Strategic Environtment and Implementation of Satellite Technology Acquisition Programs in ASEAN

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ABSTRAK – Seiring dengan pertumbuhan ekonomi di negara-negara ASEAN, keinginan negara-negara tersebut untuk menciptakan pekerjaan dengan nilai tambah tinggi atau yang padat teknologi semakin besar. Hal tersebut, dipadu dengan motivasi klasik untuk menciptakan kebanggaan bangsa dan strategi hankam, membuat negara-negara tersebut memulai pengembangan program keantariksaan. Karena merupakan pengguna satelit, beberapa negara ASEAN memulai program antariksanya dengan penguasaan teknologi satelit. Kajian literatur menunjukkan bahwa tujuan dari program tersebut adalah untuk dapat memproduksi satelit di dalam negeri. Karena latar belakang tersebut, makalah ini membahas tentang program penguasaan teknologi satelit di negara-negara ASEAN, dengan fokus pada lingkungan strategis dan implementasinya. Tujuan dari kajian adalah untuk membuat peta posisi program dari masing-masing negara. Metoda kajian adalah deskriptif analitis, di mana dibuat rangkuman dan perbandingan dari skala dan cakupan program, regulasi teknologi, dan pengembangan organisasi pelaksana di masing-masing negara. Hasil kajian menunjukkan bahwa semua negara ASEAN memulai penguasaan teknologi satelitnya dengan mengembangkan satelit penginderaan jauh. Dari negara-negera tersebut, skala program teknologi satelit milik Singapura dan Malaysia adalah yang tertinggi untuk saat ini, dan dimasa depan, program teknologi satelit Vietnam akan dapat menyamai skala program milik Indonesia dan Thailand. Karena terbatasnya investasi, program teknologi satelit Indonesia diperkirakan tidak akan berkembang lebih dari skala satelit mikro, kendati penguasaan teknologi dan badan antariksa telah dimiliki.

Kata Kunci: teknologi satelit, ASEAN, program antariksa

ABSTRACT *– With the growth of economy in ASEAN countries, their desire to create high value-added jobs or high technology industries are increasing. Such drive, in addition to the clasic motivation of creating national pride and strategy for defense and security, made many of them started to have national space program. Since they are satellite users, they started the program with acquiring satellite production technology. Due to such background, the paper discusses about satellite technology acquisition programs in ASEAN countries, with focus on the program's strategic environment and implementation. The objective of research is to establish positioning map of satellite technology aqusition program in ASEAN. The method used is decriptive analytics, in which data on the program scale and coverage, technology regulations, and institutional buildings in each countries were sumarized and compared. The study shows that all of the ASEAN countries started their satellite technology acquisition by developing remote sensing satellites. It is found that Singapore and Malaysia are the highest in current satellite technology program scale, and in the future, Vietnam's program scale will catch up with Indonesian and Thailand's. For Indonesia, even though it has technology mastering and space agency, but lack of investment made it unable to move beyond micro-satellite program*

Keywords*: satellite technology, ASEAN, space program*

1. INTRODUCTION

1.1. *Background*

Economic growth in Asia in the past 20 years has surpased the world average (IMF, 2017). Data shows that the countries' GDP per-capita, represented by Japan, Korea, China, India, Thailand, Malaysia, Philipines, and Indonesia, have increased at the minimum twice from 1990 to 2010 (Restrepo-Echavarria, 2017). Technology, i.e. mechanization and automation, and the improvement in the quality of human resources are, among others, the factors that increase productivities, and therefore, brought the economic growth (Woetzel, 2015). Such technology-based economy made Asian countries acquiring more technologies by investing in infrastructures and human resources, to ensure their sustainable economic growth. Among others, this was reflected by the growth in scientific publications made by academic communities in Asian countries, which indicates the strengthening of academic institutions and therefore knowledge-based economy (Moed and Haleva, 2014).

ASEAN (Association of South East Asian Nation) is a muti-national organization that currently consist of 10 countries in South East Asia, i.e. Thailand, Malaysia, Philipines, Singapore, Myanmar, Cambodia, Vietnam, Laos, Indonesia, and Brunei. The membership has grown from its initial 5 members when founded in 1967. The purpose of the organization is to promote cooperation in economy, politics, education, security, and socio-cutural. As mentioned by previous paragraph, some of ASEAN countries are among the highest in Asian economic growth.

As for the use of space technology, most in ASEAN countries use and own telecomunication satellites. Such usage was started by Indonesia in 1976, due to its nature as largest archipelago. Currently, all major ASEAN countries own telecomunication satellites. The satellites, however, are usually owned by private companies, as telecomunication industries in the region is among the highest in market expansion (Åström, 2015).

The United Nation started to promote the use of space-based remote sensing technology in late 80s. Since then, many developing countries, including in ASEAN, start to adopt remote sensing technology as part of their the national development strategy. Among others, Indonesia, Malaysia, Vietnam and Thailand has addopted the technology in their agriculture, environtmental monitoring, and fisheries. Unlike in telecomunication satellite, activities in space-based remote sensing is mostly done by government institution or considered public services.

1.2. *Research question*

It is expected that the study will provide comprehensive map on ASEAN countries' space program. The data can be used to predict the future of space activities in the region. One of them is whether G-to-G collaborations in space technology are possible between ASEAN countries, knowing that they have economic and political ties.

1.3. *Objectives*

The objective of the research is to establish positioning map of satellite technology aquisition programs in ASEAN countries. The study focus on the phenomena happen in the last 15-10 years, where many of the countries began developing domestic capacity in remote sensing satellite technology.

1.4. *Methodology*

The method used is in this research is descriptive analytics. Similar method has been used in space technology comparison studies as done be Ansdell (2011) and CRDS (2015). In this research, data on the program scale and coverage, technology regulations, and institutional buildings in each countries were sumarized and compared.

2. DATA MINING RESULTS

Even though the market value on the use of geostationary telecommunication satellites is much higher than low Earth remote sensing satellites, the technological difficulty for geostationary satellites is much higher. Therefore, in the effort of technology acquisitions none of ASEAN started their program with telecommunication satellite. Many of them follow the satellite development trend at universities in developing countries, where, to optimize the cost, use auxiliary payload launch opportunity. Such choice limits the satellite that can be built to micro-satellite class (weight less than 150 kg).

Thailand initiated its national remote sensing satellite development program by building TM-sat, that was launch in 1998. The micro-satellite was built with the assistance of University of Surrey, and has mission of experimental imager and capacity building (Sweeting and Pookyaudom, 1997). The country established agency named GISTDA (Geo-Informatics and Space Technology Development Agency), that in-charge in implementation of remote-sensing technology. The agency then bought a 750 kg remote sensing satellite from Astrium (France), and gave name of THEOS-1 (Thailand Earth Observation System). The satellite has 2 m panchromatic and 15 m multi-spectral imagers, with swath of 90 km, and was launched in

2008 (Vongvivatanakij, 2008). At the time it was the most powerful remote sensing satellite owned by an ASEAN country. The performance of TMSat and THEOS-1 can be seen in Figure 2-1.

After the decommissioning of Theos-1 in 2014, GISTDA plan to establish the 2nd Thailand's remote sensing satellite, i.e. THEOS-2. The plan, however, were delayed for few years, so that until now the subsequence satellite has not been launched (GISTDA, 2017).

Figure 2-1. TM-sat and its image result (San Francisco bay), and Theoss-1 image result (Vongvivatanakij, 2008)

Malaysia started its remote satellite technology development program by building its 1st micro-satellite, TiungSat, with the assistance of University of Surrey. The satellite carried an experimental imager payload, and was launched in 2000. The owner of the satellite is ATSB (Astronautic Technology Sdn Bhd). The state-owned company was established on 1997 by the Malaysian Ministry of Science, Technology and Innovation (MOSTI), and in-charge of developing satellite technology. At the time, Malaysia also has a remote sensing agency named MACRES (Malaysia Center for Remote Sensing).

Second remote sensing satellite developed by Malaysia is RazakSat-1. For its development, ATSB built satellite integration and test facilities in Malaysia (see Figure 2-2). The payload of the 180 kg satellite was developed with the assistance of Korean company SatReci (Kim et. al, 2003). The satellite imagers have resolution of 2.5 m (panchromatic) and 5 m (multispectral), with swath of 20 km, and was launched to near equatorial (low inclination) orbit as dedicated launch by SpaceX in 2009.

Figure 2-2. Malaysian 1-ton class satellite integration facility and Razaksat-1 (ATSB, 2014)

RazakSat-1 is declared inoperative 1 year after its launch. ATSB then prepares the development of RazakSat-2. The satellite will have panchromatic imager with 1 m resolution and multi-spectral imager of 4 m, and will be launched in 2019 (TDA, 2016).

Singapore started its remote sensing satellite technology development by acquiring UoSat-12 micro-satellite from University of Surrey. The owner of the satellite is NTU (Nanyang Technology University). The satellite carried an experimental imager payload, and was launched by DNPER in 1999. After that, NTU

developed its 2nd micro-satellite, XSat. The satellite has multispectral imager with 10 m resolution and 50 km swath, and was launched by PSLV (India) in 2011. The image result of XSat can be seen in Figure 2- 3.

After acquiring micro-satellite technology, Singapore went into commercial approach by developing Teleos-1 satellite. The 400 kg satellite is owned by private company, STE (Singapore Technology Engineering), has panchromatic imager with resolution of 1 m, and launched into near equatorial orbit using PSLV in 2016 (ANTRIX, 2016). Currently, STE is developing its 2nd satellite, Teleos-2, which will carry SAR payload (Hui, 2017).

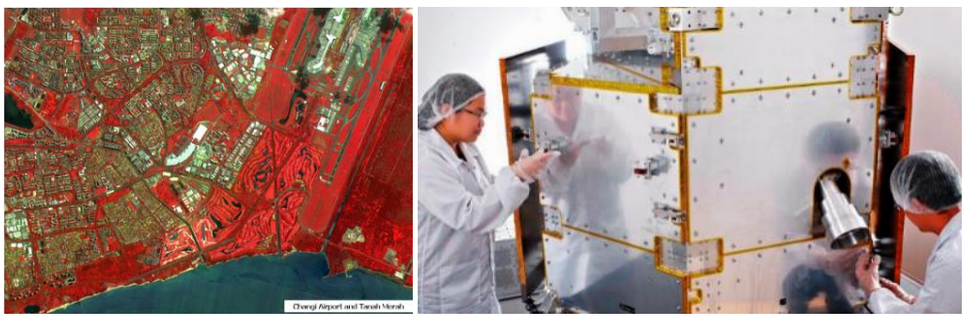

Figure 2-3. Image result of XSat (NTU, 2016) and development of Teleoss-1 (Via Satellite, 2016)

Vietnam 1st remote sensing micro-satellite is VNREDSat-1. The satellite is made by France company, Astrium, and has 2,5 m resolution panchromatic imager and 10 m resolution multi-spectral imager (see Figure 2-4). The 130 kg satellite was launched with launched as auxiliary payload of European launcher VEGA in 2013 (Phuong, 2016). The reference also mentioned that the next remote sensing satellite to be acquired by Vietnam is LotusSat-1 and LotusSat-2. Both satellites will carry X-band SAR with image resolution of 1 m. The 500kg satellites are built by NEC (Japan), and the 1st satellite is expected to be launched in 2019.

To handle the satellite development program, Vietnam Academy of Science and Technology (VAST) established Vietnam National Satellite Center (VNSC) in 2011. Especially for technology acquisition, VNSC also developed micro-satellite named MicroDragon. The satellite was built with the assistance of Tohoku University and Hokkaido University, to give VNSC personnel hands-on experience in satellite development (Hiramatsu et al., 2016). The satellite was launched by Epsilon rocket in 2018. The goal of VNSC is to be able to build LotusSat-2 in Vietnam, therefore, they prepare satellite integration and test facilities as illustrated in Figure 2- 4, to be completed in 2020 (Phuong, 2016).

Figure 2-4. VNREDSat-1 (top), JV-Lotus-1, and plan for Vietnam satellite center facilities (Phuong, 2016)

Philippines started its remote sensing satellite development program by developing PHL-sat (DIWATA-1). The 50 kg satellite is built with the assistance of Tohoku University and Hokkaido University, and launched via International Space Station (ISS) in 2016. The development and operation of DIWATA-1 uses the human resources from University of Philippines. To sustainably handle the satellite development, Department of Science and Technology (DOST) assign on of its subsidiary, Advanced Science and

Technology Institute (ASTI). The agency is now developing Philippines 2nd satellite, DIWATA-2 (Marcianno, 2016). DOST also currently crafting of a national space development and utilization policy.

Among ASEAN nation, Indonesia is the first one to have space agency, named LAPAN, in 1963. LAPAN established remote sensing application division in late 80s, and currently become the national remote sensing data center. Using data from international medium and high resolution satellites, the division serves Indonesian ministry of agriculture, for predicting harvest, ministry of forestry, for logging monitoring and forest fire detection, and mapping agency (Roswintiarti, 2010).

LAPAN started its remote sensing satellite development program in 2003, with the development of LAPAN-A1/TUBSAT. The satellite was developed at TU Berlin, Germany, with the mission of Earth surveillance and capacity building. The satellite was launched as auxiliary payload by PSLV in 2007. After its 1st year of operation, LAPAN started the development of its 2nd and 3rd microsatellite, named LAPAN-A2/ORARI and LAPAN-A3/IPB, in the country. For that, LAPAN established Satellite Technology Center, which has infrastructures to develop and operate micro-satellites (Triharjanto, 2015). LAPAN-A2/ORARI, which carry RGB camera with resolution of 5 m, and AIS (ship tracking system), was launched to near equatorial orbit as auxiliary payload of PSLV in 2015. LAPAN-A3/IPB, which carry 20 m resolution multi-spectral imager and AIS, was launched to polar orbit also with PSLV in 2016. LAPAN is currently developing and planning its 4th and 5th microsatellites, i.e. LAPAN-A4, which will carry multi-spectral imager and IR camera, and LAPAN-A5/ChibaSat, which will carry synthetic aperture radar and AIS (Triharjanto and Hakim, 2017).

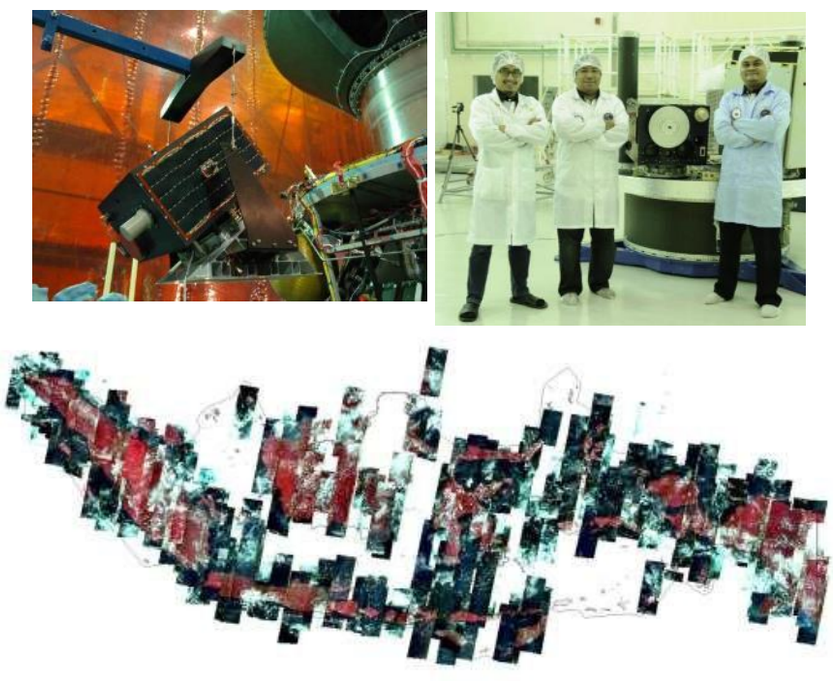

Figure 2-5. LAPAN-A1 and LAPAN-A3 during launch vehicle assembly, and almost national coverage results of LAPAN-A3 images (Hakim, 2107)

Based on references mentioned above, the ASEAN countries satellite development programs can be summarized in table 2-1 to 2-3.

Table 2-1.: General Summary of ASEAN Countries Satellite Program

Country	Program started	Satellite built		Executing agency	Space Agency /Stakeholder	Technology partners
		In the country	In partner country			
Indonesia	2003	LAPAN-A2, LAPAN-A3	LAPAN-A1	LAPAN	LAPAN /integrated with remote sensing agency	TU Berlin; Chiba Univ.
Malaysia	1995	**Razaksat-1**	Tiungsat	ATSB	Angkasa /MACRES (remote sensing agency)	Univ. Surrey; SatRec Initiative
Philippines	2014	-	Diwata-1	ASTI/Univ. Philippines	None /DOST (policy)	Tohoku/Hokkaido Univ.
Vietnam	2010	-	VNREDSat-1, Micro-dragon	VNSC	None /VAST (policy)	Astrium; Tohoku/Hokkaido Univ.; NEC
Singapore	1995	XSat, VELOX-CI, **Teleos-1**	UoSat-12	NTU, STE	None, only space industry forum (SSTA)	Univ. Surrey; Orbital-ATK
Thailand	1995	-	TM-sat, **Theoss-1**	MUT, GISTDA	None/ (remote sensing agency)	Univ. Surrey, Astrium

Note: bold-red = non-micro, dedicated launch

Table 2-2.: Satellite Mission Launched by ASEAN Countries

Country	Satellite (launch)	missions	Payloads
Indonesia	LAPAN-A1 (2007)	Experimental Earth observation	Video camera
	LAPAN-A2 (2015)	Earth observation; maritime surveillance; amateur communication	RGB camera; AIS; APRS; voice repeater
	LAPAN-A3 (2016)	Land cover; maritime surveillance	Medium res. multi-spectral imager; AIS
Malaysia	TiungSat (1997)	Land cover; amateur communication	Medium res. multi-spectral imager; store-forward
	Razaksat-1 (2009)	Land cover	High res. multi-spectral imager
Philippines	Diwata-1 (2016)	Land cover; weather	Hyper-spectral imager; IR camera
Vietnam	VNRedSat-1 (2013)	Land cover	High res. multi-spectral imager
	Micro-dragon (2018)	Land cover; weather	Hyper-spectral imager; IR camera
Singapore	Uosat-12 (1997)	Experimental	Medium res. multi-spectral imager; store-forward
	XSat (2011)	Land cover	Medium res. multi-spectral imager
	VELOX-C1 (2015)	Climate monitoring	GPS occultation
	Teleos-1(2015)	Mapping	High resolution imager,
Thailand	TM-sat (1997)	Land cover	Medium res. multi-spectral imager; store-forward
	Theoss-1 (2008)	Land cover, mapping	High resolution multi-spectral imager

Table 2-3.: Future Satellite Mission of ASEAN Countries

Country	Satellite (predicted launch)	missions	Payloads
Indonesia	LAPAN-A4 (2020)	Land cover; maritime surveillance; science	Medium res. multi-spectral imager; AIS; magnetometer
	LAPAN-A5/ChibaSat (2022)	Land cover; Land deformation; maritime surveillance; ice monitoring	Synthetic Aperture Radar; AIS
Malaysia	**Razaksat-2** (2019)	Land cover; amateur communication	Medium res. multi-spectral imager; store-forward
Philippines	Diwata-2 (2018)	Land cover; disaster mitigation	Hyper-spectral imager; IR camera
Vietnam	**JV-Lotus1**(2019)	Land cover; disaster mitigation	Synthetic Aperture Radar
	JV-Lotus2 (2022)	Land cover; disaster mitigation	Synthetic Aperture Radar
Singapore	**Teleos-2** (2021)	Land cover; disaster mitigation	Synthetic Aperture Radar
Thailand	**Theoss-2** (2019)	Land cover, mapping	High resolution multi-spectral imager

3. ANALYSIS

3.1. Program Scale

Scoring system is chosen to measure current program scale. One of them is on the program duration and investment. Data in chapter 2 shows that all the ASEAN countries started their satellite teechnology acquisition with micro-satellite program, which is known to require very low investment. Table 2-1 shows that Malaysia, Thailand, and Singapore started the endeavour, followed by Indonesia, then Vietnam, and lastly Philipines. The data shows that after their micro-satellite initiation, 3 countries, i.e. Malaysia, Thailand, and Singapore have moved into larger-class satellites, and therefore required dedicated launches. Typical cost of micro-satellite program, including its launch as auxilary payload, is about 4-9 M USD. 1-ton class remote sensing satellite, such as Theoss, cost more than 100 M USD, in which dedicated launch cost could take 30-40%. Such choice shows that the current investment put into the program by the countries which use dedicated launch are the highest.

Satellite technology mastering could be indicated by the number of satellites produced domestically. Table 2-1 shows that Indonesia and Singapore are the countries with highest number of satellites being made domestically. Countries that started the program later, i.e. Vietnam and Philipines, has ot yet produce satellite in their country.

The existence of space agency is considered important parameter in the program scale, since it might ensure the availability of human resource to run the program.Table 2-1 shows that only 2 countries have space agencies, i.e Indonesia and Malaysia. Another indicators selected to measure program scale is technology partners. Table 2-1 shows that country with highest number of technology partners is Vietnam.

The summary of parameters is shown in table 3-1. It shows that Malaysia and Singapore score the highest on current program scale. The future progam scale is indicated separately since in space program (red marks), many factors can affect its sustainability and timeliness. Table 3-1 shows that in the future, Vietnam will enter the large investment group, which currently consist of Malaysia, Thailand, and Singapore. When Philipines established its space agency, its program scale will also increase as its program scale.

Table 3-1.: ASEAN countries satellite technology's current and future (red) program scale indicators

Country	Indonesia	Malaysia	Philippines	Vietnam	Singapore	Thailand
Start of program		X			X	X
Investment		X		X	X	X
Technology mastering	X				X	
Space agency	X	X	X			
Technology partners				X		
Total current scale	2	3	0	1	3	2
Total future scale	2	3	1	2	3	2

3.2. Emerging Space Countries : Possible ASEAN Collaboration

The space technology pioneer countries, such as United States and Russia, use national defense and national pride as the motivation for their space program. The countries started their program with launch vehicle development, which considered dual-used or can be used for civilian (for satellite launcher) or military purposes (as strategic weapons). This full-fledged approach require large investment to upgrade the nations' industrial capacity and human resources.

The 2nd generation of space-faring countries, such as China, India, and European nations also uses the same motivation to drive their space program, and therefore, adopting the full-fledged space program. The different from the earlier space fairing generation are :

1. The European nations have a join space agency to for their civilian launcher program.
2. Germany and Japan does not built strategic weapons based on their satellite launcher technology, which is most probably due to post world-war II policies.
3. India and China are less industrial developed nations when their space program was started. Therefore, the effort to built industrial and human resources capacity is far greater than others.

As for the 3rd generation of space nations, there are two kinds of approaches that the countries done : i.e. the ones that try to reach the status of space-faring nation, and the ones that conduct only satellite development program and relying on space access from international market. The 1st approach is done by Brazil (Globalsecurity, 2003) and South Korea (TASS, 2016). They intended to develop independent accces to space, but at the moment still depend on their strategic partner, in this case Ukraine and Russia. The 2nd approach, which can be catagorized as partial space progam, since only develop satellite technologies, is done by many countries, including South American countries like Bolivia and Argentina; ASEAN countries as mentioned in chapter 2, and mediateranian countries Turkey (sputniknews, 2016) and Algeria (ASAL, 2016).

By not building space launcher, the 3rd generation space countries that uses 2nd approach clearly shows that their motivation is economy. Even the ones that built space launcher technology, have not indicating that the technology acquisition will be used for strategic weapon. The countries that implement partial space program usually driven by academic communities, which for ASEAN countries case highly reflected in table 2-1. For ASEAN most countries case, the use of satellite technology public services is highlited by establishing remote sensing agencies. The the use of satellite technology for economic benefit is highlited by Singapore, which private company partcipated as soon as the academic finished with technology acquisition phase.

Table 2-2 and table 2-3 shows that the majority of the mission selected by the ASEAN countries are land cover. Other mission they are interested is mapping and disaster mitigation. For such purpose, the satellite payload required is multispectral imager and SAR. Therefore, technically, colaboration in satellite program can be done among ASEAN countries, in the form of join (satellite) investment or data sharing. 3

countries, i.e. Malaysia, Indonesia, and Singapore, have launched satellite to near equatorial orbit, which is also a common interrest. However, only 2 of the ASEAN countries have space agency. This could lengthen the collaboration effort since the legal base, and interest of the countries are different.

4. CONCLUSIONS

The study concludes that among the ASEAN countries that have satellite technology development program, currently, Singapore and Malaysia are considered to have the largest program scale. Singapore got its score from investment, program duration, and technology mastery, while Malaysia earn score in investment, duration, and existence of space agency. In the near future, the program scale of Vietnam will be in the same level with Indonesia and Thailand, due to its investment. For Indonesia, even though it has technology mastering and space agency, but lack of investment made it unable to move beyond micro-satellite program. For Thailand, even though the program has been initiated 20 years ago and significant investment was done, the lack of space agency that could give future direction, halted the satellite technology mastering process.

Based on the space program strategy selected, the purpose of the ASEAN countries satellite program is clearly civilian. The program will certainly give economic benefit and improvement in quality of human resources in the country. Therefore, all of the countries' program will be sustainable if not growing in scale.

The potency for collaboration is high due to the countries' common mission interest and ASEAN economic bound. In such collaboration, the countries' can also fill-up each other weakness, and strengthen their position against space faring countries that consider them as technology market. The formality of such collaboration, however, might be complicated due to different mode of institutional building in each country.

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