

Small Satellite: The Key to Access Space Technology for Cambodia

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Satellite-related technology and its applications have been for long time a relatively elitist ecosystem, of which only the wealthier countries could be part of, mainly due to its high initial costs, and not immediate benefits. But, lately, due to the evolution of electronics and technology in general, a new wave of satellites is disrupting the scenario, drastically decreasing the barrier to enter the market, while offering a wide spectrum of applications with relatively fast-returning benefits. This aide-mémoire will uncover the types of satellites along with its multi-faceted benefits that range from human development to education and research, communications and beyond, before moving on to understanding the drives before satellite development trend in the region, specifically ASEAN. As a country that has yet to enter the satellite landscape, there are a few things that Cambodia should look into and prioritize to smoothen this part and join in the race along with the fellow ASEAN member states.

What is Satellite?

Satellites are man-made objects launched into space and orbiting around the Earth. They may greatly vary in shape and size, in accordance with

their purpose, but usually, they have two parts in common, namely an antenna, and a power source (May, 2015). The latter one is usually relying on batteries and solar panels to sustain a longer duration while in space. Satellites are important for our daily lives because they represent essential eyes capable of viewing large areas of Earth more quickly and holistically compared to on-ground instruments, in addition to the classic communication purpose. Over the past decades, an increasing number of satellites have been launched and now orbiting the earth, and the number has risen in the past few years, due to the rising number of companies specializing in launching operations, like SpaceX. Currently, there are more than 3,000 satellites actively orbiting our planet (Statista, 2020), with the majority deployed for communication and earth observation purposes (Mohanta, 2021).

Rise of Small Satellite

In the past, building a satellite was a costly process and required advanced technological capabilities. In addition, satellite operation required the construction of complex ground communication stations. Therefore, satellite utilization and its

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benefits were only available to economically wealthy nations (Sweeting, 2018). However, this unbalance of space power has drastically changed in the last few decades thanks to the rise of a new type of spacecraft called “small satellite”. A small satellite refers to a spacecraft that has a mass between 500 kg to 1,000 kg. Small satellites are further divided into subcategories according to their mass: microsatellite (under 100 kg), nanosatellite or CubeSat (under 10 kg), and picosatellite (under 1 kg).

Satellite technology has become more accessible due to two main driving forces. The first force is connected to the recent advancement of electronics, similar to what the computer and mobile device industry has experienced. Today we have computers that are smaller and cheaper than ever and thus enabling more people to own one and thus increasing the accessibility. A similar trend is also happening in the space industry. Electrical components are becoming smaller and cheaper; therefore, building a satellite has also become accessible to less wealthy countries who can rely on components that are available off the shelf for building their own satellite.

The second important force contributing to the increased accessibility to satellite technology is represented by the higher opportunity to launch a device into space. Recently, in fact, a few private space companies such as SpaceX and Rocket Lab have drastically lowered the launch cost, contributing to democratizing the race toward space and satellite deployment. Additionally, due to the smaller size of satellites currently available, these devices can be launched as a secondary payload in the unused available space. Just to provide a better idea of satellite-related costs, in the 1980s, the cost for launching a space shuttle was 85,216 US dollars per kilogram, compared to the astonishing lower today cost of 951 US dollars per kilogram using the SpaceX Falcon Heavy (Fox, 2018).

Additionally, as previously mentioned, smaller satellites have opened the door to new players in the space market. The two most relevant features of small satellites are low-cost and short development time. Compared to the large conventional satellite which may cost up to 300-400 million US dollars, a 50-kg microsatellite only costs around 3 million US dollars to build. For a CubeSat, the costs decrease to roughly 40,000 US dollars to build, excluding the personnel-related expenses. This decrease in costs is possible due to the adoption of the consumer electronics components that can be found in personal computers and automobiles. This drastic reduction allowed smaller players like universities, research institutes, and startup companies, to enter the space market, along with the wealthiest governmental agencies or private companies. This increased accessibility is also representing an opportunity for developing countries that now can access the space industry and research along with big and wealthier nations.

Furthermore, in addition to lowered cost and thus increased accessibility, another advantage offered by small satellites is represented by shorter development time. Specifically, compared to larger satellite which normally takes around five years from their design to their launch, small satellites only take one to two years for the same process. This reduction in development time allows satellites to be used in education for project-based learning as well. In fact, with a five-year development process it would be very hard to deploy satellite-related projects in learning activities due to the long span of the project itself. But education is not the only field that could benefit from satellites. Specifically, from a business perspective, a shorter development time makes it easier to see the possible return of investment for any investor. In simple words, if a company can produce a satellite quickly, it can steadily develop technology by taking a step-by-step approach. Overall, it decreases the chance of failure and

increases the chance that the business model may succeed.

The Benefits of Satellites

Satellites may be deployed for a variety of purposes. For instance, by observing the Earth, satellites help us predict weather and climate by providing information about oceans, clouds, ice, and land. Moreover, they help us with urban planning-related activities by tracking the changes in the growth of cities and in general urban areas, monitoring the growth over a time span ranging from a few years to decades. Furthermore, satellites are heavily deployed in the communication industry. Specifically, they help us in long-distance communication of data, generally called satellite communications. In addition to the most classical satellite applications, the usage of small satellites as a constellation is currently disrupting the market. Communication using small satellites also provides connectivity to populations in remote areas and facilitates access to the internet as well as the integration of ICT into public services such as healthcare and education, improving their efficiency and, as a result, the quality of life of people. By deploying thousands of small satellites at a low earth orbit, it is possible to cover a large area with daily revisit time, thus, enabling Earth observation in addition to the aforementioned communications.

In the specific, Earth observation using small satellites can benefit several sectors in multifold applications, thus, supporting the race toward the United Nation's Sustainable Development Goals (SDGs). For instance, satellites can support monitoring crops and agricultural production, water quality, land and natural resource management. Earth observation satellites are important not only for improving agricultural techniques and increasing yields but also for assessing and predicting food security, allowing for timely mitigation and prevention activities (Brown, 2015). Earth observation satellites also enable the

surveillance and consequently prevention of illicit activities such as illegal logging and natural disaster forecasts, enabling both effective prevention and reaction to these crises, eventually safeguarding populations and saving lives. Satellites offer the opportunity to use remotely sensed data, and associate geospatial science and technology, thus, offering a solution to major barriers already identified in many countries, such as the usual lack of reliable and timely, spatially explicit and scalable data on slavery activity (Boyd et al., 2018).

In addition to the already mentioned applications, control of the borders and security applications (Rath & Mishra, 2020) are other suitable examples of satellite adoptions that have multifold benefits. Satellites in fact can be deployed for environmental security (Rothe, 2017), maritime security (Carpenter, 2015), border monitoring (Akkerman, 2018; Sacco et al., 2016), and even to secure communications for IoT devices (Marchese et al., 2019). Additionally, satellites can also be deployed for tracking illegal activities like human or drugs trafficking, thus, helping in addressing the 8th goal of the SDG. Regarding this, in fact, satellites have proven efficient and powerful in the fight against human trafficking, forced labor (McDonald et al., 2021), and slavery (Boyd et al., 2018). Aside from application-driven impacts and advantages, the development of small satellites as research projects in universities is a crucial agent for the socio-economic growth of a country. It demonstrates this by enabling the growth of knowledge-based societies marked by an increase in STEM-educated people, improvements in universities and the quality of scientific research. STEM education, in fact, is an essential element to support the digitalization process and digital transformation currently happening in Cambodia (Corrado et al., 2021; Corrado & Tungjan, 2019).

The space economy is rapidly growing and is a contributor, directly and indirectly, to 10 percent of the gross domestic product in advanced

economies, through space-related technologies and assets (ITU, 2021). In fact, due to these satellite-related benefits, the ITU clearly expressed the importance of relying on satellites to reach the SDGs (ITU, 2021). With the democratization of satellite-related technology introduced by this relatively new category of satellites, several ASEAN members have taken advantage of this and boosted their satellite-related projects while expecting to benefit from the numerous affordances enabled by satellite technology.

Space Development Amongst ASEAN Countries

The space is not something new for ASEAN. In the past years, ASEAN members have already shown commitment in dedicating more attention to the space industry, with an increasing focus and investment in this field.

For instance, Vietnam has made large investments in the space-related industry, after identifying its importance in supporting military and foreign affairs plans, while at the same time, enables them to achieve sustainable development goals (Sarma, 2019). Vietnam has focused mainly on the production of space-related technological equipment, such as nano-satellites, GPS high-resolution receivers, and mobile receiving station, while at the same time boosting their research and development capability, with a specific focus on developing launcher rocket techniques (Sarma, 2019). These projects have been used also for driving international cooperation projects, both for research and human development purposes (Sarma, 2019). Indonesia has established its own national space agency called LAPAN (Judianto & Nasser, 2015) and has already shown its commitment in focusing on space science, remote sensing, development of aerospace technology, launching and commercialization of space activities, with the majority of Indonesia's space program involving applications of space communications, meteorological satellites, remote-sensing satellites and research related to legal and

socio-economic aspects of space technology (Sarma, 2019).

Thailand, which is not new to using satellite-generated data (Arepalli et al., 2019; Worrakul et al., 2017), has been using satellites for the management of its natural resources, research and development and security and defence strategies (Sarma, 2019). Regarding Singapore, even if its interest in space technology is relatively recent compared to other ASEAN members, it has shown interest in applications related to space technology for communications, control of resources, and educational aspects (Sarma, 2019). Singapore is also building a talent pool with technical expertise in satellite technologies (Levchenko et al., 2018; Potrivitu et al., 2020) and various university programs are providing the relevant courses (Sarma, 2019). Also, the Philippines showed interest in space technologies (Verspieren et al., 2018), and the major step was probably the one taken in 2012 with the creation of the Philippine Space Act. Although initially the public opinion expressed discontent toward developing expensive space technologies considering the persisting poverty rates across the country, soon after the opinion changed drastically due to the ability of satellites to support extreme natural events and, thus, save lives (Sarma, 2019).

If some of the aforementioned examples of satellites application represent the more classic satellite generation tied to high costs and investments and, thus, represent a more elitist industry for the wealthier countries, this is not true for all of them. In fact, with the introduction of small satellites previously mentioned, the situation has drastically changed, allowing developing countries like the Philippines or Vietnam to enter the satellite industry. In the specific, regarding small satellites, a few ASEAN countries, including Vietnam and the Philippines have recently participated in space activities through small satellite development projects. For Vietnam, its first small satellite called "PicoDragon", weighed 1kg, was launched in

August 2013 (Cottom, 2019). Vietnamese engineers developed PicoDragon with the help of the Japanese Aerospace Exploration Agency (JAXA). During the development of PicoDragon, many Vietnamese students were sent to study in Japan, thus, triggering and contributing to the space-related education in the country. Following a similar path, the Philippines also initiated their space activities by developing small satellites through collaboration with Japanese universities. As a result, two Filipino 50kg-class Earth-observation microsattellites named DIWATA-1 and DIWATA-2 were successfully launched in 2016, and 2018 respectively (Verspieren et al., 2018). DIWATA-1 and DIWATA-2 both carry Earth observation payloads that contribute to remote-sensing applications, including disaster assessment and environmental monitoring in the Philippines (Verspieren et al., 2018). As a result of these projects, both Vietnam and the Philippines have established their own space agencies in 2017 and 2019 respectively.

In summary, many of the ASEAN members have already identified the multifold benefits of satellite technologies, with countries like Singapore, Thailand, Malaysia, Vietnam, and the Philippines have greatly increased their focus on satellites applications. The aforementioned examples are only some of the directly related-ASEAN cases of how developing countries can take advantage of small satellite development to kick-start wider space research and development activities, while at the same time, developing local human resources in the space field.

Space Initiative in Cambodia

Currently, Cambodia is one of the ASEAN countries that neither own any satellite nor has any domestic space institute. In recent times, the Royal Government of Cambodia (RGC) has shown some interest in promoting the nation's space capabilities through the development of the first country's satellite. Specifically, in 2011, the Ministry of Post

and Telecommunications (MPTC) provided a concession to the Royal Group's Royal Blue Skies subsidiary to develop the country's first satellite starting from 2013, with a focus on high speed, high quality and high capacity telecommunications (Sok, 2017). However, the project did not meet fruition probably due to the high development costs and the lack of domestic human resources to support the endeavor.

Besides the aforementioned case, there have been a few more space initiatives from educational institutions to promote space education in Cambodia. For example, high school students from the LigerSat Leadership Academy initiated a plan of developing a 1U CubeSat called "LigerSat" in 2019 (Oun, 2019). Recently, a group of high school students from E2STEM has successfully launched their model CubeSat into the outer atmosphere using a space balloon as part of a competition (Mao, 2021). At the university level, an ongoing 1U CubeSat called Apsara-1 has been proposed, as a result of a collaboration project between the Institute of Technology of Cambodia and the University of Tokyo (Berthet et al., 2021). Overall, there is a growing interest of the young generation in studying space technology.

Why is the Space Industry not Growing in Cambodia?

The development of space technology in Cambodia is not progressing as compared to other ASEAN countries due to two main reasons. First of all, the approach to access space technology and its benefits to the social-economics aspect of Cambodia is still not yet clearly understood. Secondly, Cambodia has a limited number of experts and researchers in this field who can help raise awareness about the affordability and affordances of space technology, and thus, promoting and offering recommendations to the involved stakeholders on which path to take. Cambodia's absence in the satellite game is thus leaving Cambodia empty-handed regarding the

opportunity to use satellites for the numerous benefits aforementioned, from establishing international cooperation for human development to education and research, space communications, meteorological applications, natural disaster management and general management of national natural resources, and nurturing national and domestic security strategies.

Recommendations for Cambodia

In order to access space technology and create a sustainable space industry for Cambodia, the country should promote local space research and development, through international collaboration and exchange, following a similar path to the one taken by other ASEAN countries. Specifically:

(1) Human Resource Development

The priority consists increasing human skills in the space field. Recently, a few universities have adopted small satellite projects for their engineering curriculum due to its ability to provide useful learning experiences based on project learning for the students. To effectively produce human resources in the space sector, the Ministry of Education, Youth, and Sport (MoEYS) should promote project-based education and research training in Cambodian universities, allowing students to participate in space-related projects. To cultivate the talent and passion of the younger generations, competitions related to space shall be organized annually. Space projects such as CanSat and water rockets can be a good starting point to cultivate the talent and passion of the students. This may promote not only space-related education but may also promote STEM education in the country, which is one of the main goals of the MoEYS, together with the MPTC. It is important to start small and keep the momentum.

(2) Partnership with International Institutes

International cooperation was crucial to many ASEAN countries' early success in the space field, and it continues to be the case today. To foster the

ability to develop a satellite in a faster, cheaper, and more sustainable way, Cambodia needs to encourage universities to start working on space projects and take part in international frameworks. This would allow the establishment of collaboration with more experienced countries in space technology for building infrastructure and ensuring the training of local human resources. Strong cooperation projects may lead to knowledge transfer and positive spillover effects on other sectors of the Cambodian economy, especially those areas related to engineering and STEM in general.

(3) National Strategic Roadmap

After understanding the benefits that space technology could bring to socio-economic growth and in general to the race toward the achievements of the SDGs, it is important for Cambodia to develop a strategy and road map with a long-term vision for space utilization, that is aligned with the current policies and social-economics development goals. Without the support from the top, the bottom-up approach currently pursued by research institutes in Cambodia would hardly sustain. It is important to create a demand of space-based data amongst the Ministries. Space-based data play many significant roles in helping the RGC Ministries. For instance, the Ministry of Environment can take advantage of satellite data for forest monitoring and forest carbon capture. The Ministry of Defense can use satellite data to monitor the disputed border area. The Ministry of Agriculture can use satellite data for predicting the agriculture products yield during a year. The MPTC can leverage satellites for communications and supporting remote area coverage. Creating such needs for using space-based data would help accelerate the space research and development activities in the country.

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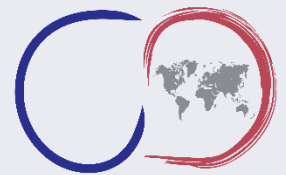
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