new commercial space business models. For example, AstroScale's orbital debris removal satellite is designed to capture and remove space debris in LEO orbit.

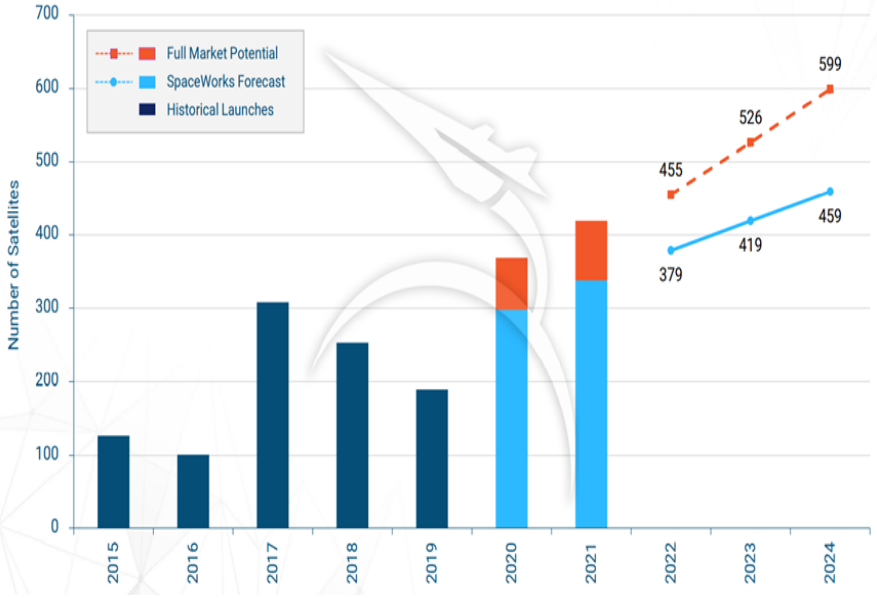

Figure 2 Small satellites launch forecast [13]

2.2 BlackSky

BlackSky Technology develops satellites and spacecraft through which it offers satellite imaging as a service that assists companies, organizations, and governments. The company was incorporated in 2013 and is based in Seattle, Washington. It aims to build a global real-time A.I. data analysis system. Building and maintaining this system represented the future demand for launching vehicles. Figure 3 shows how BlackSky's algorithm detect cargo ships from remote sensing image.

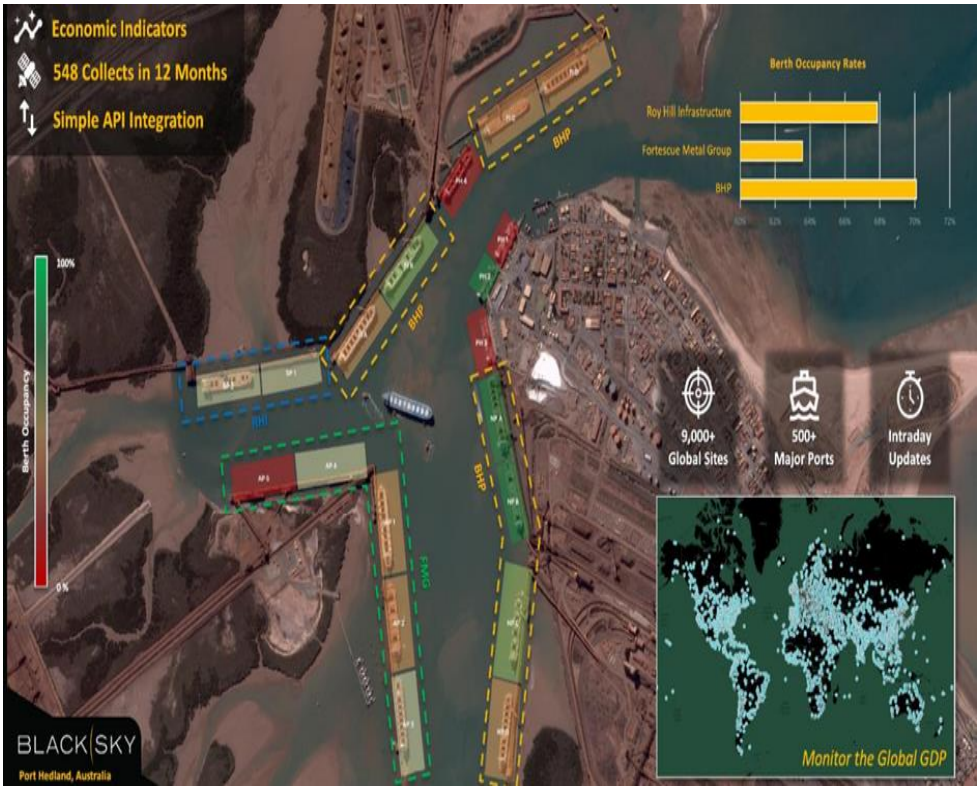

Figure 3 Sample of BlackSky's data analysis

3. SUPPLY

Currently, there are only six commercial launch vehicles that can operate in the U.S. However, a large number of companies are developing small commercial launch vehicles such as Electron in the world. This is because the major growth area of demand will be small satellite launching services in recent years. However, the rate of success is quite low. Most rockets failed in test launches (Table 1).

There are two types of commercial launch vehicles in the market, large launch vehicles and small launch vehicles. The small launch vehicle is defined as a rocket with the ability to deploy 150kg to 1000kg to LEO. For large launch vehicles like Falcon 9, the demand is mainly from large satellite launching services and commercial crew and cargo missions, which has no growth potential. Although Falcon 9 also provides rideshare services for small satellites, the competition was largely reduced by its orbit limitation. Because when choosing rideshare services, a small state has to be deployed near the main payload. It means that small sate will take months to switch into their orbit. As a result, small launch vehicles are designed to compensate for large rocket's orbit deploy disadvantage and provide a low rocket launch cost with high launching frequency. This is a business model created by small state demand and formed differentiated competition with aerospace giants.

Table 1. Mainstream small launch vehicles

Vehicle	Electron	Astra Rocket 3	Firefly α	Terran 1
Organization	Rocket Lab	Astra	Firefly Aerospace	Relativity
Total Launches	21	3	1	0
Successful Launches	18	0	0	0
LEO/kg	300	630	1000	1250
Cost per Launch/million	6	2.5	15	12

Small sate will ineluctably develop toward large global coverage constellation or bigger states with better performance. In a sense, a small state is a substitute for a large state, and a small launch vehicle is a substitute for large vehicles. For a business to access space, there is no doubt that a large payload should be deployed into space easier. As most small launch vehicles are disposable and unable to support large payload, the main challenge in the future for these small launch vehicle companies is to make enough cash flow with their small launch vehicles and develop a much larger reusable rocket like Falcon 9. Small state demand provided a chance for small companies to enter the rocket industry, but they have to seize this opportunity and rapidly transform to large rocket development. Only in this way, these company can be benefited from the growth of the space economy created by small sate and themselves. If they fail to develop a large vehicle, they can only gain a small share of growth from small sate maintain demand.

3.1 ROCKET LAB

Rocket Lab was listed on NASDAQ through SPAC in September. It has successfully launched 105 satellited into LEO orbit. Their Electron rocket, with a payload mass of 175kg into the LEO, is the second most frequently launched U.S rocket annually. In general, Rocket Lab is the most successful and representative company in the small launch vehicle industry. Detail of the rocket can be seen in Figure 4.

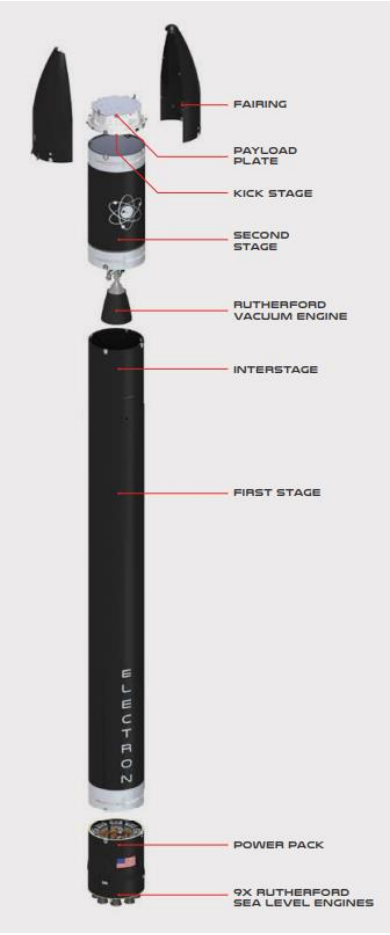

Figure 4 Components of Electron rocket [12]

Rocket Lab developed two key technology that enables it to dominate the small launch vehicle industry. First is its fully automatic production line and specially designed 3D printed Rutherford Engine (Figure 5). This enables the company to produce rockets at unprecedented speed. The rocket's cost and launch frequency were drastically improved. The second technology is its specially designed Photon Kick Stage (Figure 6). The kick stage enables small satellites individually deployed into their orbit when launched in the group. It also enables the rocket to take interplanetary missions.

Figure 5 Rutherford Engine [10]

After rosing one billion dollars in September's IPO, Rocket Lab will use the fund to finance its Neutron Rocket's development. Neutron is capable of sending an 8000kg payload into LEO, which is close to Commercial Broadband Constellation's 7700kg payload per launch with 11 satellites. In other words, it is specially designed to match great constellation launching demand in the future. Rocket Lab is using its technology and capital accumulation from Electron's success into Neutron's development. Rocket Lab is the first small launch vehicle developer that is transforming into a larger launch vehicle.

Figure 6 Photon Kick Stage [12]

4. CONCLUSION

This paper concluded that small-set demand was predicted to have a continuously increase, although most small-set service providers are at the preliminary stage of building their space infrastructure. Due to the LEO orbit's characteristics, such demand will be sustainable if these business models are proved to be efficient.

For commercial small launch vehicle providers, they will gain significant growth if they specialize in satisfying small set consumers in the next five years. The launch cost and launch frequency of this vehicle are decisive, and the difficulty of research and developing a successful rocket is also tremendous. But it will be very important for them to reinvest larger launch vehicles like Neutron (1500kg-8000kg) as after 2028, most small-set operate in the constellation.

Finally, in the optimistic estimate, positive feedback between lower launch service and space business model innovation could be formed and create an immeasurable long-term growth potential.

This paper provides an insight of how the specific technology development of both supply and demand side of small vehicle launch industry promoted industry growth. Based on technology, the paper analysed the trend and business model of the industry, which is necessary to pay attention to this industry that is likely to have disruptive innovations in the next decade.

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