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Unit of Study: INFO5992 Understanding IT Innovations

Assignment name: Innovation Research Report

Tutorial time: 8:00pm Monday

Tutor name: Yash Mehta

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Innovation Analysis Report on Nanosatellites Technology

1. Definition and Development

1.1 Definition of Nanosatellite

Nanosatellite can be loosely defined as any satellite which weighing less than 10 Kilograms and deployed low-earth orbit [2]. Comparing with conventional satellite, nanosatellite has smaller physical dimensions but with better performance. It can be widely used in various fields, such as communication, scientific observation, education and even military. In addition, lower price and shorter development cycle make that more attractive.

1.2 The Development of Nanosatellite

Since the first nanosatellite mission unsuccessfully launched on December 1957, there are hundreds of nanosatellites have been launched to LEO [3]. However, there is not any launch missions between 1963 and 1996 [3]. At that period, advanced satellite technology cannot be integrated in a small satellite due to the technology limitation. Nowadays, as the CubeSat standard was introduced in 1999, organizations can use commercial electronic parts from numerous technology suppliers, that not only reduce the cost but prompt the development of nanosatellite.

At present, scientists are devoting to find out nanosatellite applications which can open new market or replace existing conventional satellites. For earth observation, Algerian space agency has presented a plan of building a constellation of four low earth orbit nanosatellites for disaster monitoring [4]. The low-cost disaster monitoring constellation allows African developing countries to acquire satellite images and better to deal with different natural disasters such as flood and desertification. Also, nanosatellite technology has promoted the development of education. As of 2010, more than half of nanosatellites were built with an educational objective (Fig.1)

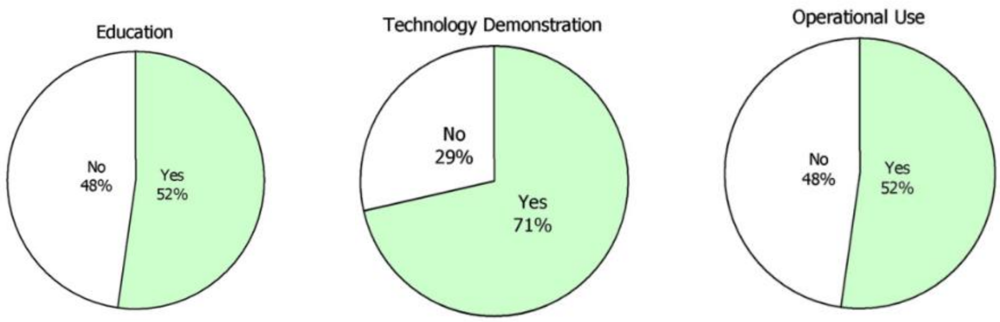

Fig.1. Distribution of nanosatellite mission objectives by 2010. [3]

In military field, as one of the most powerful militaries in the world, U.S. military has used nanosatellites to replace conventional satellites for beyond-line-of-sight communications [1]. That allows them save lots of military spending but maintain military position.

Now, the bottleneck for nanosatellite is the control of attitude and orbit determination [3]. That indirectly limits satellite-ground communication data rates. In the future, with the development of technology, nanosatellite will have greater data processing and transmission capacity. High precise formation flights will be possible, that can allow continuous coverage of a ground target from LEO orbits and provide more applications [5].

1.3 The Market Potential of Nanosatellite

Nanosatellites are increasingly introduced for civil and commercial systems. Although it is difficult to predict the future market for highly innovation industry, some trends that can already be glimpsed. In agricultural field, based on the images which taken by nanosatellites, crop damage caused by extreme weather and diseases can be estimated. In weather prediction field, nanosatellites can provide accurate weather forecasts and natural disasters. That will facilitate more effective rescue and relief work. In communication field, by combining nanosatellites with IoT, equipment and asset which in remote area can be easily managed by companies.

2. Importance to Australia & Role of Government

2.1 The Impact to Australia

Although Australia has neglected the satellite manufacturing for many years, they are now paying growing attention to the nanosatellite industry. In 2018, Australia's first nanosatellite mission control station was constructed in SA. It will enable space start-ups in Australia and around the world to monitor their nanosatellites with lower cost as well as access data faster [6]. That can be used to help support billion-dollar industries in Australia such as precision farming on remote farms in Tasmania, maritime monitoring, and food supply chain management [6]. According to a report released by the SASIC, there are around 1.5 million Australian companies need these space-derived applications. Logistics professionals, mining engineers, environmentalists, and farmers will all benefit from these applications.

Besides those actual impacts, nanosatellite technology will provide support for scientific research and education in Australia. Based on its advantages, small and medium-size organizations as well as universities all have ability to launch their own nanosatellites for different purposes. That will further promote the development of Australian science and technology. Also, the development of nanosatellites will bring more new jobs and great export potential to Australia.

2.2 The Role of the Australian Government

In the process of nanosatellite development and commercialization, the support of the Australian government is particularly important. Since the Australian Space Agency was established in Adelaide in 2018, the government is promoting cooperation in related industries. By the end of the year, the size of the Australian space sector will triple to $12 billion and 30,000 jobs [7]. Nowadays, lots of innovative space startups born in Australia, most of them initially backed by matched seed funding from the South Australian Government [8]. Over the coming years, these enterprises will play an important role in space leverage and exploration. At same time, they will create great business value in various fields such as agriculture, mining, and logistics.

3. General-Purpose Technology Evaluation

According to the four features for GPT that differs from other technologies, nanosatellite technology can be considered as a general-purpose technology.

- Is pervasive-spreading to most sectors.

  Nanosatellite technology as an innovation satellite technology, has offered a cheaper and more compatible solution to lots of applications such as earth observation, telecommunication, navigation, meteorology services and so on. Nowadays, nanosatellites have been used in wide fields: agriculture, military, communication, mining industry, and weather monitoring industries.

- Continually improve in usefulness and lower in cost.

  As mentioned, nanosatellites have less size, lower prices, and short development cycle than conventional satellites. Nowadays, comparing with initial nanosatellites, nanosatellite developed based on CubeSat standards has significantly reduced cost and improved the possibility of choosing numerous technology suppliers. That further improve its usefulness.

- Spawn innovation in other areas.

  Due to a satellite-based communications network that can reach areas that cellular networks can’t, the nanosatellite technology has offered a great opportunity for IoT industry development especially in remote areas [9]. For instance, based on nanosatellites communications, connected vehicles will be able to work in everywhere.

- Is the GPT fundamentally disruptive and foundational?

  Yes. Nanosatellite technologies represent a low-end-market disruptive innovation, the standard production process reduces the cost of design, manufacture, and deployment [10]. New Space has usually been considered as a disruptive market. For IoT, low-cost satellite communications can provide IoT services in remote areas without communications infrastructures and further drive deployment of the IoT in developing markets [9]. For earth observation, the low-cost disaster monitoring constellation based on nanosatellites allows developing countries which cannot afford the cost of conventional satellites acquire satellite images and better to response different natural disasters.

4. Diffusion of the Innovation

There are five main factors that determine the rate of adoption. According to the result of analysis, the rate of the technology is between 16% and 50%.

- Relative Advantage

  Compared with conventional satellites, nanosatellites are highly innovative and have many advantages. Besides the lower cost, shorter development cycle, and less size, nanosatellite can offer more flexible service as well as have higher data security. In a constellation, renewing any nanosatellite can improve the features and solutions offered [11].

- Compatibility- consistent & needs

  For those developed countries which have sufficient funds and resources to support conventional satellites industry, nanosatellite is a good alternative to help reduce cost and improve efficiency. For example, in 2015, China sent 20 nanosatellites into orbit via single rocket [12]. Those nanosatellites can serve the same purpose as traditional satellites and the launch vehicle do not need to redesign. For developing countries, low-cost nanosatellite creates a great opportunity to utilize space resource.

- Simplicity

  CubeSat specification define genera, mechanical, electrical, operational, and testing requirements for CubeSat development [13]. Also, this standard makes it possible for companies to mass produce related components. Following the standard, it is easily for any organizations to invest in developing and deploying their own nanosatellites.

- Trial-ability

  Besides the low development cost caused by CubeSat standard, the standardized size and shape also significantly reduce the cost of transport and deployment [14]. Therefore, the technology can be experimented with low cost. The degree of trial-ability is high.

- Observe-ability

  The beneficial result of use nanosatellite technology is observable. As mentioned, it provides an opportunity for all organizations and developing countries to use space resource. Applications derived from it such as earth observation, communication and so on play a great role on lots of industries. In 2018, the market size has reached at USD 1.8 billion and will increase to USD 4.8 billion by 2025 [15]. Also, for commercial field, the broadband revenues from nanosatellites are predicted to improve at a CAGR of 29% by 2024 [15].

By analyzing the adoption rate and the characteristics of each stage in TAL model, the technology is currently in the Early Majority stage. As of 2020, nanosatellite has been used for communications, earth observation, scientific research and various fields in 64 countries [15]. The market size has reached at USD 1.8 billion and will increase to USD 4.8 billion by 2025 [15]. It is obviously that almost all aerospace powers have a positive attitude towards this technology and have invested in it. Meanwhile, considering that the advantages of this technology have not yet been reflected in those countries which have no ability to use space resource before, it can be considered that this technology is in the Early Majority stage.

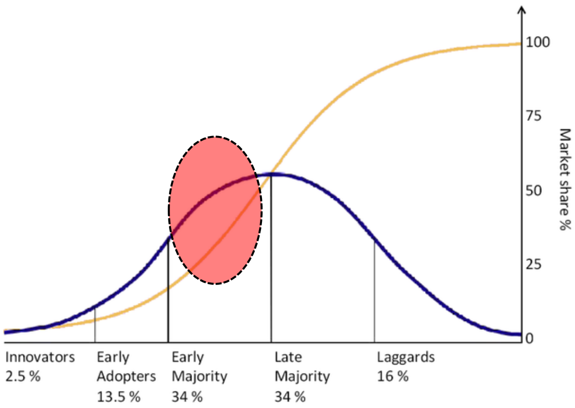

Fig. 2 Technology Adoption Lifecycle Model [16]

5. Dominant Design Analysis

Although there are many differences in structure and design between nanosatellites and conventional satellites, they all belong to the product category: artifical satellite. Artifical satellites have many shapes and sizes, but most of them have two things in common: an antenna and a power source [17]. Antennas are usually used to send and receive information from the Earth. The power source could be a solar panel or a battery. They orbit earth at different speeds and heights. Artificial satellites can collect more data faster than ground-based instruments, this characteristic is the basis of all applications derived by satellites.

There is a dominant design architecture for the artificial satellite now: Cubesat design specification. This architecture has now been adopted by most nanosatellites and is the main factor that reduce the cost of construction as well as deployment. All nanosatellites and related standards are part of the same CubeSat revolution [3].

Some factors in its initial rise to dominance:

- Open and stable architecture. “CubeSats are small satellite multiples of 1 U (10 × 10 × 11.35 cm, weighing less than 1.33 kg), including all the basic subsystems as large satellites but using COTS components" [18]. This standard controls characterics such as shape, size and weight of nanosatellite. When meeting complex massion, the cubesats can be designed to contain multiple 10-centimeter units. For interface, the Cubesat standard define the mechanical external interfaces, such as referring to the interface of the orbital deployer [18].

- Easily available components and low cost. The standard allows related components can be mass produced by suppliers. That makes users can use commerical electronic parts and choose multiple technology suppliers. At the same time, this factor also reduce the cost.
- Design has attracted significant market share and also opened up the low-end market. As of 2019, the total number of nanosatellites launched globally is 1,186, of which 1088 are CubeSats [18].

Nanosatellite technology is a technological discontinuity that is posing a threat to the conventional satellite. For conventional satellite, the high cost and high-tech resource demand form a high entry threshold for developing countries. Nowadays, nanosatellites based on cubesat standard change the situation. Since it can be considered that the cubesate as a dominant design has emerged plus traditional satellites have experienced decades of development, the product category can be evaluated in the Transition Stage. At this stage, industry demand is growing rapidly, and at the same time, with the accessibility of the main design, barriers to entry have become lower [19]. According to the statistic data from Nanosats Database, there are around 400 CubeSat companies are offering missions, platforms, components, software and services for or with nanosatellites [20]. Due to the emergence of dominant design and the path of technological disruption became clearer, Organizations are considering reducing experiments, rationalizing production processes, and acquiring other companies to directly acquire technology.

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