Integration Review of National Remote Sensing Ground Station Based on Virtual Ground Station by Full Remote and Nearly Automation

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Abstract – National Institute of Aeronautics and Space (LAPAN) has long experience in Remote Sensing Ground Station operation, so that it is able to carry out its development and operation independently. LAPAN's Remote Sensing has also received support from the government especially with the Roadmap, Law, and Government Regulation. Therefore, in accordance with the mandate of LAPAN in this matter represented by Technology and Data Center of Remote Sensing is required to make list, guidance, and supervision in development and operation of remote sensing ground station in Indonesia. The next stage to do is to integrate LAPAN's Ground Station with all or some Remote Sensing Ground Stations operated by other Indonesian Ministries/Institutions in receiving remote sensing satellite data of low and medium resolution. It will use fully remote and nearly automation method in Remote Sensing Ground Station development, such as acquisition, processing and reporting stages Therefore, it is not necessary for operators in the ground station, so that it can be developed and operated optimally and efficiently according to the government's mandate.

Keywords: Integration, Ground Station, Remote Sensing, National, Virtual.

1. Introduction

Along with the increased needs of remote sensing data, especially for disaster mitigation system and information on natural resources for development in all regions in Indonesia, it must be balanced with an increase in the development of remote sensing ground station technology. LAPAN, in this case represented by the Remote Sensing Technology and Data Center (Pustekdata) has built several ground stations for remote sensing satellite data reception to meet the needs of national remote sensing data. This is because the geographical conditions in Indonesia are very long and broad, so that to cover the entire territory of Indonesia, several ground stations are needed so that the entire regional images of the Republic of Indonesia can be received and recorded.

LAPAN has long experience in operating remote sensing ground stations ranging from data acquisition, data processing, advanced data processing, and public information services of remote sensing data. In addition to these activities, in the operation of ground stations also carried out maintenance of ground station equipment and construction of facilities and infrastructure to facilitate operational activities carried out every day. Pustekdata-LAPAN has 3 operational remote sensing ground stations, namely Parepare Ground Station, Rumpin Ground Station and Pekayon Ground Station. The Ground Station conducts daily operational activities for low, medium, high (CSRT), very high remote sensing satellites (CSRST), and radar (SAR) data. The need for Remote Sensing Satellite data ranging from low to very high resolution and radar from Ministries / Institutions, Army, Police, and Local Government has become a priority requirement that cannot be delayed anymore to fulfill the implementation of national priority activities. The effort to meet the needs of remote sensing satellite data, the provision of remote sensing satellite data in LAPAN is carried out through direct acquisition with a license for the Government of the Republic of Indonesia. Based on this, LAPAN has proposed a direct acquisition of satellite remote sensing data through LAPAN Remote Sensing Ground Station until 2028 [1] as shown in Figure 1 below.

Figure 1. Roadmap for remote sensing satellites acquisition of LAPAN ground stations until 2028

Over time, LAPAN was mandated by the government to do part of the government's tasks in the field of space, whose role was supported by several regulations. Among them are Law No. 21 of 2013 concerning Space on August 6, 2013 and Government Regulation No. 11 of 2018 concerning Procedures for Implementation of Remote Sensing Activities on April 10, 2018.

Based on excerpts of Law No. 21 of 2013 concerning the Section of Article 103 [2], and Government Regulation No. 11 of 2018 concerning Procedures for Implementation of Remote Sensing Activities Article 12-14 [3] is used as a reference for carrying out the tasks and functions of the Institution. The core of the regulation is LAPAN in this case Pustekdata as a remote sensing ground station operator who has long experience in operating the ground station being the only institution that can build and operate ground stations, so it is necessary to collect data on remote sensing ground stations in Indonesia both inside and outside LAPAN. Then based on excerpts of Law No. 21 of 2013 concerning Space of Article 103, all owner of ground stations are required to report on the construction and operation of ground stations that have been in existence at the latest 1 (one) year since the Act applies. Therefore the Institute (LAPAN) is tasked with integrating the operational activities of remote sensing ground stations into a network of National Remote Sensing Ground Stations (BDPJN).

The integration of the remote sensing ground station system is more important because of the increasing advancement of automation technology, and the need for simplifying processes for easier management. The integrated system will streamline the process, reduce costs and ensure efficiency [4]. Pustekdata-LAPAN has the ability to operate the remote sensing ground station system (Parepare,
Rumpin, and Pekayon) into an integrated ground station system with the National Remote Sensing Data Bank (BDPJN) [5, 6]. Based on this experience, remote sensing ground stations that have been operating in LAPAN and in every Indonesian government institutions can be optimized to support the developed system. The system built is connected to BDPJN, as a national data bank node through an integrated data communication network.

This activity aims to study the integration of the virtual national remote sensing ground station system that works in fully remote and nearly-automation through several phases. With this developed national remote sensing ground station system, it is expected to improve coordination, reduce costs and improve the acquisition efficiency of remote sensing satellite data for disaster mitigation, natural resource information, and others.

2. Method

The integration process of the remote sensing ground station adopts from reference [7] which is divided into four phases such as figure 2:

1. Requirements
2. Architecture
3. Detailed Specification
4. Testing and verifications

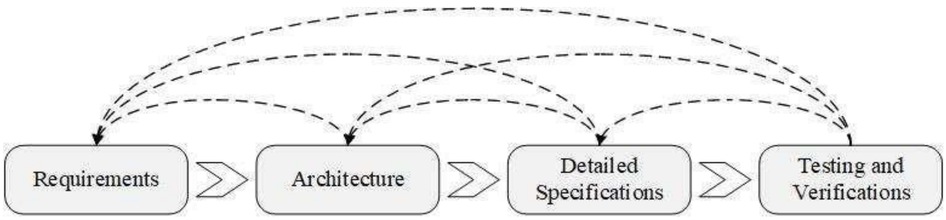

Figure 2. Integration phases and iterative process

In the requirements phase, the parts to be achieved in the ground station system integration are determined, including:

- Integration of data communication networks
- Integration of reception, which includes integration of acquisition, control and monitoring of acquisitions
- Integration of raw level processing to standard levels
- Catalog integration
- Data integration into BDPJN

In the architecture phase, the main building blocks and system integration interfaces are decided. Next in the detailed specifications phase, the details of each interface are determined. In this section three main specifications will be specified, namely man, machine and money. Finally, in the testing and verifications phase, the interface specifications proved to work well and stable with the real-life devices. The four phases above are overlapping and iterative. For example, requirements can be added, changed, or reduced during the next phase if the technical solution requires it. Likewise, the technical solution in the detailed specification can change because there is a problem in the testing and verification phase. The concept of the integration of the national remote sensing ground station system can be seen in Figure 3 below.

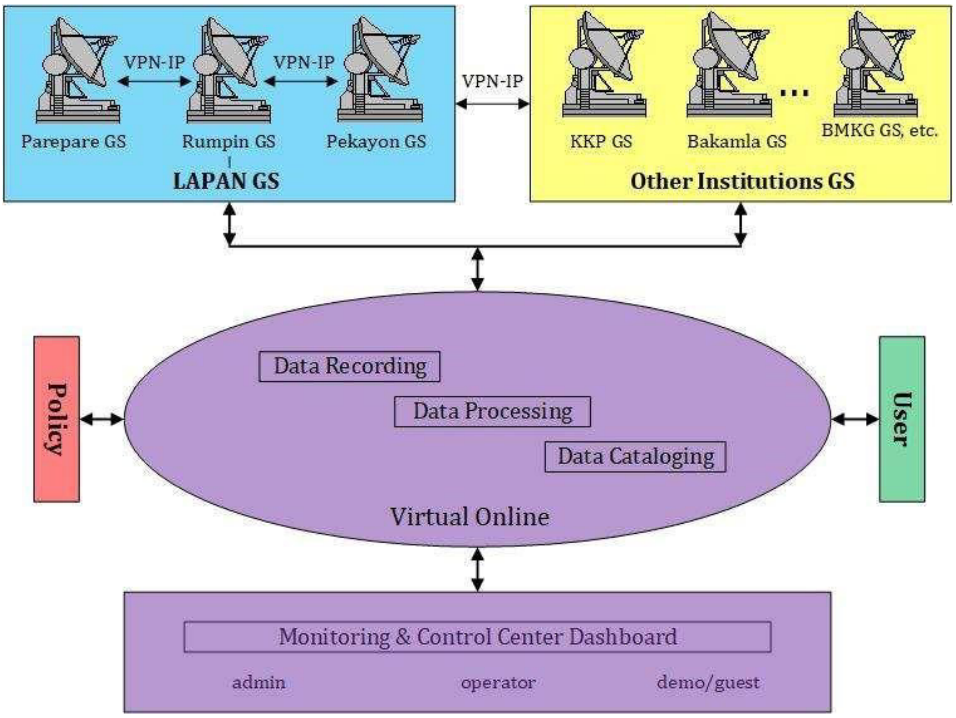

Figure 3. The system concept of integrating remote sensing ground stations with fully remote and nearly-automation

3. Result and Discussion

In this study activity, 3 of the 4 phases of remote sensing ground station integration above have been carried out. The results and discussion of the phases of the national remote sensing ground station integration process can be explained as follows:

3.1. Requirements Phase

In conducting the requirements phase, LAPAN has held technical coordination with the institution / agency managing the remote sensing ground station that operates at this time. Technical coordination is done either by making a direct visit to the location of the ground station owner and holding a focus group discussion (FGD). From the results of technical coordination (as shown in table 1), data and information on infrastructure, the location of remote sensing ground station owned by other agency outside LAPAN, the operational use status as well as the future needs and recommendations.

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Table 1. Data and information on the remote sensing ground station system from other agency (outside LAPAN)

Institutions	Existing Infrastucture	Location	Operational Use Status	Future Needs and Recommendations
BIG	Timestep 0.9m antenna	Geomarin Science Park Parangtritis, Jogjakarta	In-active	Data access to LAPAN via internet online for NOAA, MetOp, etc. data
BMKG	C-Band 3.5m antenna	STMKG Campus	Himawari-8 data reception operation	Operational continue
	Timestep 0.9m antenna	Entire Indonesia (9 regions)	NOAA, MetOp data reception operation	Operational continue
	X-band ES&S 3.m antenna	Kantor Pusat BMKG	Terra, Aqua data reception operation	Operational continue (interference), need to be considered
KKP	Orbital 3m antenna	Perancak, Bali	In-active	Maintenance and service
	Viasat 5.4m antenna	Perancak, Bali	Operasional untuk penerimaan data Radarsat, CosmoSkymet (sd 2017)	Existing operation will be continued and developed for the receiption of other data (high resolution)
Bakamla	Viasat 5.4m antenna	Bangka Belitung	In-active	Maintenance and service
	China 7.3m antenna	Bangka Belitung	Sudah dibangun tapi belum operasional	Continue until it can be operated
	EOSphere 3m antenna	Bitung, North Sulawesi	Operasional untuk penerimaan data low res (Terra, Aqua, NOAA)	Operation continue with the addition of JPSS data acquisition
	EOSpehere 5.4m antenna	Bitung, North Sulawesi	In-active	Maintenance and service

After the locations of each ground station owned by LAPAN and the remote sensing ground station owned by other institutions outside LAPAN are known, then the location information of the coordinates of the ground station system can be mapped in Google Earth, as shown in Figure 4 below.

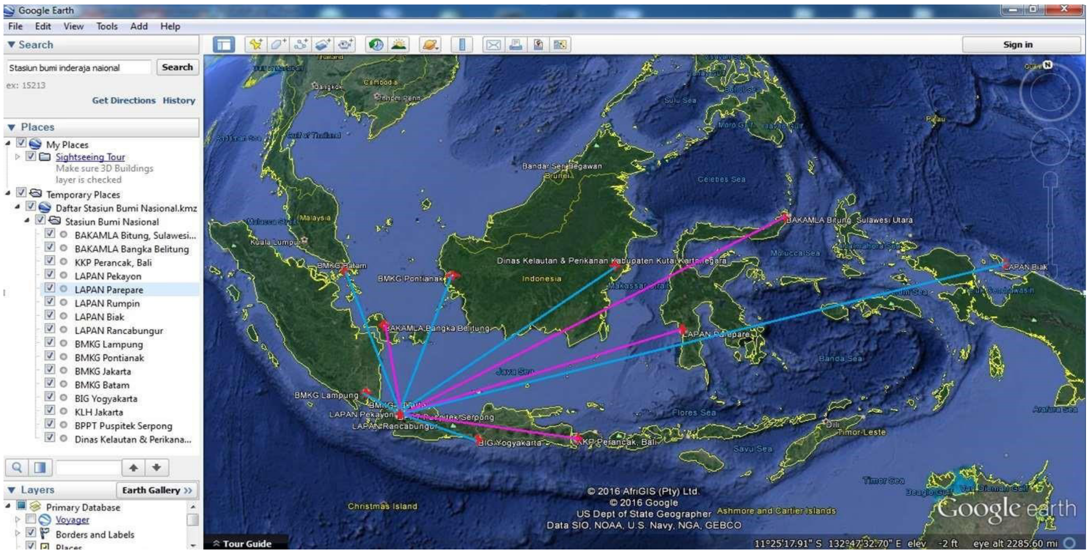

Figure 4. Distribution of position and location of the national remote sensing ground station

Then, with the knowledge of any satellite data acquired by each of the remote sensing ground stations, the satellite trajectory can be predicted and monitored as it passes through the coverage of each ground station through a web-based satellite acquisition tracking acquisition application system that has been developed by LAPAN as it appears in Figure 5 below.

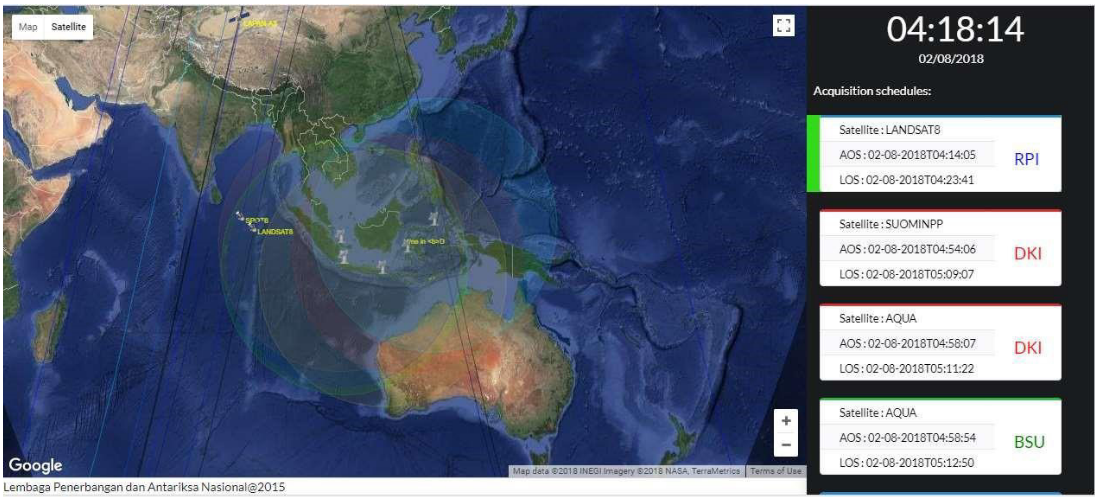

Figure 5. Sistem monitoring lintasan tracking akuisisi satelit penginderaan jauh nasional

Based on the analysis of scheduling scenarios and priority scales to jointly collect remote sensing satellite data by LAPAN remote sensing ground stations that have been carried out in previous activities [6], scheduling scenarios and priority scales for remote sensing satellite data acquisition by the system integration of the national remote sensing ground station can be seen in table 2 below.

Table 2. Scheduling and prioritizing acquisition of integrated national remote sensing ground station systems

NO	ANTENNA	SATELI TE	PRIORI TY	N O	ANTENNA	SATELLI TE	PRIORI TY
1	ViaSat 5.4m Parepare	TerraSAR -X	2	3	ViaSat 5.4m Rumpin	Landsat 7	1
		TANDE M-X	2			Landsat 8	1
		Pleiades 1A	2			TERRA	1
		Pleiades 1B	2			AQUA	1
		SPOT 6	2	4	TimeStep Pekayon	NOAA-18	1
		SPOT 7	2			NOAA-19	1
		Landsat 7	1	5	ES&S 3.0 Pekayon	NOAA-18	1
		Landsat 8	1			NOAA-19	1
		TERRA	3			MetOp-A	1
		AQUA	2			MetOp-B	1
2	Orbital 3.0m Parepare	SNPP	1	6	Himawaricast Pekayon	Himawari-8	1
		NOAA-20	2	7	Zodiac 7.3m Parepare	TerraSARX	1
		TERRA	3			TANDEM -X	1
		AQUA	4			Pleiades 1A	1
		NOAA-18	4			Pleiades 1B	1
		NOAA-19	5			SPOT 6	1
		MetOp-A	5			SPOT 7	1
		MetOp-B	6			Landsat 7	2
		Fengyun 3A	6			Landsat 8	2
		Fengyun 3B	6			TERRA	3
		Fengyun 3C	6			AQUA	3
8	C-Band 3.5m BMKG	Himawari -8	1	11	Viasat 5.4m Perancak, KKP	Radarsat	1
9	Timestep 0.9m BMKG	NOAA-18	1			CosmoSkymet	1
		NOAA-19		12	EOSphere 3m Bakamla	Terra	1
		MetOp-A	1			Aqua	1
10	X-band ES&S 3.m BMKG	Terra	1			NOAA-18	1
		Aqua	1			NOAA-19	1

3.2. Architecture Phase

In this phase, based on the data and information obtained, an integrated national ground station system architecture has been created as shown in Figure 6 below. All systems of remote sensing ground stations owned by LAPAN and other agencies outside LAPAN that are different locations will be connected to

VPN (Virtual Private Network)-IP and internet-based data communication networks. With VPN-based services, the connection of all integrated ground stations will be safer.

Furthermore, the entire remote sensing ground station system will be controlled and monitored for all or part of the process that is being carried out, including the process of receiving, recording, processing, cataloging, and storing data to the BDPJN system. LAPAN has developed a web-based ground station control and monitoring system [8] as shown in Figure 7 below. This system can be developed as a dashboard to control and monitor the integrated national remote sensing ground station system.

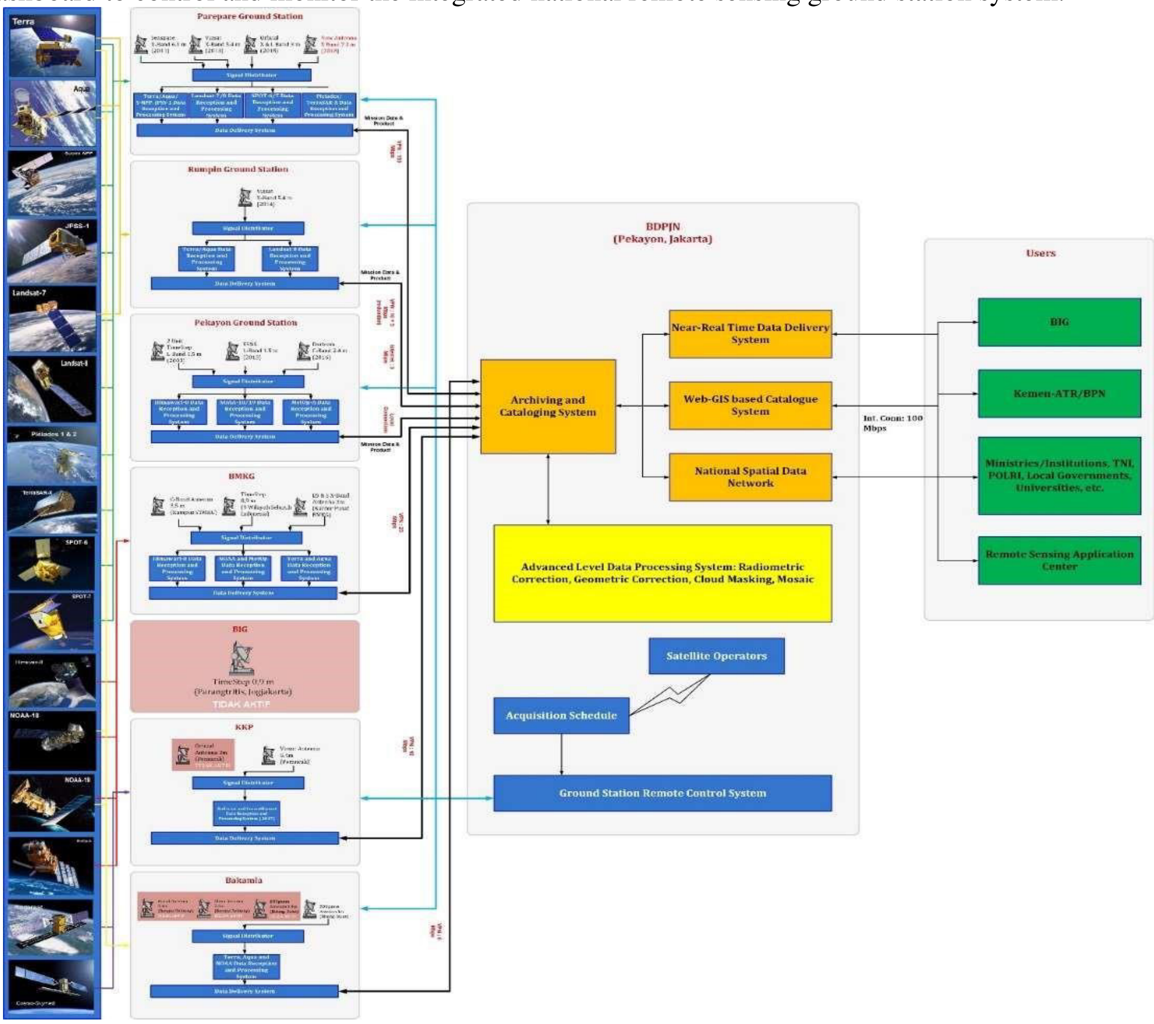

Figure 6. National remote sensing ground station integration system architecture

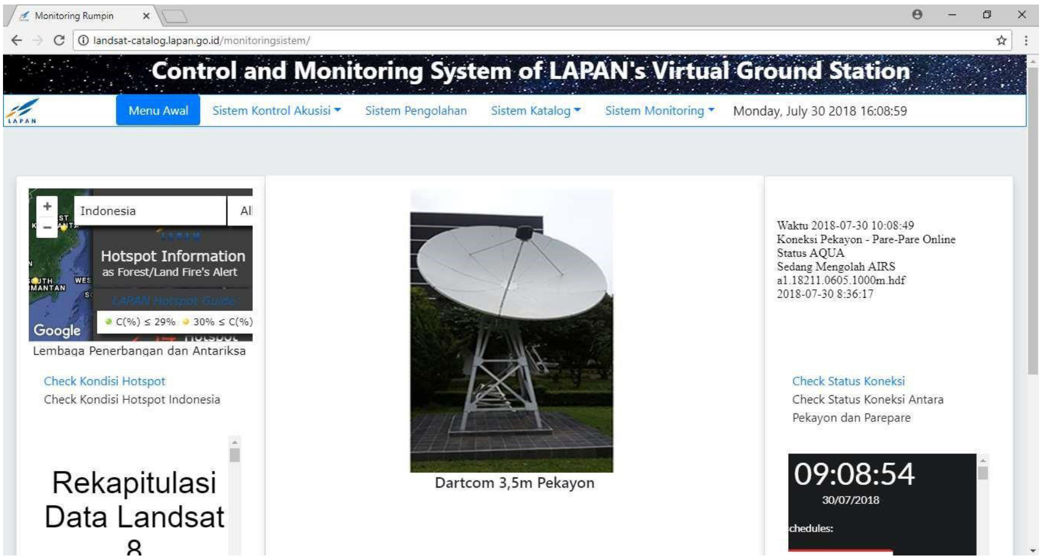

Figure 7. Prototype of the national remote sensing ground station control and monitoring system

3.3 Fase Detailed Specifications

In this phase, detailed specifications of 3M (man, machine, and money) have been specified [9] to meet the needs of the national remote sensing ground station integrastion system as shown in the table 3 below. Man (operator) is needed to control and monitor operational ground station systems. Likewise, man (technician) is needed to perform routine maintenance, troubleshoot, and repair functions if there is an interruption in each ground station system in accordance with the operational procedures (SOP) of antenna maintenance that has been made in Pustekdata-LAPAN [10]. It takes a total bandwidth of around 395 Mbps for data communication network connections between all national remote sensing ground stations with BDPJN. Details of bandwidth requirements for each ground station can be seen in the table 3 below.

Table 3. Detailed specifications related to 3M (man, machine, money) for national remote sensing ground station integration system

No	Stasiun Bumi	Instansi	Data	Bandwidth (Mbps)	Operator (org)	Teknisi (org)	Antena	Internet/VPN	Operasional*	Pemeliharaan/ Perbaikan**	Annual Fee***
1	Pekayon	LAPAN	Backhoul, NOAA, MetOp	200	3	2	Timestep 0.9m	Rp 4,800,000,000	Rp 744,000,000	Rp 500,000,000	
			NOAA, MetOp				ES&S 3.0m			Rp 1,500,000,000	
			Himawari-8				HimawariCast			Rp 1,000,000,000	
2	Rumpin	LAPAN	TERRA, AQUA, Landsat 7, Landsat 8	5			ViaSat 5.4m	Rp 120,000,000		Rp 2,500,000,000	Rp 2,500,000,000
3	Parepare	LAP	Landsat 7,	150	6	2	ViaSat 5.4m	Rp	Rp	Rp	

		AN	Landsat 8, TERRA, AQUA					3,600,000,000	888,000,000	2,500,000,000	
			TERRA, AQUA, SNPP, NOAA 18/19/20, MetOp A/B, Fengyun 3A/B/C				Orbital 3.0m			Rp 1,500,000,000	
			TerraSAR-X, TANDEM-X, Pleiades 1A/B, SPOT 6/7				Zodiac 7.3m			Rp 3,000,000,000	Rp 100,000,000,000
4	Parangtritis Geomaritime Science Park DIY	BIG	Antena Tidak Aktif	1	2	1	Timestep 0.9m	Rp 24,000,000	Rp 636,000,000	Rp 1,000,000,000	
5	Kampus STMKG	BMKG	Himawari-8	2	2	1	C-Band 3.5m	Rp 48,000,000	Rp 636,000,000	Rp 1,500,000,000	
6	9 Wilayah	BMKG	NOAA, MetOp	18	18	3	Timestep 0.9m	Rp 432,000,000	Rp 1,524,000,000	Rp 9,000,000,000	
7	Kantor Pusat	BMKG	TERRA,AQUA	3	2	1	ES&S 3.0m	Rp 72,000,000	Rp 636,000,000	Rp 1,500,000,000	
8	Perancak, Bali	BPOL KKP	Antena Tidak Aktif	10	3	2	Orbital 3.0m	Rp 240,000,000	Rp 744,000,000	Rp 3,000,000,000	Rp 2,500,000,000
			Radarsat				ViaSat 5.4m		Rp 480,000,000	Rp 2,500,000,000	
9	Bangka Belitung	Bakamla	Belum Operasional	1	3	2	Tiongkok 7.3M	Rp 24,000,000	Rp 744,000,000	Rp 2,500,000,000	Rp 2,500,000,000
			Antena Tidak Aktif				ViaSat 5.4m			Rp 3,000,000,000	
10	Bitung, Manado	Bakamla	TERRA, AQUA, NOAA	5	3	2	EOSphere 3.0m	Rp 120,000,000	Rp 744,000,000	Rp 2,000,000,000	Rp 2,500,000,000
			Antena Tidak Aktif				EOSphere 5.4m			Rp 2,500,000,000	
JUMLAH				395	42	16	17	Rp 9,480,000,000	Rp 8,736,000,000	Rp 41,000,000,000	Rp 110,000,000,000
Total											Rp 169,216,000,000

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Then related to money, it requires a budget of around 169 billion rupiahs per year for internet/VPN, operator and technician honorariums, maintenance and repair of antennas, and payment of satellite monthly data fees. In the Operational Table column* section, it is assumed that the operator's honorarium is around IDR 4,000,000/person/month and the technician's honor is around IDR 5,000,000/person/month, as well as other operational costs IDR 10,000,000/month/antenna. In the maintenance/repair table column section**, maintenance is intended for ground station antennas that are being operational or repair is intended for inactive ground station antennas. Cost of the Annual Fee*** table section, assuming a budget of IDR 2,500,000,000, - for the acquisition of Landsat data per Institution and IDR 100,000,000,000, - for high resolution, very high, and SAR data acquisition.

4. Conclusion

With the development of a virtual integration of the national remote sensing ground station system (fully remote and nearly-automation), it will minimize errors due to human error, be more efficient (fast), and can be controlled and monitored better and easier. Although the ground station system works automatically, it is still necessary for the operators to monitor the process, and the technicians to carry out maintenance and repair in the event of a disruption to the ground station system. In the next phase, namely testing and verification, there will be more technical coordination with remote sensing ground station agencies so that the system can work well and stable.

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