End of AY 2017 Report for SIP – Group 4

Project Title

Disaster Management for the Future: Technological packages for Natural Disasters

Team

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Objective: Explain what social/global issues that this project tried to address and why the issue is important.

The social issue we address in this project are the frequent natural disasters in Southeast Asia, which has interfered with its sustainable development. The goal of this project is to think about ways to prevent/mitigate natural disasters in Asia - with a special focus on Southeast Asia - using space-based assets. This proposed program aspires to achieve this via two-pronged holistic approaches. One is to evaluate the demand for managing and mitigating natural disasters in Southeast Asia. The other is to design a feasible observation system for natural disasters considering supply and cost-profit calculations. And the "technological package" is a concept of our way of solving social issues. Generally, space technology itself can not contribute to application field easily, and it is difficult to be handled in developing countries because of its difficult operation and management, as well as expensive use of the observed data. Thus, we provide our solutions as "technological packages" with concrete business model and economic efficiency.

Method: Explain through what kind of approaches you tried to achieve the objective.
*About the list and details of the interview, add the appendix.

[1st-year approaches]

First, in order **i) to clarify the concrete demands for managing/mitigating natural disasters in Southeast Asia**, we tried to identify what kinds of damage and social problems have been caused by natural disasters there by categorizing the types of natural disasters and investigating some disaster cases, and summarized the statistics on damages caused by natural disasters. Besides, **ii) we investigated through several discussions and a bibliographic survey about what kinds of space technologies are effective to prevent the occurrence of natural disaster/mitigate damages from natural disasters or to minimize the disaster risk**, and found that a synthetic aperture radar (SAR) satellite technology could be a breakthrough in terms of its versatility for any situations caused by disasters. We confirmed the effectiveness of the technologies and determined how to utilize this technology while considering the limitation of the technology export, difficulties of analyzing the raw data, and cost-effectiveness. Finally, **iii) we made a business model as "technological package", which provides the SAR-satellite data to Southeast Asia as a package including not only raw data but also developing satellite observation systems, data collection/analysis, and information providing services**.

[2nd-year approaches]

Our project this year is focusing more on **iv) the output of this project to the society in order to verify the feasibility and further applicability of this technological package by getting feedback from specialists or multiple stakeholders including space agencies, technology developers, launch providers, investors, international organizations**. The International Astronautical Congress (IAC) is one of the largest conferences, and there are many specialists in that field attending every year. We refined our project to a more realistic one by receiving such fruitful feedback from specialists. Besides, **v) we shared our outcomes and what we have learned through this 1.5-year project with other GSDM students by opening an IEL on Feb.28**.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

In this project, we proposed a system of 14 small satellites with X-band SAR, which can be used to mitigate typical natural disasters in Southeast Asia: wildfires and floods. Compared to conventional SAR satellites such as ALOS-2 with a 14-day revisit time, the proposed system realizes frequent observation with a 2-day revisit time, enabling immediate imaging.

To investigate its economic feasibility, we calculated the total system cost, assumed three price scenarios, and analyzed the break even volume for two demand scenarios. The results of break even volume analysis showed that it is economically feasible in some scenarios if the price is more than 1.0 USD/km^2, and in all scenarios if the price is more than 1.5 USD/km^2.

Budget: List the budget this project implemented. *About the details, add the appendix.

Purposes	**Expense (JPY)**
Attendance at the International Astronautical Congress - air tickets	208,000
Attendance at the International Astronautical Congress - other expenses	90,800
Total	298,800

*See the appendix for the details.

Appendix (Option)

We submitted the following paper to the 68th International Astronautical Congress (IAC2017). We had a presentation there and received some feedbacks from audience.

① Nowadays, more and more companies are actively trying to launch a business employing SAR system. ② Providing only raw data of SAR information should not be competitive in the satellite image market. The price of raw data should go down near future. ③ Some of Southeast Asian countries are now cooperating with the universities regarding analyzing SAR data. So, our product should be very sophisticated to play a dominant role in SAR image market. ④In terms of hardware, Southeast Asian countries are not well equipped with the technology to produce SAR-mounted small satellites. Japanese companies can make use of their technological advantages to pioneer the SAR-based industry.

Monitoring of Natural Disaster based on Synthetic Aperture Radar (SAR) Satellite in Southeast Asia

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Abstract

Southeast Asia is a region that is severely affected by a variety of natural disasters, such as typhoons, heavy rain, earthquakes, and volcanic eruptions. Synthetic-Aperture Radar (SAR) has a large advantage in speed of data acquisition and observation because it can observe in the night or through clouds. SAR has been implemented only on large satellites so far. However, recently, a new concept of SAR and a high-speed downlink system using single small satellites has been developed. This technology can drastically decrease development costs of SAR satellites, increase the frequency of observations using a constellation of SAR satellites, and enable many developing countries to have SAR satellites. Moreover, this technology enables Southeast Asian countries to construct a shared rapid disaster observation system internationally.

In this paper, a possible business model from the viewpoints of Japanese manufacturer and governments that utilize a feasible SAR satellite system based on MicroXSAR is described. A cost-benefit analysis is conducted and presented from the perspective of the manufacturer. Besides, the price of the whole observation systems is also calculated using a cost-estimation method of satellites, and is evaluated from the aspects of economic powers of Southeast Asian countries.

Keywords: Synthetic Aperture Radar, Southeast Asia, Small satellites, Disaster Monitoring

Acronyms/Abbreviations

GSD: Ground Sample Distance, SAR: Synthetic Aperture Radar, SSO: Sun-Synchronous Orbit, USD: United States Dollars

1. **Introduction**

1.1 Conventional Disaster Monitoring System

Optical and thermal-infrared remote sensing techniques mounted on satellites have been used for various Earth monitoring missions. Optical remote sensing can be applied to health monitoring of forest, farmland, waterside and so on, whereas thermal-infrared remote sensing is utilized for monitoring temperature distribution of grounds and sea surface, activities of volcanos. Though optical and thermal-infrared remote sensing techniques have contributed to the Earth observation, they have several disadvantages. The most remarkable demerit is that the observation is impossible in the night or when clouds cover the grounds. In addition, the resolution is relatively lower than that of microwave remote sensing. Therefore, optical and thermal-infrared remote sensing are not suitable for disaster monitoring because it is necessary for disaster monitoring to monitor Earth continuously in order to detect disasters rapidly. To compensate for the disadvantage of optical and thermal-infrared remote sensing, SAR technology has begun to be noticed as the solution.

1.2 SAR

Nowadays, SAR is a key technology for many kinds of scientific, commercial and disaster-managing applications aiming to produce high-resolution images of the Earth surface. The technology of SAR utilizes the flight path of the platform to simulate a large antenna electronically and produces the two-dimensional images of the Earth surface. It is suitable for monitoring missions because it generates the images independent from daylight, cloud coverage and weather conditions. For this reason, many space-borne SAR systems have been developed and operated in recent years. [1-3]

The Japanese SAR satellites, ALOS series, have high performances of mapping and precise regional coverage for disaster monitoring. [4] ALOS series contributed to disaster monitoring in various disasters in Southeast Asia as well as in Tohoku Earthquake in 2011. However, because the Japanese government always has had just a SAR satellite on a SSO, highly frequent and robust observation systems have not been constructed or provided.

1.3 Small Satellites

In the recent years, the industry and developments of small satellites have been growing rapidly. [5] That is mainly because the cost of manufacture and launch of small satellites are considerably cheaper than conventional large satellites. This feature makes it possible for small start-up companies to develop and produce satellites by themselves. Small satellites have the potential to widen the fields of their activities. In addition, they are suited for making constellations because they are superior to large satellites in terms of system redundancy and individual cost.

When it comes to the use of satellite constellation, small satellites have many advantages. For example, they can implement the observation of some kinds of events with high-frequency revisit time and wide ground coverage without high development cost.

1.4 Potential Application

SAR technology with small satellites could be potentially used to tackle many social issues. In the area of disaster management, SAR could be used as part of disaster monitoring and relief operation. For example, SAR could be used for flooded area mapping, fire disturbance and monitoring, landslides monitoring, earthquake and volcano monitoring, drought monitoring, ocean wave height and direction measuring, wind speed measuring. Moreover, SAR can be used to enhance food security by providing useful information for potential food crises. For instance, SAR could be used for drought early detection, crop monitoring, crop production forecasting, crop biomass measuring, soil moisture measuring and crop classification. In addition, SAR could also be used for urban management such as urban and infrastructure planning, urban growth and road traffic monitoring. [6]

1.5 Purpose

In the potential applications of SAR technology, prevention and mitigation of natural disaster in Southeast Asia is one of the most attractive application in terms of social contribution.

Southeast Asia is the most disaster prone region in Asia and is facing with the rising number of natural disasters. Between 2000 and 2016, 855 disasters were reported in Southeast Asia, accounting for 31 per cent of Asia's 2,769 disasters (see Fig.1). Moreover, 362,323 natural hazard-related deaths were recorded in the region, 47% of the Asian total. Furthermore, the region incurred more than 109 million USD in economic damage over the same period, equivalent to an average 6.1 million USD loss per year. In addition, the number of natural disaster in Southeast Asia has been significantly increasing since 1960 (see Fig.2). Particularly, flood and storm have been noticeably rising, both accounting for 68% of the total disaster.

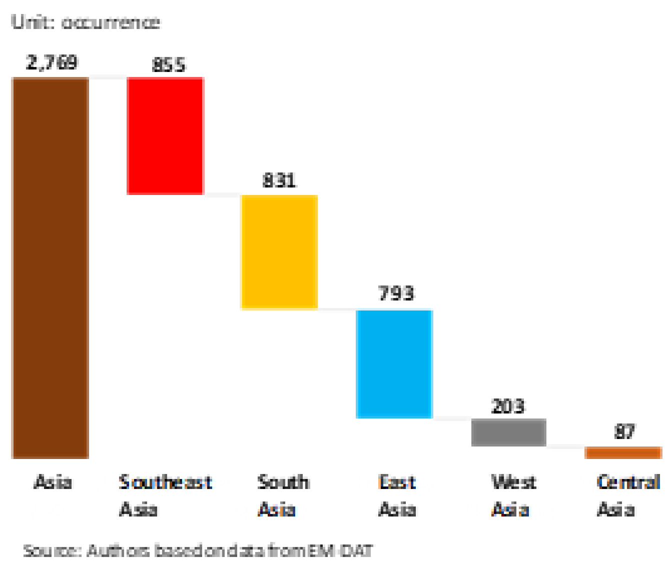

Fig. 1. Natural Disaster Occurrences in Asia

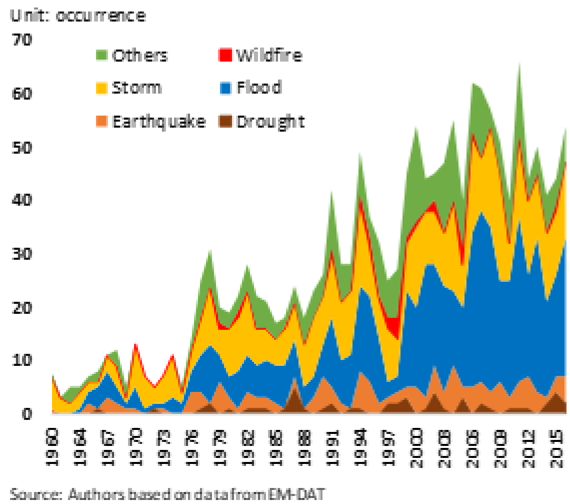

Fig. 2. Trend of Natural Disaster in Southeast Asia

In this paper, a possible business model from the viewpoints of Japanese manufacturer and governments that utilize a feasible SAR satellite system based on MicroXSAR is described. In our project, the natural disaster in Southeast Asia is focused on as a target application as a case study. A cost-benefit analysis is conducted and presented from the perspective of the manufacturer. Besides, the price of the whole observation systems is also calculated using a cost-estimation method of satellites, and is evaluated from the aspects of economic powers of Southeast Asian countries.

2. Proposed System

2.1 System Overview

In this section, the outline of the proposed business model is mentioned. Fig. 3 shows the system overview of the proposed business model (The procedure images of the data processing in Fig.3 are cited from [6].). The model contains four sections, that is, satellite developments and production, launching and orbit insertion, data processing, possible customers.

The blue section indicates the developing and production system of the satellites and the relationship between the system integrator and the component producers. A commercial small satellite company is in charge of the system design and manufacture of the small satellites with the SAR system. The company develops and produces the satellites in accordance with the design requirement of a data processing company indicated as the green section. The SAR sensor is the most important component and should be developed in accordance with this business model. The specification of the satellites is discussed in detail in 2.2.

As mentioned above, the green section shows the business description of the data processing company. This company makes the SAR images delivered from the satellites into useful information on the basis of customer’s demand. The company is also in charge of the satellite operation. In order to acquire profitable information for customers, it is better that the company is capable of operating the satellites in line with what kinds of data customers want. The most important role of the company is the data processing which converts SAR raw data into useful information for customers. 2.3 shows how the data processing is achieved in terms of technology.

At last, the red section indicates the possible customers in this business framework. There are many possible customers, and they can be classified by the type of the application: prevention or mitigation. 2.4 provides the concrete explanation of the possible customers.

For the sake of clarity, we focus on measurement of forest biomass level for prevention of wildfire and detection of the flooded area for damage mitigation in this paper.

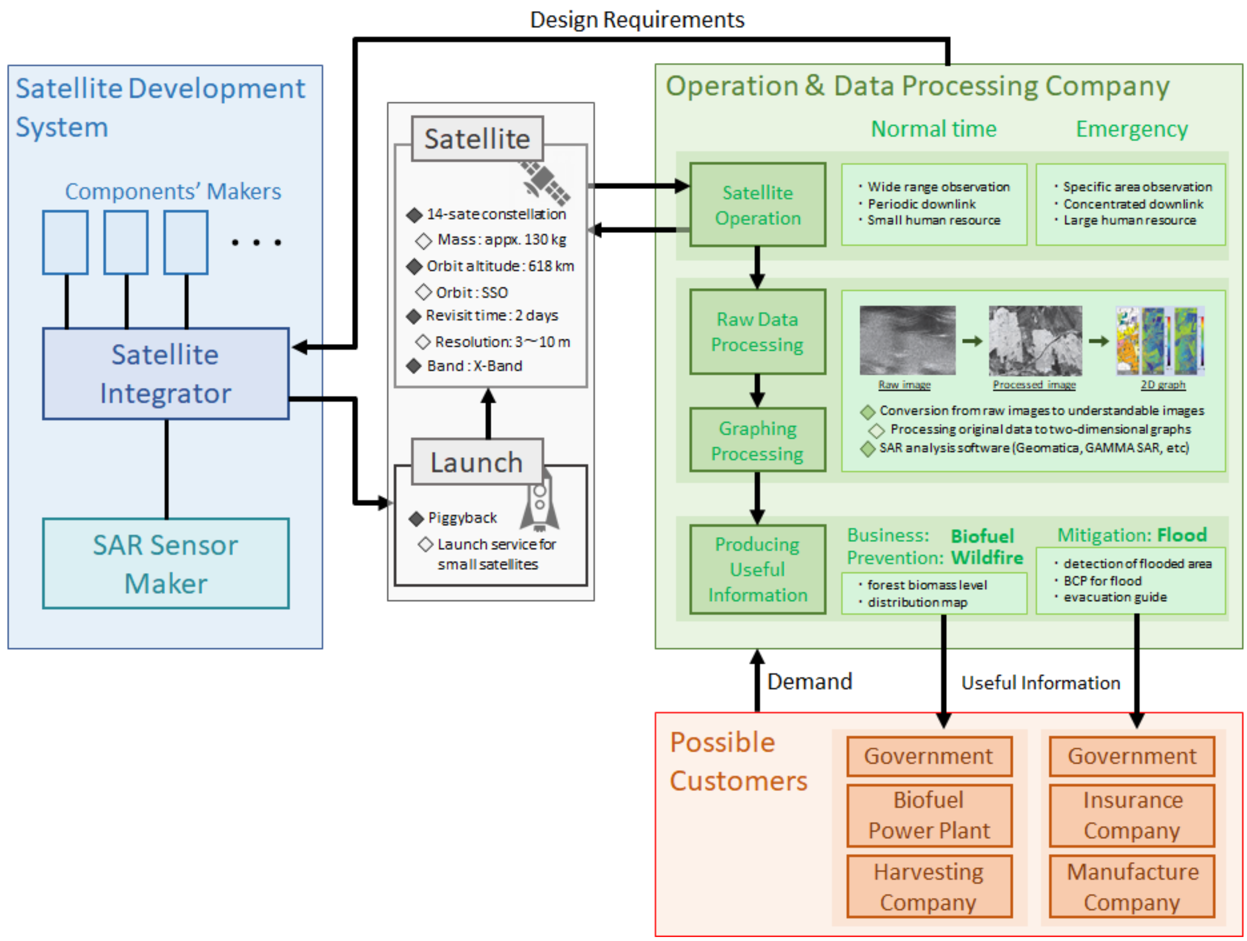

Fig. 3. System Overview

2.2 Small Satellites with SAR

This section presents the specifications of the proposed small satellite constellation for SAR observation and compares them to that of ALOS-2 [7].

The proposed system consists of 14 small satellites as a constellation in a SSO. Compared to conventional large satellites such as ALOS-2, small satellites cannot be equipped with a large antenna or a large solar panel to generate high power. Therefore it is relatively difficult to realize a high-resolution observation. However, since one small satellite costs much less than a large one, it is possible to form a constellation to realize a short revisit time, which is crucial to disaster detection and monitoring.

Table 1 shows the specifications of the proposed system compared with ALOS-2. We adopt MicroXSAR, a 130-kg small satellite with an X-band SAR proposed by Saito et al. [8], as satellites for the proposed system. The proposed system cannot achieve as long swath as ALOS-2 to realize the same image resolution. However, it succeeds in shortening the revisit time from 14 days to 2 days by employing 14 satellites as a constellation.

In case of emergency, a satellite can change its attitude to observe the area of interest. This maneuver can shorten the time between the event and the observation to 2.1 hours.

Table 1. Satellite System Specifications Compared with ALOS-2

	Proposed system	ALOS-2
Satellite mass	130 kg	2 tons
Orbit	SSO (Altitude: 618 km)	SSO (Altitude: 628 km)
Swath (observable)	28 km (~650 km)	50-70 km (1160 km)
Band	X-band	L-band
SAR image resolution	10 - 3 m	10 - 3 m
Number of satellites	14	1
Revisit time (observable)	2 days (2.1 hours)	14 days (16.2 hours)

2.3 Operation & Data Processing

Compared to optical sensors in satellites, SAR data needs to be transformed in a somewhat useful way to be fully utilized. In our model, SAR data processing consists of following steps. First, raw data from microsatellites is acquired. (The frequency of data acquisition from satellites should depend on its purposes; prevention or mitigation of natural disasters) Second, we transform raw data from satellites to graphical data implementing a commercial software.

The output of this step can either be a final product of our model or there can be an additional treatment regarding customer requirement. For example, we can carry out time series analysis based on our SAR dataset since our system has more frequent revisit time of 2 days than the conventional satellite systems visit time of 14 days. Moreover, we can further adjust it to the customer demand.

2.3.1 Prevention of natural disasters (Normal Operation)

Among possible applications of our model for preventing natural disasters, in this paper, we will focus on the prevention of wildfires based on forest biomass level. Backscattering coefficient data (σ^0) from SAR has been known to be able to measure forest biomass level. [9] Forest biomass refers to all above-ground plant material. It can include small or dead trees, shrubs, and the tops, foliages. Since these materials are typically left on the forest floor and easy to be a potential fuel for spreading wildfires, clearing out these materials with biomass harvesting can be helpful to either suppress the outbreak of wildfires by preventing the fire from spreading around, or lead to smaller wildfires around the nation. By monitoring and graphing forest biomass distribution from SAR data, biomass harvesting can be carried out in more efficient ways in terms of allocation of resources and time compared to conventional harvesting way. For example, given the biomass distribution or time series analysis of biomass from our system, they can prioritize their allocation of harvesting machines or operators on duty. [10,11]

2.3.2 Mitigation of natural disasters (Emergency Operation)

In addition to the normal operations such as biomass observation, the proposed system can be used for mitigation of natural disasters such as flood, earthquakes, and volcanic eruptions. This section describes how the proposed system can be applied to estimate the flooded area as an example.

The luminance value of the backscattered wave of the SAR image varies before and after the flood. This is because the microwave reflects specularly with respect to the water surface.

Geometric corrections and the difference analysis of the luminance value are performed on the SAR image. This can lead to a quick estimation of the flooded area at the time of flood occurrence. [12,13]

2.4 Customer

There are many potential customers targeted in this business. Table 2 shows some examples of potential customers and demands. For biomass imaging, main customers are subcontractors of the companies of biofuel power plant. In Southeast Asia, According to conservative estimates, the amount of biomass residues generated from sugar, rice, and palm oil mills is more than 200-230 million tons per year which corresponds to cogeneration potential of 16-19 GW [14]. Biomass has two origins. One of them is "Agrofuel," which is from crop harvesting and other kinds of by-products from agricultural activities left in the field. Another is "Wood-fuels", which are Wood from forests, shrubs and other trees used as fuel [15]. The production of biomass is mostly commercialized in southeast Asia these days, and the consumption of Woodfuels has been gradually reduced because of shifting to other energy resources. However, there is potential motivation to reduce the dense forest. There is a report that woodfuels, especially tree modality due to insects might cause wildfire [16]. Visualizing biomass could help not only with efficient collection of biomass but also with preventing wildfire.

As an application to floods, we provide the information of the damaged area and evacuation guide, which could be useful for government and local government. Besides, if the information is provided via mobile applications, people could easily have access to the information. Also, potential customers including insurance companies and manufacturers might be interested in how much damage would be estimated by the disasters.

Table 2. Potential customers and demands

Customer	Demand (application)
Biomass	
Biofuel power plant	Visualize biomass distribution
Harvesting company	Visualize biomass distribution
Government	The possibility of wildfire to cleanup
Forestry/Farmer	Visualize biomass distribution

Flood	
Government	Damaged area (infrastructure, etc.) to let people evacuate
People	Evacuation area (safe area) and path to evacuate correctly
Company (manufacturer etc.)	Damaged area to carry products with less delay
Insurance company	Trends of flood and its damage to estimate the insurance fee for the flood.

3. Cost Calculation

3.1 Manufacturing and Launch

Though SAR is a well-known remote sensing technique with reliable capabilities that offer advantages over an optical sensor, SAR sensors require relatively large antennas with several meters. Thus, large or medium size satellites with hundreds kg or more have been used for SAR sensors. These large or medium satellites cost 100M USD including launching cost, which limits the number of potential customers.

The current technology of SAR that has 10-3 mm ground resolution with 4.7x0.7 m2 can be mounted on small satellites with 100 kg. These cost 10-20M USD including launching cost [17].

3.2 Operation & Human Resources

After manufacturing and launching our satellites with SAR, operation and human resources are needed to maintain the system. Table 3 indicates the cost-details of operation and human resources of our system.

Table 3. Cost Calculation of Operations and Human Resources

Operation			
	Num.	Cost [USD]	Details
Image-Processing Software	1	3,000	Commercial Software (ex. Geomatica)
Computer	10	20,000	Enough to operate commercial software
Miscellaneous expenses	-	10,000	Tables, Office rents, etc.
Total	-	33,000	-
Human Resources			
	Num.	Cost [USD / year]	Details
Software Engineer	3	150,000	Image Processing, Platform Service
Hardware Engineer	2	100,000	Radio Frequency, Electromagnetic Interference

Finance	1	50,000	FP&A Analyst
Company Operation	1	50,000	Administrative Assistant
Project Management Office	1	50,000	Technical Program Manager
Quality Assurance	1	50,000	Quality Engineer
Sales	1	50,000	Customer Service, Representative
Total	10	2.5M (5 years)	-

4.Feasibility analysis

4.1 System design cost

In accordance with the previous sections 2 and 3, the cost and price of the images from our system are estimated in this section. The lifetime of small satellites is known to be less than 10 years. Therefore, we estimated the cost and price of this system under the assumption that the satellites work properly for 5 years. The initial cost for operation is 33,000 USD from the section 3.2. The annual cost for employment is set to be 50,000 USD per person, and 10 people which include engineers and managers are necessary for the proposed system. Therefore, the cost for human resources is 2.5M USD for 5 years. The manufacturing and launch cost of one small satellite is estimated about 10M USD in section 3.1. In the proposed system, 14 satellites form the constellation; thus it costs 140M USD to prepare the constellations. As a result, the total cost of the whole system is about 140.3M USD, which should be recovered within 5 years. (Table 6)

Regarding our system, we assume two cases for applications under 3 different Market Share Assumptions (MSA) (Table 8) and carry out Break Even Volume (BEV) analysis under 3 different price scenarios (Table 7). As case 1, we assume 40 percentages from the area of Southeast Asia should be affected by natural disasters and stakeholders of those regions can be our potential customers to mitigate the damages from natural disasters. As a case 2, we assume that our system can also be utilized for flood-prone areas as well as forest areas in Southeast Asia. The image cost per area is estimated from the area of some regions customers are interested in and the cost mentioned above.

For case 1, we made an assumption that 40% of the area of Southeast Asia should be affected by natural disasters. According to Table 6, the total land area of Southeast Asia is 4,326,131 km^2. Therefore, 40% of the area is 1,730,452 km^2. We assume that our system will be utilized 30 times per year to get the images of those areas. Based on the assumptions mentioned above, we found out the total cost of our system can be covered within 5 years under two conditions; price scenario 2 with MSA 3 & price scenario 3 with all MSAs.

For case 2, we assumed that our system can be employed for both flood-prone areas and forest areas of Southeast Asia. As flood-prone areas of Southeast Asia, Table 4 indicates the percentage area in each flood hazard category [18]. From the data of Table 4, the area prone to flood damage is calculated as 792,007 m^2, which is equivalent to 17.7% of the total area of the ASEAN countries. As forest areas of Southeast Asia, Table 5 indicates the percentage area of Southeast Asia and its coverage. From Table 5, total forest area of Southeast Asia is 214,064 km^2, and its coverage is 49% of Southeast Asia. According to our assumptions, we found out that the total cost of our system can be covered within 5 years under 3 conditions; price scenario 1 with MSA 3, price scenario 2 and 3 with all MSAs.

Considering market price of SAR images from Table 10, the image price itself of our system which ranges between 0.6 ~ 1.5 is higher than conventional market price. However, our products should be provided with additional or on-demand data treatment as well as better resolutions (3 ~ 10 GSD).

Table 4. Percentage Area in Each Flood Hazard Category of the ASEAN Countries

	Total Area [1000 m^2]	Extreme [%]	High [%]	Mod [%]	Flooded Area [km^2]
Brunei	5.765	0.75	0	0.75	86
Cambodia	181.0	26.9	6.49	5.43	70,264
Indonesia	1,905	2.39	3.32	6.04	224,000
Laos PDR	236.0	6.98	6.25	5.25	43,760
Malaysia	330.0	2.45	5.32	6.54	47,338
Myanmar	676.6	9.76	5.29	5.68	140,259
Philippines	300.0	7.82	2.43	0.95	33,600
Thailand	513.1	15.7	6.95	2.84	130,687
Vietnam	331.2	23.0	5.06	2.84	102,175
Total	4,481.0	-	-	-	792,007

* The data of Singapore is not included in the list because there is no effective data for flood damage in the country and the area is much smaller than the other countries.

Table. 5 Forest Area & Cover of Southeast Asia [19]

	Forest Area [km^2]	Forest Cover [%]
Cambodia	10,094	57
Indonesia	94,432	52
Laos PDR	15,751	68
Malaysia	20,456	62
Myanmmar	31,773	48
Philippines	7,665	26

Thailand	18,972	37
Vietnam	13,797	42
Southeast Asia	214,064	49

Table. 6 The Cost Calculation Result

Initial Cost [USD]	33,000
Operation Period [years]	5
Annual Cost [USD/year]	500,000
Number of Satellites [satellites]	14
Satellite Manufacturing Cost [USD/satellite]	10,000,000
Total Cost [USD]	140,300,000
Area of Southeast Asia [km^2]	4,326,131
Revisit Time [days]	2.0

Table 7. Price per unit and Break Even Volume on Price Scenario

	Price per unit [USD / km^2]	Break Even Volume [km^2]
Price Scenario 1	0.6	237,555,000
Price Scenario 2	1.0	142,533,000
Price Scenario 3	1.5	95,022,000

Table 8. Market Share Assumption (MSA)

	MSA 1 [%]	MSA 2 [%]	MSA 3 [%]
Year 1	20	30	30
Year 2	30	40	50

Year 3	40	50	70
Year 4	50	60	90
Year 5	60	70	90

Table 9. Case Analysis

Case 1 (40% of Southeast Asia is affected by natural disasters)			
Observed Area per one visit [km^2]		1,730,452	
Observation frequency per year [times]		30	
Total observed area per year [km^2]		51,913,572	
Case 2 (Biomass + Flood-prone area of Southeast Asia)			
Biomass		Flood-prone Area	
Observed Area per visit [km^2]	792,007	Observed Area per visit [km^2]	2,140,640
Observation frequency per year [times]	30	Observation frequency per year [times]	30
Total observed area per year [km^2]	23,760,230	Total observed area per year [km^2]	64,219,200
Total observed area per year [km^2]		87,979,430	

Table 10. Market Price of SAR Images [20]

Satellite	Image / GSD [km / m]	Price [USD / km^2]
ALOS	70 x 70 /10 or 20	0.18
TerraSAR-X	100 x 100 / 16	0.34

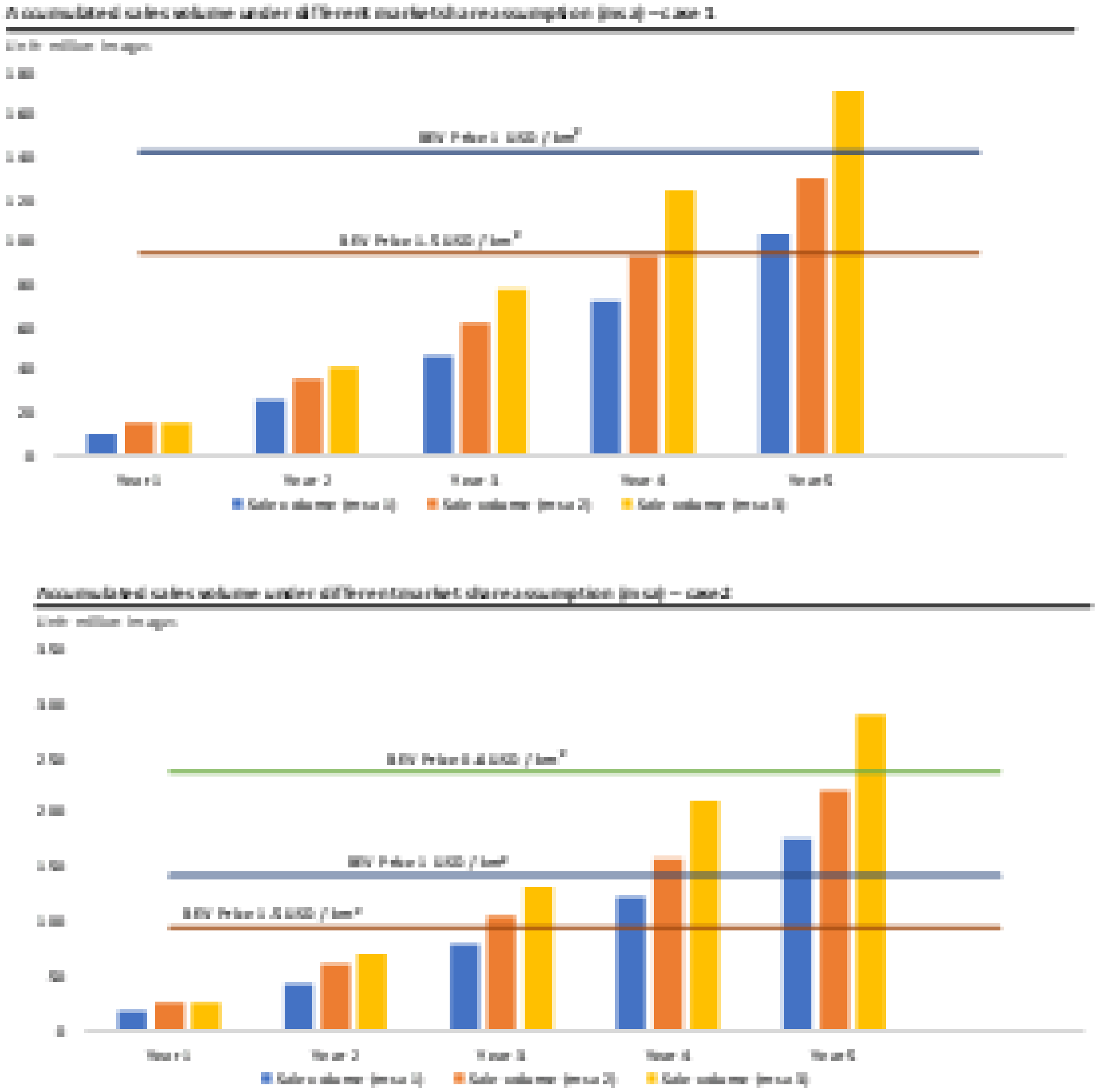

Fig. 4. Break Even Volume Analysis

5. Conclusions

We proposed a constellation of 14 small satellites with X-band SAR. By employing multiple satellites, the proposed system realizes short revisit time compared to conventional large SAR satellites such as ALOS-2 and TerraSAR-X. The frequent SAR observation can be used for prevention and mitigation of natural disasters including wildfires and floods. We analyzed its economic feasibility for two different cases where the proposed system is used for natural disaster prevention and mitigation in Southeast Asia. The results showed the system is feasible with the selling price of 0.6-1.5 USD/km^2.

Acknowledgements

The present work was supported through the Leading Graduates Schools Program, “Global Leader Program for Social Design and Management,” by the Ministry of Education, Culture, Sports, Science and Technology in Japan.

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Budget details

Description	**Unit price**	**Qty**	**Price**
Air tickets	104,000 JPY (6,263 CNY)	2 people	208,000 JPY
Nitto	4,500 JPY	3 days x 2 people	27,000 JPY
Accommodation	8,500 JPY	2 nights x 2 people	34,000 JPY
Conference fee	13,150 JPY (149.06 AUD)	2 people	26,300 JPY
Visa fee	1,750 JPY (20 AUD)	2 people	3,500 JPY
<u>Total</u>			<u>298,800 JPY</u>