ANALYSIS OF ANTENNA SPECIFICATION FOR VERY HIGH RESOLUTION SATELLITE DATA ACQUISITION THROUGH DIRECT RECEIVING SYSTEM (DRS)

Muchammad Soleh[1], Ali Syahputra Nasution, Arif Hidayat, Hidayat Gunawan, and Ayom Widipaminto
Remote Sensing Technology and Data Center
Indonesian National Institute of Aeronautics and Space
[1]E-mail: muchammad.soleh@lapan.go.id
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Abstract. Very High Resolution Satellite Image (VHRSI) data for Indonesian Government license is required by ministries/agencies, TNI, police, and local government to support national programs. But Indonesia did not have a VHRSI data recipient facility to directly acquire this data. In accordance with Law 21/2013 on Space, LAPAN is mandate to provide high resolution satellite data, and based on a roadmap for provision of satellite data in 2017, LAPAN will provide a VHRSI data reception facility through direct receiving system (DRS). This will be more efficient than other methods in providing the data. Priority provision of satellite data is for acquiring Pleiades and TerraSAR-X operating in the frequency range 8 GHz (X-Band). Therefore, to receive both data, it requires antenna subsystem with optimum coverage throughout Indonesia. Parameters to obtain the minimum antenna specifications include Free Space Loss (FSL), Carrier to Noise Ratio (C/No) and Antenna Gain to Noise Temperature (G/T). The calculation of G/T antenna is done for both satellites based on satellite parameters and analysis of antenna product availability in the market. Based on the calculation of satellite parameters shows that the minimum G/T value with the elevation of 5 degrees is 27.71 dB/K for Pleiades data reception and the minimum G/T value of 26.10 dB/K for the TerraSAR-X data reception. In general, the minimum G/T value for receiving the Pleiades and TerraSAR-X data is at 28 dB/K. While based on the calculation of antenna products availability in the market is require G/T value of 33.45 dB /K for the elevation of 5 degrees with a diameter of 7.5 mm antenna. This can be conclude that the antenna products meets the minimum requirements specification and to receive both satellite data. However, both calculation for the antenna subsystem still will be evaluated further in order to be directly installed at Parepare Remote Earth Station (SPBJ), South Sulawesi.

Keywords: *VHRSI, Optic, SAR, Direct Receiving System (DRS), Antenna*

1 INTRODUCTION

Recently, satellite data of Very High Resolution Satellite Image (VHRSI) with panchromatic channel at <1 meter, has been on a high demand for utilization and important due to support national priority activities, such as completion of the preparation of a Spatial Detail Plan (RDTR), mapping of Priority Industrial Estates (KIP) and Special Economic Zones (KEK) and mapping of border areas, optimize planning and monitoring of urban/regional development. This in accordance with the Presidential Regulation of the Republic of Indonesia Number 79 of 2017 concerning Government Work Plans (RKP) and to support national program at providing large scale map (1:5,000). LAPAN and Geospatial Information Agency (BIG) are the Indonesian's government institutional that lead in supporting the program,

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where LAPAN's responsibilities is mostly to provide VHRSI data.

Provision of data through procurement of VHRSI data at LAPAN has been carried out since January 2013 to October 2016. The VHRSI data includes Pleiades (70 cm), Quickbird (50 cm), GeoEye-1 (41 cm), Worldview-2 (46 cm) and Worldview-3 (31 cm) with cloud cover <20% in primary level and Geotiff (Airbus DS 2006; Digital Globe 2016). All VHRSI data before 2017 are archived in the National Remote Sensing Data Bank (BDPJN) with total coverage area at 998,835.21 km^2, but requires more circa 923,734.79 km^2 in order to cover the entire Indonesian land area. Therefore, in order to fulfill the rest of the area it will requires 3 years to obtain the imagery circa 310,000 km^2/year.

Indonesia as a tropical climate country causes the optical satellite data are largely constrained by clouds. For this reason, complementary data is needed such as SAR satellite data that can penetrate clouds and can be acquired at any time of day or night. Currently the infrastructure for providing the VHRSI and SAR data is not available at LAPAN. Based on current conditions, to prepare the VHRSI and SAR data acquisition system, additional equipment is needed in the form of X-Band receiving antenna subsystem as shown in Figure 1-1.

The objective of this research is to carry out the preparation and operation of Direct Receiving System (DRS) to achieve the target number of high resolution optical VHRSI and SAR data.

2 ACQUISITION OF REMOTE SENSING SATELLITE DATA ON LAPAN GROUND STATION

Regarding the provision of satellite data through direct acquisition, LAPAN has already three ground stations system located in Parepare, Jakarta/Pekayon, and Rumpin. The ground station that is located in Parepare has 3 antenna system units and has been operating to carry out direct acquisition and processing of various satellite remote sensing data, such as Terra satellite data, Aqua, Suomi NPP, SPOT-6, SPOT-7, Landsat 7 and Landsat 8, while the ground station in Jakarta acquires and processes NOAA-18, NOAA-19, METOP-A, and Himawari-8 satellite data. The third ground station located in Rumpin acquires Terra, Aqua and Landsat 7 and Landsat 8 satellite data.

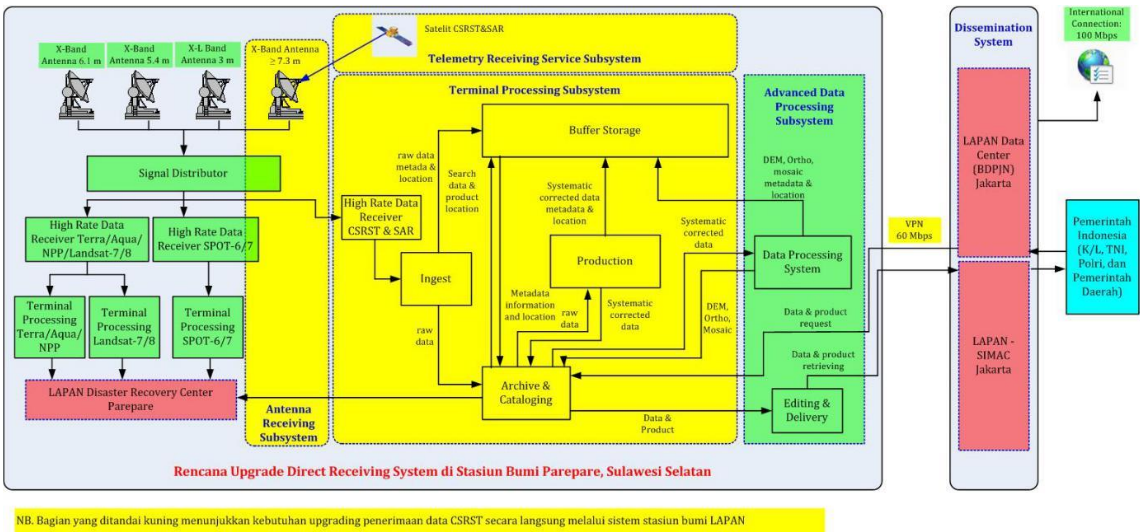

Figure 1-1: Current LAPAN Parepare Ground Station system architecture (green) and post reinforcement (yellow)

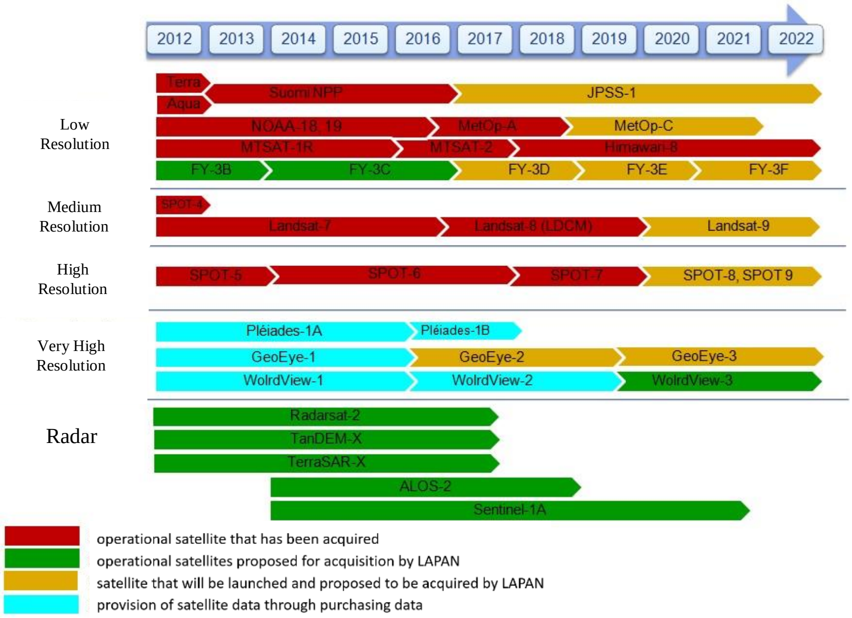

Figure 2-1: Plans for the acquisition of satellite remote sensing data by the LAPAN Ground Station until 2022

In early 2018, LAPAN Parepare ground station has planned to acquire VHRSI Optical data and high SAR resolution. The addition of a new antenna subsystem with X-Band frequency for receipting Pleiades optical satellite data and TerraSAR-X radar satellite data in order to meet the target number of optical VHRSI data area and high SAR resolution is shown in Figure 2-1.

2.1 Efforts to Provide Pleiades and TerraSAR-X Data through Direct Receiving System (DRS)

Pleiades satellite is one of the earth monitoring satellites with polar orbit which has a very high resolution of 0.5 m for panchromatic imagery and 2 m for multispectral imagery as shown in Figure 2-2. This Pleiades satellite is one of the constellation satellites operated by Airbus Defense and Space which has 4 spectral bands namely Panchromatic (480-830 nm), Blue (430-550 nm), Green (490-610 nm), Red (600- 720 nm), Near Infrared (750-950 nm) (Eoportal 2017). With the advantage of having a constellation satellite, the Pleiades Satellite can get data for an area everyday so that the process of observing the area to be observed can run with maximum changes. This very useful for observing areas that are being affected by disaster and monitoring an area under construction. The Pleiades-1 Satellite and the Pleiades-2 Satellite are planned to be received in the Parepare Remote Sensing Ground Station.

The TerraSAR-X satellite is one of the radar satellites built by the German Aerospace Center (DLR) and EADS Astrium as shown in Figure 2-3. The TerraSAR-X satellite uses an active radar sensor onboard which the data is not interfere by the weather (Eoportal 2017).

The satellite has 3 imaging modes namely SpotLight, StripMap and ScanSAR. The SpotLight imaging mode has a spatial resolution of up to 1 m with the dimensions of the image in one portrait at 10 km (width) x 5 km (length). The StripMap imaging mode has a spatial resolution of up to 3 m with image dimensions 30 km (width) x 50 km (length), and the last TerraSAR-X Satellite has ScanSAR imaging mode, where the imaging mode has a resolution of up to 16 m with 100 km image dimensions (width) x 150 km (length) (Eoportal 2017).

The TerraSAR-X Satellite has been widely used for several applications such as mining, oil and gas exploration, topographic mapping, state defense and security, monitoring flood areas, earthquake prone areas, land use monitoring and others.

Provision of Pleiades and TerraSAR-X data above can be done with two alternatives, namely through purchasing/procurement for multi-users (limited licenses) and through direct acquisition/DRS (Direct Receiving System) which under the license of the Government of the Republic of Indonesia.

Provision of data through the procurement will be very limited to the availability of archived data acquired by satellite operators. In addition, the licenses given are usually limited, with a maximum of 10 users. Moreover, the provision for multi-users (limited licenses) will initially be cheaper and simpler when compared to direct data acquisition and no need to upgrade the antenna processing system at the earth station.

However, to meet all ministries/institutions and regional needs with limited license and to fulfill the rest of the target's coverage, it is necessary acquire the data through order programming the satellite, yet more expensive prices, with almost twice the price of archived data.

Comparing with the procurement in obtaining the data, in the long term, acquiring the data through DRS will be far more economical. In addition, user access for all ministries/institutions and local governments is not limited, because the license to use it is an Indonesian Government License.

The transmission from both satellite will sends a large data capacities at more than 300 Mbps. Therefore, to avoid damage to data when shipping, fading margins, it needs to be calculated so that the interference during transmission can be avoided.

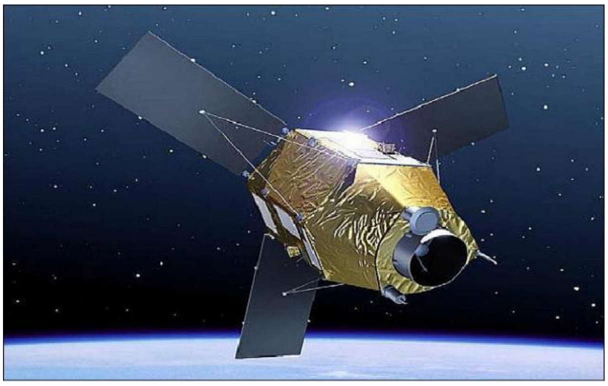

Figure 2-2: Pleiades-1/2 (Eoportal 2017)

Product : Panchromatic : 50 cm
Multispectral : 2 m
Revisit rate : Daily (constellation)
Spectral Bands : Panchromatic (470 – 830 nm)
Blue (430 – 550 nm)
Green (500 – 620 nm)
Red (590 – 710 nm)
Near-infrared (740 – 940 nm)
Swath Width : 20 Km
Processing Level : Primary (1A)
Ortho (automatic) or Tailored Ortho

Figure 2-3: TerraSAR-X (Eoportal 2017)

Product : Staring SpotLight : up to 25 cm
High Resolution Spot Light : up to 1 m
StripMap : up to 3 m
Scan SAR : up to 16 m
Wide Scan SAR : up to 40 m
Revisit rate : 11 days
Polarisation : Single, dual - depending on imaging mode quadruple is available as advanced polarisation mode for dedicated acquisition campaigns

The other benefit of acquiring the data through programming order through DRS are the flexibility to obtain the VHRSI data in meeting high priority needs to cover all regions of Indonesia. Through direct data acquisition or DRS, the latest data can be obtain quickly according to priority. Another advantage of providing data with direct data acquisition is that it is flexible in producing multiple levels of data (bundle products and/or pansharpened products), better access services (emergency tasking, priority tasking, standard tasking and / or archive data), operational guarantee of acquisition by several satellites, wider data area compared to the purchase of archived data (for the same budget amount), and data licensed by the Government of the Republic of Indonesia.

The benefit of obtaining the SAR data is to be the complement of optical data due to ability to penetrate clouds.

In term of build the earth station system for direct reception (DRS) for VHRSI optical data and high resolution SAR, there are 3 main subsystems to be considered, namely the Telemetry Receiving Service Subsystem (TRSS), Antenna Receiving Subsystem (ARS) and Terminal Processing Subsystem (TPS).

This research is limited to reviewing and analyzing the Antenna Receiving Subsystem (ARS) subsystem which is planned to be implemented at LAPAN Parepare Ground Station through DRS for receipt of Pleiades optical satellite data and TerraSAR-X radar satellite data. LAPAN Parepare Ground Station was chosen because of its location which is able to cover almost all parts of Indonesia.

As shown in Figure 2-4, the main components of the ARS subsystem for optical VHRSI data acquisition and high resolution SAR include several subsystems, namely the RF section consisting of X-Band, LNA and Feed-Power antennas and IF parts consisting of X-Band Down- Converter, Line Driver to Demodulator. All the systems must be able to be integrated with the antenna system that is already in LAPAN Parepare Ground Station.

2.2 High Resolution Satellite Parameters

Low earth satellite communication system has been using a single carrier communication system (Hidayat, 2006). Where sending data is sent in one channel, so that if there is damage then the data is not received properly. Single carrier transmission has a vulnerability to distortion interference due to interference or multipath signals. In addition, errors due to error pointing in tracking can be one of the causes of reception interference in the recipient (Hidayat et al. 2017; Hidayat 2014). We need a careful calculation so that the entire system can run according to needs.

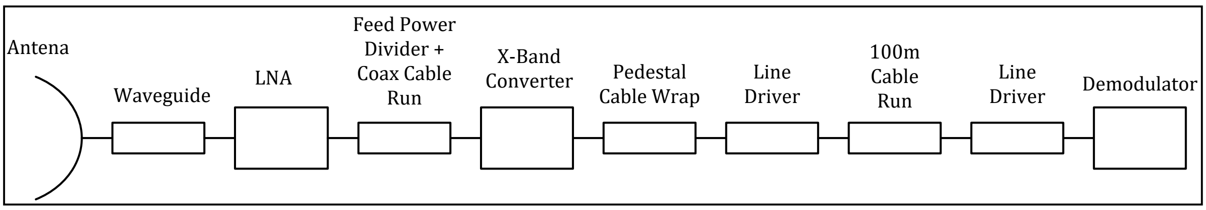

Figure 2-4: The main antenna system components on ARS (*Antenna Receiving Subsystem*)

To obtain the required G/T antenna parameters, a satellite EB/No value will be needed (Judianto, 2012). EB/No parameters can be seen in Figure 2-5a and b. The parameter value for Figure 2-5a is EB/No without coding gain while 2-5b uses error coding gain control, (Thales 2012). Error control coding functions as a control if there is damage or error bits of information received by the demodulator (Haykin 2007). Using error control coding can reduce the bit energy needed by satellite transmitters.

The use of error control reduces the number of bits of information transmitted because correction bits. According to Symon Haykin (2007), the bit rate value can be calculated with Equation:

Data Rate = log 2 (Modulation) * Bandwidth (2-1)

However, when using the control bit, the calculation is multiplied by coding rate. Calculation of the value of data rates based on the coding value of 8 PSK gain multiplied by effective bandwidth multiplied by the coding gain factor (Hidayat 2006).

Data Rate = Modulation * Bandwidth * Coding Rate (2-2)

The Pleiades satellite technical data can be seen in Table 2-1. Satellite Pleiades has 2 constellations, namely Pleiades 1 and Pleiades 2. Satellite Pleiades 1 and Pleiades 2 have 3 channel downlink, with EIRP 15.3 dB at an altitude of 694 km with modulation of 8 PSK. The required EB/No value is 8.9 dB. From the satellite data, the value of the C/No system and G/T will be determined in the antenna demodulator. Following are the Pleiades satellite downlink parameters according to the Space Agency 2017 and Thales 2017.

The technical data of TerraSAR-X and Tandem-X satellites can be seen in Table 2-2. The TerraSAR-X satellite is a satellite made in Germany. This satellite has active SAR sensor capabilities. The downlink parameters of this satellite are shown in Table 2-2.

2.3 Geometry of Receiving Satellite Data and Power Requirements in Antenna Demodulators

The position of the satellite against the ground station antenna is depicted in Figure 2-6. Antenna elevation and satellite position on the antenna affect the distance of the satellite to the ground station. The lower the position of the antenna towards the horizon the further the position of the satellite is towards the ground station. The LEO satellite (Low Earth Orbit) moves quickly around the earth according to the speed of rotation. The distance between satellites and the earth varies very quickly. The tracking time is only 5 to 30 minutes depending on the antenna elevation to the horizon line.

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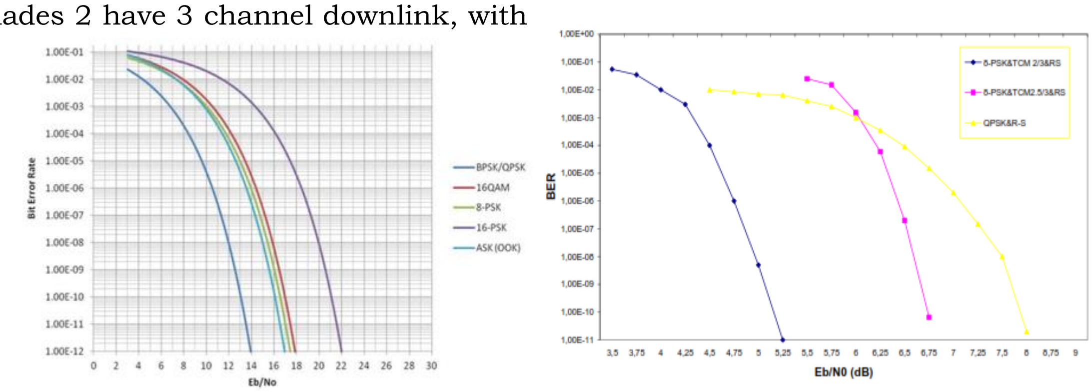

(a) (b)

Figure 2-5: BER Graph against EB/No. (a) Without Error Control, (b) With Error Control ¾ Trellis Code

Table 2-1: PLEIADES DOWNLINK PARAMETERS (UK SPACE AGENCIES, 2017)

No	Parameters	Pleaiades 1	Pleiades 2
1	Apoge & Perigee	694 km	694 km
2	Inclination	98.3 Degree	98.3 Degree
3	Carrier Freq Ch 1	8165.5 MHz	8165.5 MHz
4	Carrier Freq Ch 2	8295.5 MHz	8295.5 MHz
5	Carrier Freq Ch 3	8353.5 MHz	8353.5 MHz
6	Bandwidth Ch1, Ch2, Ch3	105 MHz total 315 MHz	105 MHz total 315 MHz
7	EIRP ch 1,Ch2,Ch3	15.3 dB	15.3 dB
9	Modulation	8 PSK	8 PSK
10	BER	Min 10E-11	Min 10E-11
11	EB/No with Coding Gain	8.9 dB	8.9 dB
12	Data Rate at 8 PSK	155 Mbps Single Channel	155 Mbps Single Channel
13	Data Rate at 8 PSK	465 Mbps Full Channel	465 Mbps Full Channel

Table 2-2: TERRASAR-X AND TANDEM-X DOWNLINK PARAMETERS (UK SPACE AGENCY, 2017).

No	Parameters	TerraSAR X	Tandem X
1	Apoge & Perigee	514.8 km	514.8 km
2	Inclination	98.3 Degree	98.3 Degree
3	Carrier Frek	8150.0MHz	8150.0MHz
4	Bandwidth	225.0 MHz	225.0 MHz
5	EIRP	23dB	23dB
6	Modulation	QPSK	QPSK
7	BER	10 E-11	10 E-11
8	EB/No without coding gain	12 dB	12 Db
9	Bitrate	450 Mbps	450 Mbps

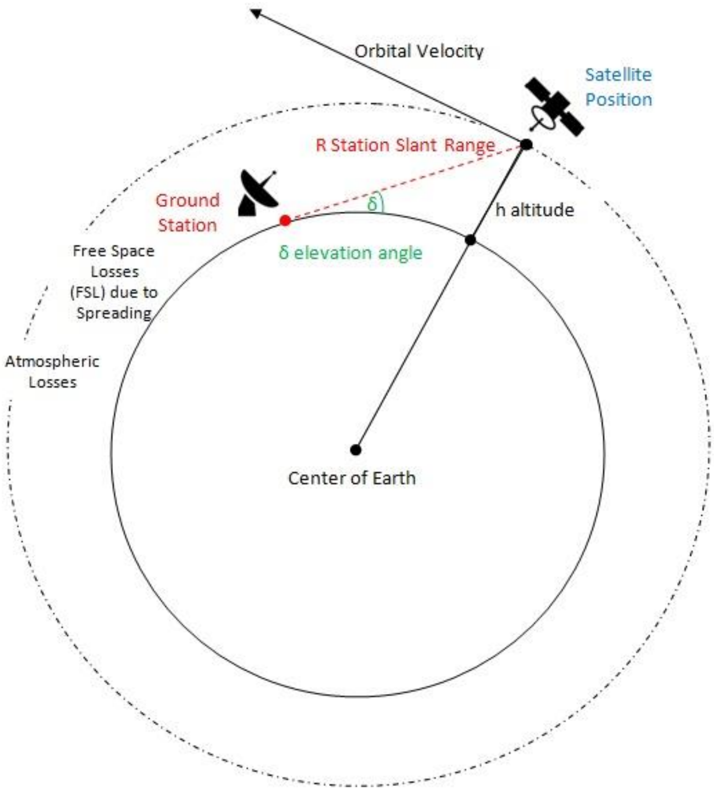

Figure 2-6: Illustration of Satellite Position on Earth Station Antennas

Calculation of the slant range distance from the highest elevation to the 5 degree elevation limit is done to obtain Free Space Losses (FSL) which will be used as C/No and G/T antenna calculations. The distance of the satellite with an antenna (RStation Slant Range) can be calculated based on the finger of the earth at the center of the earth with the satellite using equation 2-3 (Judianto, 2012).

$$\boldsymbol{R_{station\ slant\ range}} = \boldsymbol{R_{earth}}\left[\sqrt{\frac{(h+R_{earth})^2}{R_{earth}^{\ 2}}-\boldsymbol{cos^2(\delta)}}-\boldsymbol{sin(\delta)}\right] \quad (2\text{-}3)$$

where:

$\boldsymbol{R_{station\ slant\ range}}$	= Distance from Satellite to Antenna (km)
$\boldsymbol{h}$	= Altitude (km)
$\boldsymbol{R_{earth}}$	= The radius of earth (km)
$\boldsymbol{\delta}$	= Elevation Angle (degree)

To get the maximum distance, can be measured from the calculations of satellite geometry, where the maximum distance will be obtained when reaching 5 degrees elevation. According to Judianto (2012) the calculation of satellite distance to the earth station consists of several components, namely the distance of the satellite to the surface of the earth, the finger of the earth, the elevation angle of the antenna, the angle of the satellite with the center of the earth.

To measure the power lost in free space without obstacles, the FSL value is determined. FSL depends on two parameters, namely carrier signal frequency (f) and wireless transmission distance (h). The FSL value is obtained from the following equation 2-4.

$$Free\ Space\ Losses\ (FSL) = 32.44 + 20\log(h) + 20\log(f) \quad (2\text{-}4)$$

where:

FSL	= Free Space Losses (dB)
h	= Altitude (km)
f	= Carrier Frequency (MHz)

The carrier value for Noise Ratio (C/No) in the receiving antenna is obtained by multiplying Energy per Bit to Noise Power Spectral Density Ratio (EB/No) with a divided Bitrate (Rb) with Bandwidth (B) (Hidayat 2014). Mathematically C/No in the receiving antenna in the logarithmic form is stated in equation 2-5 (Judianto 2014):

$$\boldsymbol{\frac{C}{No} = \frac{Eb}{No} + Rb - B} \quad (2\text{-}5)$$

where:

$\boldsymbol{\frac{C}{No}}$	= Carrier to Noise Ratio (dB)
$\boldsymbol{\frac{Eb}{No}}$	=Energy per Bit to Noise Power Spectral Density Ratio (dB)
$\boldsymbol{Rb}$	= Bit Rate (dB)
$\boldsymbol{B}$	= Bandwidth (dB)

The last parameter calculated is the value of antenna performance (G/T). G/T is a measure of the antenna's ability to obtain satellite data where G is an Antenna Gain and T is a System Noise Temperature, so G/T is the ratio of the Antenna Gain to System Noise Temperature. The relationship between C/No and G/T is expressed in the equation 2-6:

$$\boldsymbol{\frac{C}{No} = EIRP + \frac{G}{T} - FSL - L - K - B} \quad (2\text{-}6)$$

The G/T value can be calculated as follows:

$$\frac{G}{T} = \frac{C}{No} - EIRP + FSL + K + B \qquad (2\text{-}7)$$

where:

G/T = Antenna gain-to-noise-temperature (dB)

EIRP = *Effective (or Equivalent) Isotropic Radiated Power* (dbW)

FSL = *Free Space Losses* (dB)

K = *Boltzman Constant* (1.38064852(79) × 10^{-23} J/K)

B = Bandwidth (dB)

L = *Loss Margin* (dB)

ARS Technical Needs for VHRSI Optical Data Acquisition and SAR High Resolution.

In general, the ARS technical requirements that will be applied in the LAPAN Parepare Ground Station are shown in Table 2-3.

The antennas operate on X-Band channels (8-12 GHz), minimum antenna diameter 7.3 m, polarisari RHCP/LHCP antenna (Right/Left Hand Circular Polarization), antennas are intended to be able to receive directly (DRS) data Pleiades and TerraSAR-X.

3 RESULTS AND DISCUSSION

3.1 Analysis of Free Space Loss dan G/T Antenna

The results of calculation of $\boldsymbol{R_{station\ slant\ range}}$ for Pleiades and TerraSAR-X are shown in Figure 3-1. $\boldsymbol{R_{station\ slant\ range}}$ Indicates the distance of the satellite to the earth station antenna. The image is plotted using Equation 3. It can be seen that the distance at elevation is high, while the slant range for the two satellites tends to be closer to the satellite and both have similar value, which are for the Satellite Pleiades is 694 km and for TerraSAR-X is 514.8 km. While the calculation results at low elevation, the slant range distance for the two satellites tends to show far differences and the slant range between satellites and earth stations is very significant. The results are for Satellite Pleiades is ca. 3,055.23 km and for TerraSAR-X is ca. 2,613.79 km.

In this research, the author uses the antenna elevation reference value of 5 degrees, where for Pleiades $\boldsymbol{R_{station\ slant\ range}}$ = 2,549.50 km and for TerraSAR-X $\boldsymbol{R_{station\ slant\ range}}$ = 2,116.36 km.

The calculation of the value of the antenna elevation is used because the satellite transmission signal will begin to be captured by an antenna in a lock position at an elevation of 5 degrees. This also avoids the satellite transmission signal experiencing multipath fading and interference from the obstacle around the earth station at very low elevations (generally <3 degrees) (Hidayat, 2017).

Table 2-3: TECHNICAL NEEDS OF ANTENNA RECEIVING SUBSYSTEM (ARS)

Parameters	Specifications
Reflector Diameter	Minimum 7.3 m
Panel Material & Reflector Trusses	Aluminium
Feeder Type	Cassegraine
Tracking Ability	Program Track & Autotrack
Polarisation	
Data Channel	Simultaneous RHCP/LHCP
Tracking Channel	Selectable RHCP/LHCP
Frequency	X-band only
G/T	
Data Channel	Minimum 32.5 dB/K @ 5 degree elevation
Tracking Channel	Minimum 31.0 dB/K @ 5 degree elevation
Accuration	

Autotracking	Maximum 0.05° rms BRE
Pointing	Maximum 0.10° rms BRE
Insertion loss	Maximum 0.20 dB
Passband ripple	Maximum ± 0.05 dB
Axis Support	Az/El/Train or Az/El/Tilt
Position Accuration	0.025° rms
Center Frequency \IF	720 MHz (1200 MHz preferable)
Down Converter Availability (DC)	Minimum 3 units (Dual channel data reception, 1 channel traking)
Up Converter Availability (UC)	Minimum 1 unit
Converter Type	Block/Modular
Temperature Outdoor	
Operational	-40°C to +55°C
Storage	-40°C to +65°C
Wind	
Operational	72 km/hr Gusting to 85 km/h
Survival	200 km/hr, sustained
Radome	Optional
Guaranteed availability of maintenance and spare parts	Minimum 10 years
Satellite Support	Could receive very high resolution optical satellite data such as Pleiades; and Radar satellite data such as TanDEM-X, TerraSAR-X
Can be integrated with existing LAPAN Parepare Ground Station devices	Mandatory

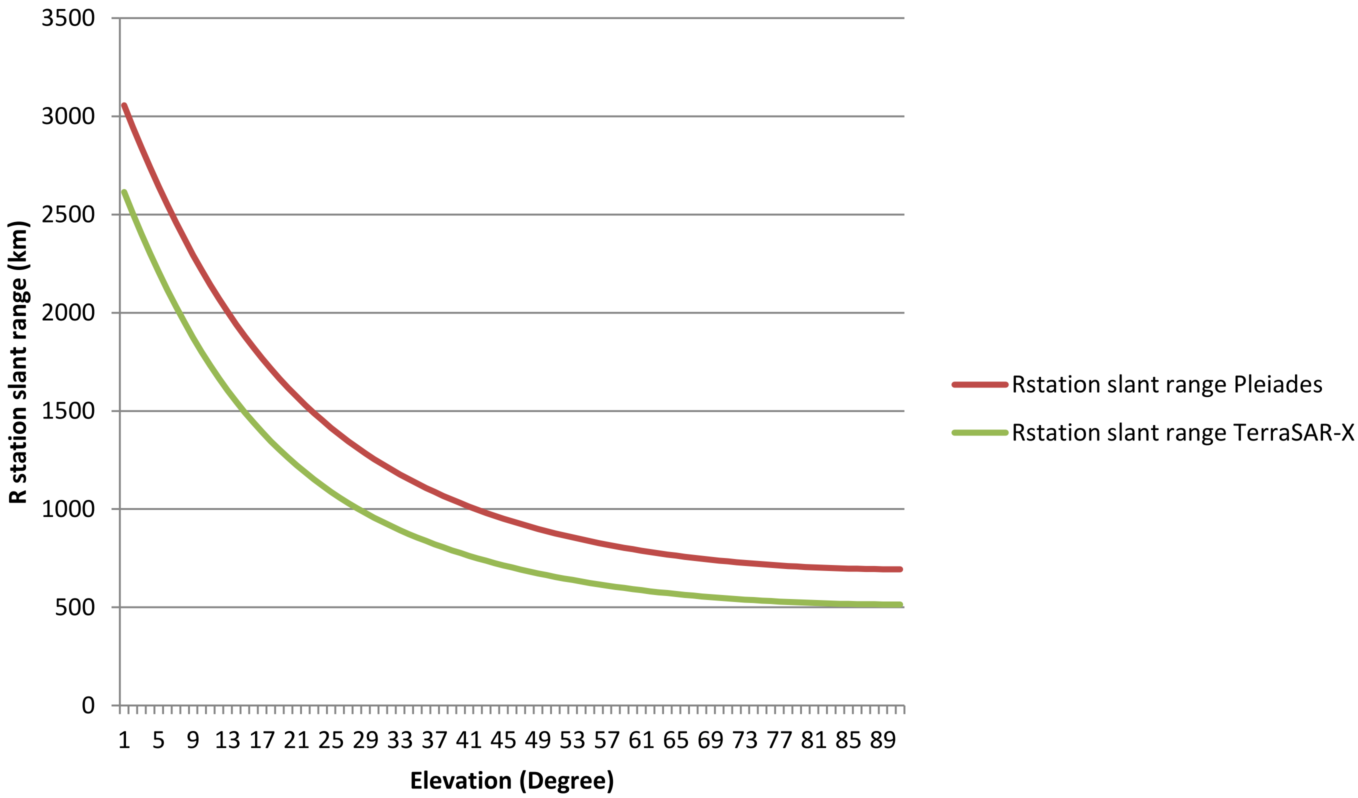

Figure 3-1: Distance of Pleiades and TerraSAR-X satellites to Earth Station Antennas

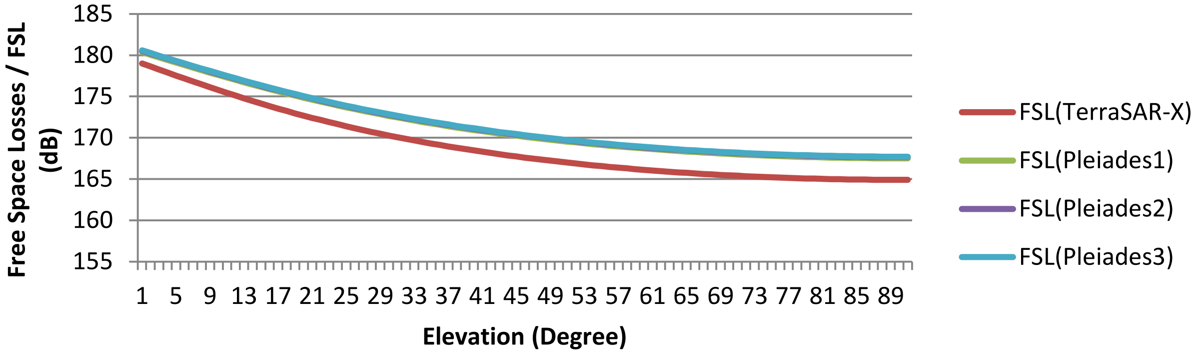

Figure 3-2: Free Space Loss (FSL) of Pleiades and TerraSAR-X Satellite

Table 3-1: Carrier to Noise Ratio (C/No) calculation values of Pleiades dan TerraSAR-X Satellite

No	Satellite	C/No (dB)
1	Pleiades	10.59
2	TerraSAR-X	15.01

Table 3-2: Parameters of Pleiades and TerraSAR-X Satellite Data Receipt at 5 Degrees Elevation

Downlink (Satellite to station)	Pleaides 1	Pleaides 2	Pleaides 3	TerraSAR-X	Unit
C/No Requirement di Demodulator	10.59	10.59	10.59	15.01	dB
EIRP	15.3	15.3	15.3	23.0	dBW
Loss Margin	2.0	2.0	2.0	2.0	dB
Bolzmant	228.6	228.6	228.6	228.6	dBW
Free Space Losses	178.81	178.95	179.00	177.17	dB
Bandwidth (B)	80.2118	80.2118	80.2118	83.5218	dB
G/T	26.10	26.53	27.14	27.71	dB

Electromagnetic waves emitted to the earth by the frequency of X-Band experience a loss of power due to vacuum and air. The power loss can be calculated based on the function of distance and frequency (Haykin, 2007). From the slant range distance parameters, the calculation can be derived to find the Free Space Losses (FSL) parameter values. The FSL calculation results are shown in Figure 3-2.

FSL values for TerraSAR-X appear to be lower than Pleiades, one of which is due to the TerraSAR-X slant range is smaller than the Pleiades. And based on its elevation, the FSL values of the two satellites will be greater at lower elevations and the smaller the FSL value at high elevation. But at 5 degrees, the FSL Pleiades (1,2 and 3) and TerraSAR-X values are relatively similar, where the values are 178.81, 178.95, 179.00 and 177.17 dB, respectively.

Another parameter to calculate the antenna G/T requirement is the Carrier to Noise Ratio (C/No). C/No can be written as satellite transmit power plus reinforcement against noise minus loss minus the Boltzman constant and total Banwidth in logarithmic form as shown in Equation 5. From the calculation results, it is shown in Table 3-1. The TerraSAR-X satellite has a C/No value greater than the Pleiades even though it uses QPSK modulation because it does not implement error control code.

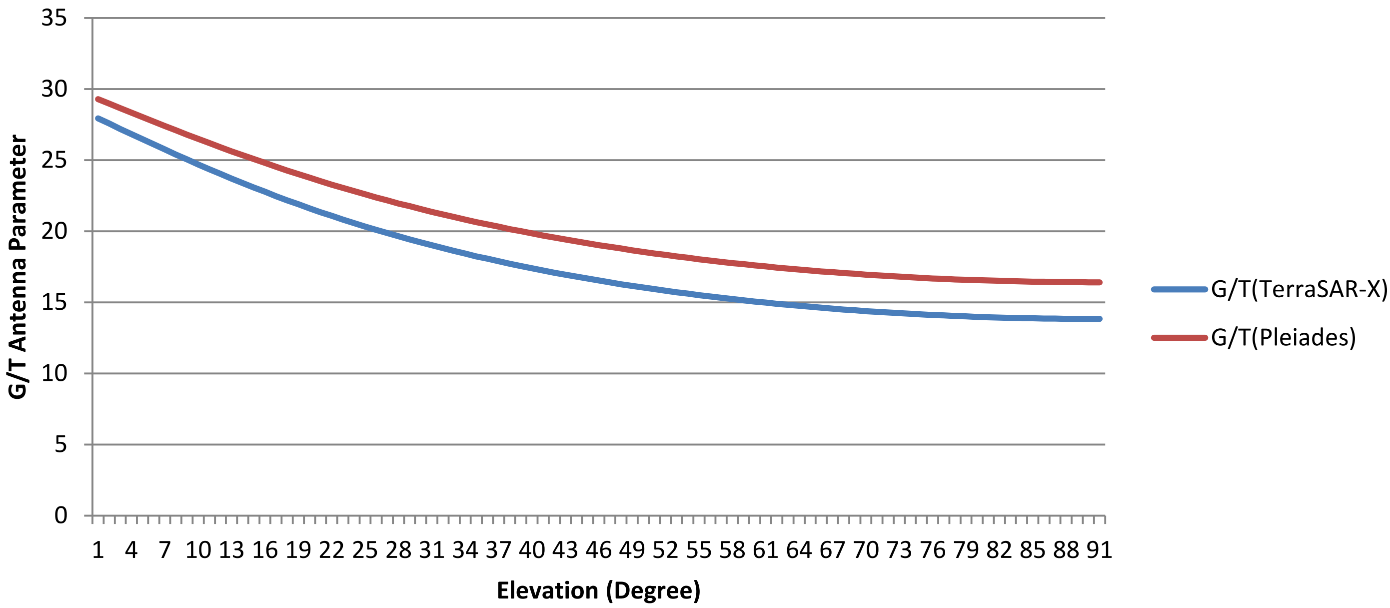

Figure 3-3: The Need for G/T Antenna for Every Elevation Based on Satellite Downlink Parameters

From result of calculation the FSL and C/No parameters, those value will be used to calculate the minimum G/T antenna requirements based on satellite downlink parameters that based on Tables 2-1 and 2-2 as shown in Figure 3-3.

All of the G/T values in Figure 3-3 above are expressed in logarithmic form derived based on satellite downlink parameters. According to R. Metzig (2011) and Klugel (2012) antennas used for data reception systems in Germany use an antenna with G/T 32 dB/K. In this section, the real demand for G/T will be calculated at the receiving antenna at the earth station based on previously calculated satellite parameters, namely C/No demodulator, FSL, Satellite EIRP, Bandwidth frequency and cable attenuation and connectors (Loss Margin) based on Equation 6. At an elevation of 5 degrees, the minimum requirement for G/T Pleiades is 26.10 dB/K and for TerraSAR-X is 27.71 dB/K. The results of G/T antenna calculations based on all satellite downlink parameters are summarized in Table 3-2.

3.2 Calculation of Requirements Analysis of G/T Antennas based on Availability of Antenna Products

Another calculation for determining the antenna G/T requirements for receiving VHRSI data is by reviewing it based on product specifications available on the market. Antenna input parameters that are taken into account include: antenna diameter, antenna efficiency, frequency, Sky Temperature, Waveguide, LNA, Power Divider Feed + Cable Run Coax, X-Band Converter, Pedestal Cable Wrap, Line Driver, 100m Cable Run and Demodulator. If the antenna diameter is 7.5 m with an efficiency of 71.72% and the signal frequency is 8 GHz, then the signal wavelength (λ) transmitted is $\lambda = \frac{c}{f}$ = 0.0375 meters and Gain Antenna $G = \frac{4\pi DF}{\lambda^2}\ x\ efficiency$ amounting to 54.52 dBi. By calculating losses due to noise/temperature noise on the antenna system (T_{sys}) of 21.06 dB/K, the antenna G/T value is obtained at 33.45 dB/K. Table 3-3 is a summary calculation to determine the G/T value of an antenna by considering several input parameters as mentioned above.

Table 3-3: CALCULATION OF G/T ANTENNAS BASED ON AVAILABILITY OF ANTENNA PRODUCTS IN THE MARKET

No	Parameters	Values	Units
Input Parameters :			
1	Antenna Diameter	7,5	meter
2	Antenna Efficiency	71,72	%
3	Operating Frequency Antenna	8000	MHz
4	Sky Temperature	52,8	Kelvin
5	Waveguide Temperature	290	Kelvin
6	Waveguide Gain	-0,53	dB
7	LNA Temperature	45	Kelvin
8	LNA Gain	45	dB
9	Feed Power Divider + Coax Cable Run Temperature	290	Kelvin
10	Feed Power Divider + Coax Cable Run Gain	-5,6	dB
11	X-Band Converter Temperature	290	Kelvin
12	X-Band Converter Gain	8	dB
13	X-Band Converter Noise Figure	19	dB
14	Pedestal Cable Wrap Temperature	290	Kelvin
15	Pedestal Cable Wrap Gain	-4,5	dB
16	Line Driver Wrap Temperature	290	Kelvin
17	Line Driver Gain	25	dB
18	Line Driver Noise Figure	6	dB
19	100m Cable Run Temperature	290	Kelvin
20	100m Cable Run Gain	-6,5	dB
21	Line Driver Temperature	290	Kelvin
22	Line Driver Gain	0	dB
23	Line Driver Noise Figure	0	dB
24	Demodulator Temperature	290	Kelvin
25	Demodulator Gain	0	dB
26	Demodulator Noise Figure	25	dB

No	Parameters	Values	Units
Calculation Results (Output) :			
1	Signal Wavelength	0,0375	meter
2	Antena Gain Calculation Result	283139,2111	
3	**Antena Gain Calculation Result**	**54,5200**	**dBi**
4	Noise Contribution From Antena	46,7341	Kelvin
5	Noise Contribution From Waveguide	33,3165	Kelvin
6	Noise Contribution From LNA	45,0000	Kelvin
7	Noise Contribution From Coax Cable Run	0,0241	Kelvin
8	Noise Contribution From X-Band Converter	2,6115	Kelvin
9	Noise Contribution From Pedestal Cable Wrap	0,0096	Kelvin
10	Noise Contribution From Line Driver	0,0443	Kelvin
11	Noise Contribution From 100m Cable Run	0,0002	Kelvin
12	Noise Contribution From Line Driver	0,0000	Kelvin
13	Noise Contribution From Line Driver	0,0662	Kelvin
14	**System Noise Temperature (T_{sys})**	**127,8066**	**Kelvin**
15	**System Noise Temperature (T_{sys})**	**21,0655**	**dB K**
16	**System G/T**	**33,4545**	**dB K**

The results of the calculation of G/T antenna requirements are carried out for both satellites based on satellite parameters and an analysis of the availability of antenna products on the market. From the satellite parameters obtained the calculation of the minimum G/T value at 5 degrees elevation of 27.71 dB/K for receipt of Pleiades data and the minimum G/T value of 26.10 dB/K for receiving TerraSAR-X data. Whereas based on the calculation of available antenna products on the market, the G/T value of 33.45 dB/K is obtained at 5 degrees elevation with a 7.5 meter antenna diameter. The analysis shows that the minimum G/T value for receiving Pleiades and TerraSAR-X data is 28 dB/K, and based on analysis of available antenna products on the market meet the minimum requirement specifications and allow them to receive data from both satellites with G/T values reaching 33 dB/K at 5 degrees elevation if using an antenna with a diameter of 7.5 m. Therefore, it technically can be stated that the minimum requirement of G/T antenna to receive Pleiades and TerraSAR-X data is possible to be implemented in SPBJ Parepare. But the two results of these calculations need to be tested and evaluated directly for the X-Band antenna subsystem that will be planned to be installed at the Parepare Remote Sensing Ground Station, South Sulawesi.

Regarding the wiring and power problems on the X-Band antennas, the proposed is to build a new X-Band antenna with a diameter of 7.5 m at the LAPAN Parepare ground station which according to the results of the study is planned as shown in Figure 3-4, where the red line shows the cable line for power and the yellow line is the IF (Intermediate Frequency) cable line.

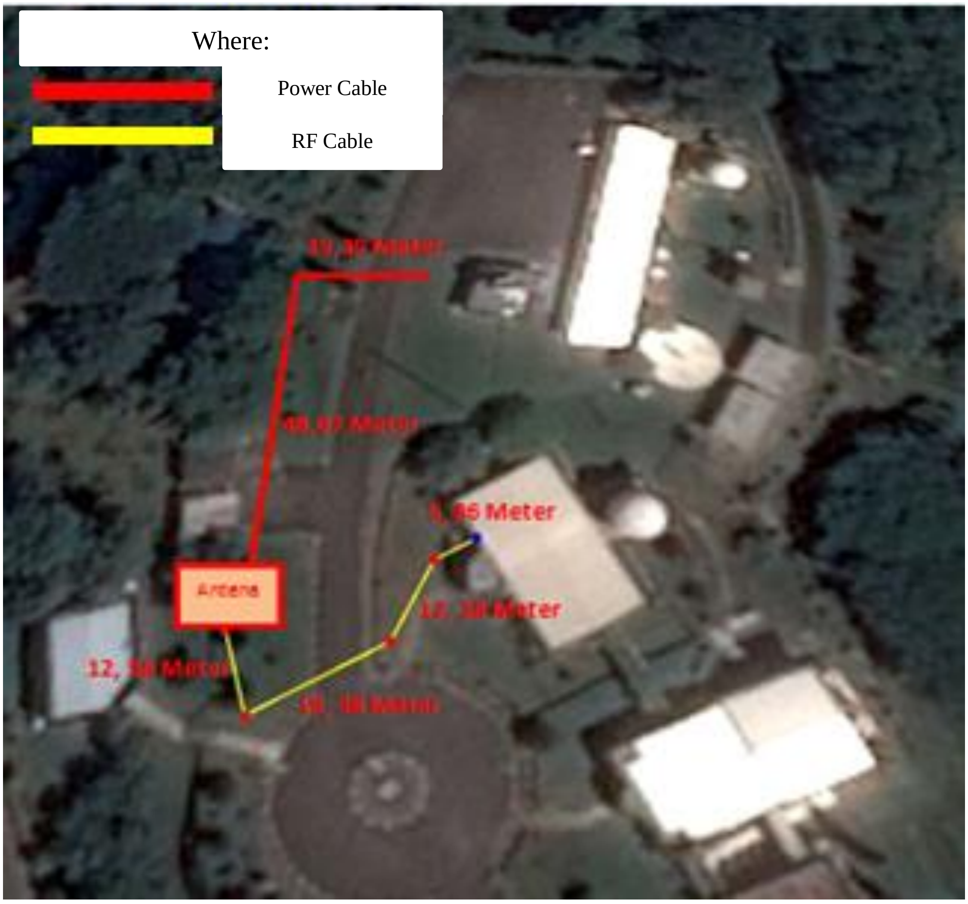

Figure 3-4: X-Band Antenna Allocation Plan For VHRSI Data Acquisition

4 CONCLUSION

This study and analysis of the antenna subsystem is carried out for the reception of VHRSI optical data and direct high-resolution SAR (Direct Receiving System) data in order to meet the amount of data to support national priority programs. The benefit of acquiring the data through the DRS systems is to obtain the latest data of VHRSI (Pleiades) and SAR (TerraSAR-X) that can be provide quickly based on national priority. Another advantage of providing data with direct data acquisition is the flexibility in producing multiple levels of data (bundle products and/or pansharpened products), better access services (emergency tasking, priority tasking, standard tasking and / or archive data), operational guarantee of acquisition by several satellites, wider data area compared to the purchase of archived data (for the same amount of budget), and data with licenses from the Government of the Republic of Indonesia and the data provided can meet user needs in accordance with their priorities, while the advantages, in obtaining the Synthetic Aperture Radar (SAR) is for the complement of optical data due to ability to penetrate clouds.

Based on the measurement, in supporting the development of DRS for acquiring Pleiades and TerraSAR-X, some of the finding are to suggest that the new antenna will better has elevation reference value at 5 degrees due to a lock position types. This in order to avoids the satellite transmission signal experiencing multipath fading and interference from the obstacle around the earth station usually occurred at very low elevations (<3 degrees). The elevation reference at 5 degrees also will gives best FSL (relatively similar) for all the satellite (TerraSAR-X, Pleiades 1,2 and 3) which benefit to minimize the loss of power due to vacuum and air.

Moreover, based on the results of the calculation of G/T antenna requirements have been carried out for both satellites based on satellite parameters and an analysis of the availability of antenna products on the market, the satellite parameters obtained for the calculation of the minimum G/T value at 5 degrees elevation of 27.71 dB/K for receipt of Pleiades data and the minimum G/T value of 26.10 dB/K for receiving TerraSAR-X data. Whereas based on the calculation of available antenna products on the market, the G/T value of 33.45 dB/K is obtained at 5 degrees elevation with a 7.5 meter antenna diameter. The analysis shows that the minimum G/T value for receiving Pleiades and TerraSAR-X data is 28 dB/K, and based on analysis of available antenna products on the market meet the minimum requirement specifications and allow them to receive data from both satellites with G/T values reaching 33 dB/K at 5 degrees elevation if using an antenna with a diameter of 7.5 m. Therefore technically it can be stated that the minimum requirement of G/T antenna to receive Pleiades and TerraSAR-X data is possible to be implemented in Parepare Ground Station. But the two results of these calculations need to be tested and evaluated directly on the X-Band antenna subsystem which will be planned to be installed at the Parepare Ground Station, South Sulawesi.

Regarding the wiring and power problems needed to operate X-Band antennas, the proposed placement of a new X-Band antenna with a diameter of 7.5 m at the LAPAN Parepare Ground Station according to the results of the study is shown in Figure 3-4. Where the red line shows the cable line for power and the yellow line is the IF cable line.

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