



Analysis of Microwave Communication Network Planning on Ocean Topography Using Space Diversity

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ABSTRACT

One of the challenges often met by planners of the telecommunications network using microwave radio is surface conditions, especially when passing through the ocean. Propagation conditions above sea surface often result in increasing fading, which significantly affects the reliability of the microwave network. On the other hand, considering that Indonesia is an archipelago, ocean topography is unavoidable, and the use of microwave networks generally considered to be the most efficient among other technologies, especially in Eastern Indonesia. This research aims to respond to such a challenge by planning a microwave communication network using a space diversity technique. The type of microwave network used is a point to point, which links Bali and Lombok islands. The results showed that the use of space diversity techniques could increase fading margins from 34.42 dB to 35.15 dB and availability value from 99.99667% to 99.99873%. Therefore, this technique recommends implementing by telecommunications network providers in accelerating the deployment of connecting networks in areas that have ocean topography.

1. Introduction

The United Nations Convention on The Law of the Sea (UNCLOS, 1982) states that Indonesia is geographically the world's largest archipelagic state with its water territories encompass an area of 5.8 million km². Around 2/3 of Indonesia's region consists of water that connects its islands, including the Lombok Strait, which connects the islands of Bali and Lombok of West Nusa Tenggara Province. Bali and Lombok islands are Indonesia's most popular tourism destinations, making proper communication network planning is significant. One of the challenges in microwave communication networks planning in the Karangasem area of Bali and Mataram area of Lombok is that the ocean separates the two site points. Telecommunications technology plays a pivotal role in connecting one person to another with a microwave communication link.

Microwave communication means wireless communication with air as a transmission media (Ramadan, Jambola, & Hardiansyah, 2016). The consideration for the use of microwave communication is the high operational cost of submarine networks operation, and the substantial damage factors in the underwater networks contributed by natural and human factors (Mulia, SB, Hidayat, 2014) so that an alternative technology is needed to back up the submarine network. Microwave communication applies point to point connection to carry out the communication process so that communication between one site and another runs Line of Sight (LOS). LOS is a condition where two sites are connected and free of any obstacles so that the signal transmitted at the site transmitter can directly receive at the receiver site (Mahmud & Khan, 2009).

In this research, the Point to Point microwave planning will deploy with a network connecting Bali (Karangasem) and Lombok (Mataram) islands as the planned site. Lombok and Bali's islands are Indonesia's most popular tourist destinations, so that communication network access planning is significantly needed. One of the challenges in microwave communication networks planning in the Karangasem area of Bali and Mataram area of Lombok is that the ocean separates the two site points. Attenuation, which occurs above the water surface, is higher than attenuation above the ground, causing multipath fading, which may lead to disruption of information data transmission through the transmitter to the receiver (Liu, Wahyudi, &

Nugraha, 2017). Besides, multipath fading can affect the availability value. Another factor that can also affect availability is the presence of obstacles, as shown in the results of the study (Kristiadi & Nashiruddin, 2019).

Availability is a measurement of a system's reliability so that an order is said to be ideal if the availability percentage value is 100% (Triwibiwo, Wahyudi, & Larasati, 2019). However, since attenuation or loss occurs in point to point microwave communication, it is difficult to achieve an ideal system. Diversity techniques used to overcome this problem. Diversity is a process of transmitting and/or receiving several waves simultaneously and then adding or combining all at the receiving end or selecting one of the best data information (Freeman L., 2007). One of the available techniques is a space diversity technique where two or more antennas installed within a particular distance use, and the best signal will be chosen and eventually processed by the receiver. The use of multiple antennas or space diversity techniques expected to increase availability (level of reliability) on communication network systems. In planning the microwave communication network system, a study needed to find out and analyze the influence of a diversity technique, that is, space diversity. In this case, the results of the analysis can use to determine the best solution for planning a point to point microwave communication network system.

2. Literature Review

2.1. Microwave Communication

Microwave communication means wireless communication with air as a transmission media (Ramadan, Jambola, & Hardiansyah, 2016). Microwave communication divided into two main parts, namely, transmitter (Tx) and receiver (Rx), in which information is transmitted from the transmitter (Tx) and received by the receiver (Rx). The characteristic of microwave communication is an obstruction-free path between points of microwave signal transmission and reception antennas. The clear path is usually called Line of Sight (LOS). The LOS propagation is present in Figure 1.

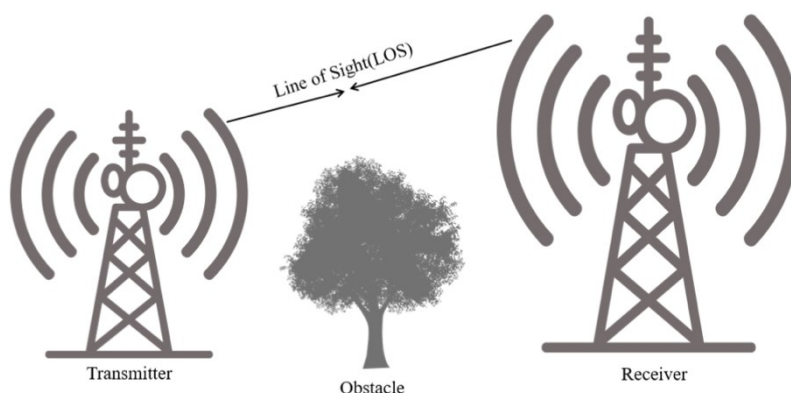


Figure 1. Line of Sight (LOS) propagation

In addition to Line of Sight (LOS), it is also necessary to consider other factors in a microwave communication system, which includes regional conditions, loss (attenuation), and link budget. Microwave transmission can carry channel capacity so that it can use as an alternative in radio link installation (Meitasari, Nugroho, & Azman, 2016). Microwave communication works by using Quadrature Amplitude Modulation (QAM) modulation measured in Bit Error Rate (BER) of 10^{-6} .

2.2. Synchronous Digital Hierarchy (SDH)

SDH is a technology with a hierarchical transport structure and designed to transport information (payload) that is adjusted appropriately in a transmission network (Palle, 2013). SDH (Synchronous Digital Hierarchy) transmission is a digital transport network that transmits information signals from one place to

another with high flexibility and can distribute SDH signals. The unit of SDH is STM-1 (Synchronous Transport Module) with a bit rate of 155.52 Mbit/s recommended by ITU-T G.707, SDH is a transport hierarchy based on multiple 155.52 Mbit/s. Table 1 shows the SDH hierarchy as presented in Table 1.

Table 1. Hierarchy SDH (Synchronous Digital Hierarchy)

Level Hierarchy	Bit Rate	STM-N
1	155,52 Mbps	STM-1
4	622,08 Mbps	STM-4
16	2,5 Gbps	STM-16
64	10 Gbps	STM-64

2.3. Fading

The mechanism of fading includes refraction, reflection, diffraction, scattering, and attenuation (Utomo, & Suni, 2016) (Mubarokah & Handayani, 2015). The explanation for the causes of fading illustrated in Figure 2.



Figure 2. The Factors Which Causing Fading

The followings cause fading:

- a. Reflection occurs because a signal hits an object with a dimension more significant than the signal wavelength.
- b. Diffraction occurs when a signal hits a sharp-shaped object.
- c. Scattering occurs when an obstacle or particle with dimensions smaller than signal wavelength.

2.3.1. Large Scale Fading

Large scale fading is a fluctuation of propagation attenuation due to signal propagation over long distances, large areas, and long time intervals. Large scale fading is resulted by reflectors and obstacles that act as an obstructor in the propagation path. It is also influenced by the earth's contour, resulting in changes in the signal's phase and time delay.

2.3.2. Small Scale Fading

Small scale fading can describe as a rapid fluctuation of the received power level due to changes of sub-wave at the receiver. This effect is caused by constructive (mutually reinforcing) and destructive (mutually weakening) interference in many multipath waves that are received by the receiver.

2.3.3. How to Handle Fading

Fading may occur due to several factors. However, some measures can be applied to handle fading, which comprise:

- a. Amplifying aperture antenna by increasing performance at the receiver by using Low Noise Amplifier (LNA) in front of the mixer or increase the power of the transmitter.
- b. Use diversity techniques to reduce fading.

2.4. Diversity

Diversity is a process of transmitting and receiving several waves simultaneously and then adding or combining all at the receiving end or selecting one of the best data information (Freeman L., 2007). Diversity can be in the form of space, frequency, and time domains. The most commonly used methods of diversity to minimize the effects of multipath fading are space diversity and frequency diversity. Diversity divided into the following three classes:

- a. Frequency Diversity
Frequency diversity is when more than one carrier frequencies will be modulated by information signal and fading, carrier frequencies will spread over at least the wide of a path coherent bandwidth.
- b. Time Diversity
Time diversity is information signals to be transmitted at different time slots, and replica signals will send at a particular time delay. To avoiding the fading between the original signal and replica signal, the delay between time slots should be arranged carefully, at the minimum of equal to the path coherent time.
- c. Space Diversity
Space diversity is information signals to be transmitted using multiple transmitter antennas, and numerous, which are set at distances to fading occurs between antennas, are mutually independent.

2.5. Link Budget Parameter for Microwave Communication

The link budget is an essential factor in planning point to point microwave communication. The link budget defines as the estimated power budget. It ensures that the level of receiving power is higher than the threshold power level. Meanwhile, the threshold power level is the minimum power level required by the system at the receiver to be able to work correctly following the required quality. Therefore, in analyzing link budget parameters so that point to point microwave communication can work properly, it is necessary to consider several parameters with the specifications and conditions of an area to be established as a microwave communication planning site.

2.5.1. Fresnel Zone and Clearance Factor

Fresnel Zone is one of the factors to be considered in the planning of the microwave communication path. The Fresnel Zone is required to be free of obstacles or sight obstruction because it can cause path attenuation (Andersen, 1964).

Based on Figure 3, F_1 is the radius of the first Fresnel zone, with the formula:

$$F_1 = 17,3 \sqrt{\frac{d_1 d_2}{f(d_1 + d_2)}} \text{ (meter)} \dots\dots\dots(1)$$

- Where: F_1 = Radius of first fresnel zone
 f = working frequency (GHz)
 d_1 = distance between T_x and obstacle (km)
 d_2 = distance between R_x and obstacle (km)
 d = $d_1 + d_2$ = distance between T_x and R_x (km)

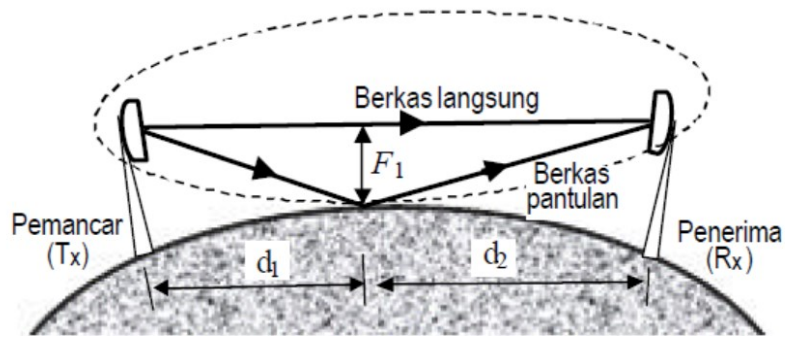


Figure 3. Fresnel Zone

Due to the spherical shape of the earth, height correction is necessary. It affects the height of the obstacle along the path of the microwave communication system. The equation is as follows.

$$h_k = \frac{d_1 d_2}{12,75 \times K} m \dots\dots\dots(2)$$

Where: h_k = correction of height associated with the ocean surface (m)
 K = Earth's curvature factor (constant)
 d_1 dan d_2 = Distance between site and obstacle path (km)

The clearance factor is the distance between the central axis of the microwave communication path and the obstacle peak. Therefore, the height of the obstacle must be considered. It calculated at the point where the highest obstacle located. So that Line of Sight (LOS) is met. The equation is as follows.

$$h_c = \frac{h_1 d_2 + h_2 d_1}{d} - h_k - h_s \dots\dots\dots(3)$$

Dimana: h_c = the obstacle height associated with the ocean surface (m)
 h_1 = the antenna one height associated with the ocean surface (m)
 h_2 = the antenna two height associated with the ocean surface (m)
 h_k = correction of height associated with the ocean surface (m)
 h_s = the obstacle height associated with the ocean surface (m)
 d_1 dan d_2 = distance between site and obstacle path

Path Loss is a system whose value can calculate using the Free Space Loss (FSL) equation if the radius of fresnel zone 1 is free of obstacles. Path loss can be calculated based on the level diagram shown in Figure 4. The path loss equation is calculating base on the link budget:

$$P_{RX} = P_{Tx} - L_{FTX} + G_{TX} - LP + G_{RX} - L_{FRX} \dots\dots\dots(4)$$

so:

$$LP = P_{Tx} - L_{FTX} + G_{TX} - P_{RX} + G_{RX} - L_{FRX} \dots\dots\dots(5)$$

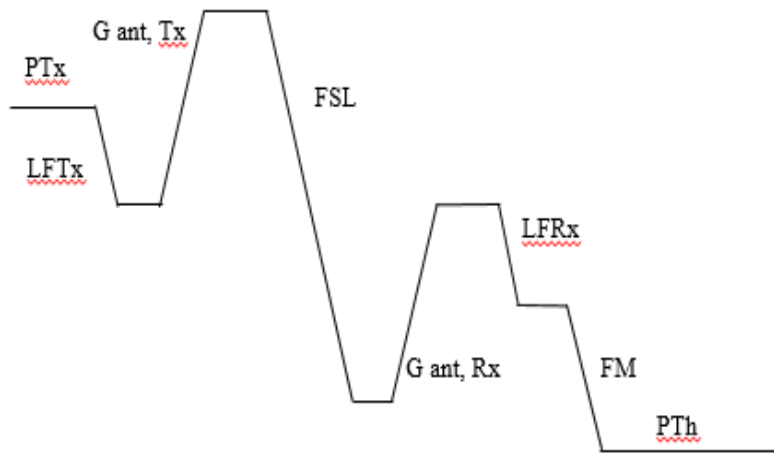


Figure 4. Pathloss Level Diagram

2.5.2. Effective Isotropically Radiated Power (EIRP)

The Effective Isotropically Radiated Power is a parameter for the measured energy emitted or radiated by an antenna or access point. It happens when the power radiated from the transmitter supply (PTx) experiences a loss or attenuation in power at LTx and also experiences again by the transmitter antenna (GTx). The Effective Isotropically Radiated Power (EIRP) equation can state as follows.

$$EIRP = P_{Tx} - L_{Tx} + G_{Tx} \dots\dots\dots(6)$$

- Where: P_{Tx} = Output transmitter Power (dBm)
- L_{Tx} = transmitter total loss or attenuation (dB)
- G_{Tx} = transmitter total gain (dB)

2.5.3. Free Space Loss (FSL)

Free Space Loss (FSL) is a parameter for a loss in or attenuation of power caused by the propagation of microwaves from one place to another, which experiences the spread of energy along the free space path (Freeman L., 2007). The formula for Free Space Loss (FSL) expressed as follows (Goktas, Topcu, Karasan, & Altintas, 2015).

$$FSL = 92,45 + 20\log D_{(km)} + 20\log f_{(GHz)} \dots\dots\dots(7)$$

- Where: D = distance between transmitter (Tx) and receiver (Rx) in a path (km)
- f = Frequency (GHz)

2.5.4. Isotropic Received Level (IRL)

Isotropic Received Level is the sum of power measured at a receiver isotropic antenna (Rx). A model for Isotropic Received Level (IRL) expressed as the following equation (Attamimi, S., 2014).

$$IRL = EIRP - FSL \dots\dots\dots(8)$$

- Where: IRL = Isotropic Received Level (dBm)
- FSL = Free Space Loss (dB)
- EIRP = Effective Isotropically Radiated Power (dBm)

2.5.5. Received Signal Level (RSL)

Received Signal Level is the sum of power received by the receiver (Rx) and is influence by losses along the path. For a point to point microwave communication system to run correctly, the Received Signal Level (RSL) value must be higher than the threshold power level value. The RSL equation is express as follows.

$$RSL = IRL + G_{Rx} - L_{Rx} \dots\dots\dots(9)$$

- Where:
- RSL = Received Signal Level (dBm)
 - IRL = Isotropic Received Level (dBm)
 - L_{Rx} = receiver total loss (attenuation) (dB)
 - G_{Rx} = receiver total gain (dB)

2.5.6. Fading Margin and Availability

On a microwave communication propagation, reflection occurs due to the earth's contours, so that receiver receives multiple waves with different distances and time. Fading margin is provided as a backup power level to prevent this.

Availability is a measure of system reliability, where ideally, the system will work optimally with 100% system reliability. However, this ideal state is impossible to achieve because of the loss and the system unavailability factors (Freeman L., 2007). The relationship between the fading margin value and the level of reliability (availability) present in Table 2 below.

Table 2. Fading Margin and Availability for Rayleigh Fading

Availability (%)	Fading margin (dB)
90	8
99	18
99,9	28
99,9	38
99,999	48

Source: (Freeman L. Roger, 2007)

3. Research Method

This research is conduct with a quantitative approach where connecting variables, collecting data and analyzing data undertake to obtain conclusions. In planning a point to point microwave communication network system, an analysis and comparison of results between microwave communication link plannings are carry out. In this study, the preparation of a microwave communication network system is divide into two scenarios, namely:

- a. Without the space diversity technique.
- b. Space diversity technique.

3.1. Simulation Technique

In addition to analyzing the level of reliability, this study also analyzes the link budget factor. The link budget is a significant factor for it is the estimation of power budget that needs taking into account in ensuring that the value of the received level is higher than equal to that of threshold power level (Freeman L., 2007).

In the link budget parameter, there is a signal strength attenuation factor that will affect the receipt of information data on the transmitter (Rappaport, 1996). Analysis of link budget results between the two scenarios carried out will lead to a conclusion about the planning of the microwave communication network system linking Karangasem site - Mataram site. In this regard, the results of this study can provide solutions for point to point microwave communication.

3.2. Research Flow Chart

The process of microwave communication network planning begins with identifying the technical needs, including the link budget, and determining the location of the site to find out the path to be designed. The next step was determining scenarios that will carry out. Next, a simulation test was carried out with two scenes, namely planning using space diversity and without space diversity by using the Pathloss 5.0 simulator to obtain link budget calculations and reliability analysis of radio wave communication systems. A conclusion will draw from the results of these simulations. In general, the research flow diagram present in Figure 5 below.

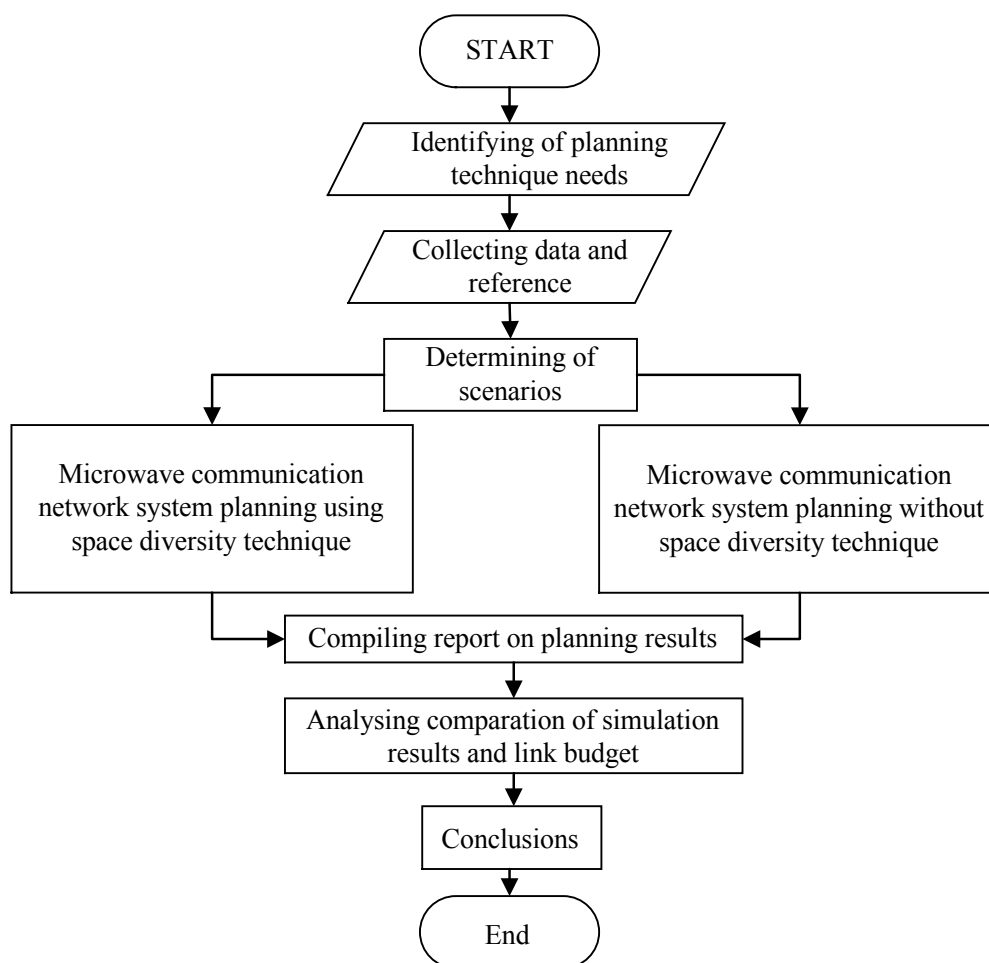


Figure 5. Research Flow Chart

4. Results and Discussions

This study focused on Karangasem and Mataram cities because of their strategic locations and how the Lombok Strait borders these regions. The next step was collecting data from each city, which included geographical conditions, coordinates, and distance between Karangasem and Mataram. The distance between the two sites is 51.48 km across the waters area of the Lombok Strait. The design of point-to-point microwave

communication made by using data in Table 3, which includes the sites' coordinates (longitude and latitude) and elevation.

Table 3. Information on microwave communication planning site

	Site Karangasem	Site Mataram
Longitude	-8,444284	-8,562387
Latitude	115,635362	116,087642
Elevation	114,50 m	10,75 m

Figure 6 shows the Karangasem site and Mataram sites, which are setting up to become points at the point to point microwave communication planning observed from the Goggle Maps.

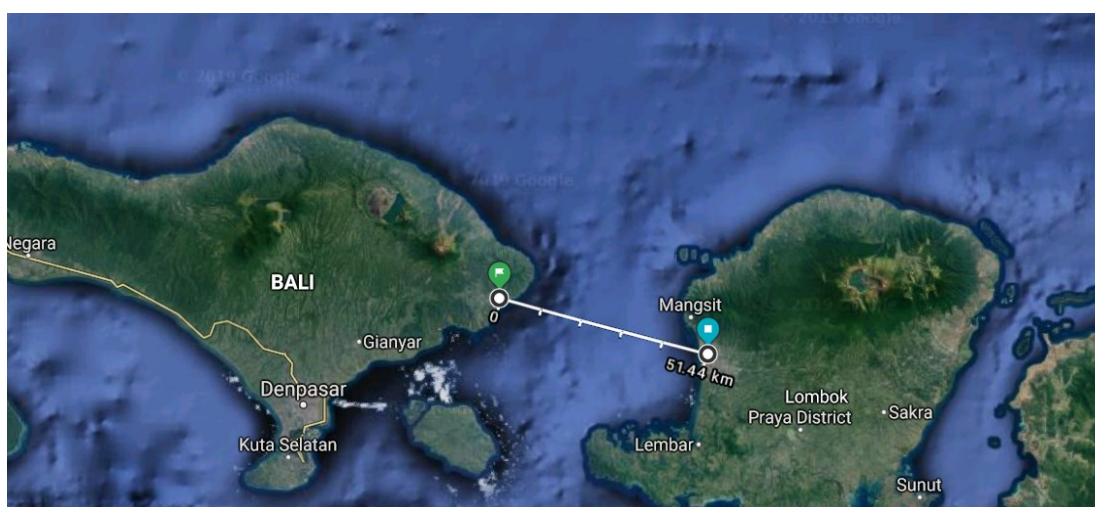


Figure 6. Site Karangasem - Site Mataram on Google Maps

After collecting information on the geographical conditions of both sites, the next step is to determine the specifications that will be used at each location, such as link budget, antenna type, loss feeder, the frequency used, and others. The use of the spectrum is complying with Regulation of Minister of Communications and Informatics No. 33 of 2015. For this study, the frequencies used for microwave communication links were between 7,125 MHz - 7,425 MHz (Regulation of Minister of Communications and Informatics, 2015). Specifications for the microwave communication network systems planning includes:

- a. Assuming the height of the antenna tower used for the Karangasem site is 39 meters, while the antenna height at the Mataram site is 30 meters. The heights of the antennas used in both microwave communication planning using space diversity techniques and microwave communication planning without space diversity are the same;
- b. Synchronous Digital Hierarchy (SDH) is defined as a technology with a hierarchical transport structure and designed to transport information (payload) that is adjusted appropriately in a transmission network (Palle, 2013). Following ITU-T Recommendation G.707/Y.1322 Network node interface for the synchronous digital hierarchy (SDH), the data rate used is 155.52 Mbit/s (STM-1) (Rec. ITU-T G.707, 2007);
- c. 128-QAM modulation;
- d. BER (Bit Error Rate) of 10^{-6}

4.1. Point to point microwave communication planning without Space Diversity technique

In the first stage of the planning, we do the simulation of point to point microwave communication planning without space diversity: it only one transmitter antenna and one receiver antenna used in this simulation.

In thi planning simulation, to achieve a Line of Sight (LOS) on the Karangasem site--Mataram site path, the path between the two sections must be free of obstacles or obstructions. Therefore, it is necessary to consider the settings of the transmitter and receiver antennas' height because they affect the clearance factor and fresnel zone. The height of the antennas in this point to point microwave communication planning was 39 m at the Karangasem site and 30 m at the Mataram site. The clearance factor and fresnel zone are shown in the path profile, as shown in Figure 7 below.

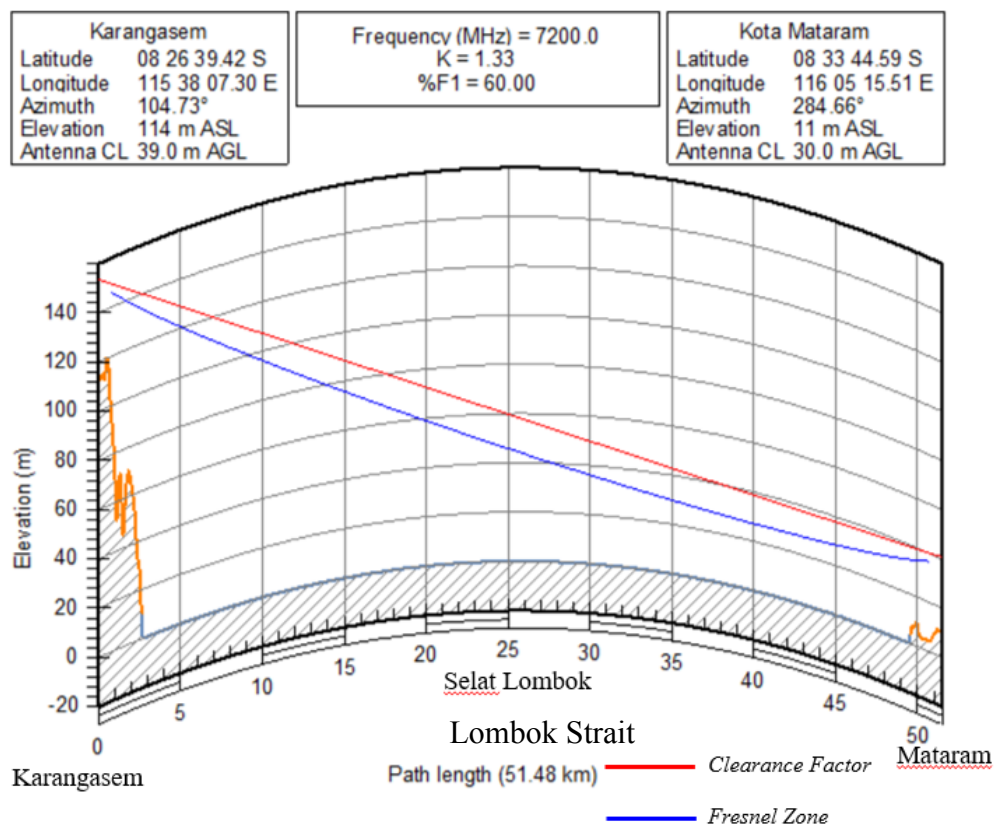


Figure 7. Path Profile on Planning Without Space Diversity Technique

In Figure 7, it can see that the clearance factor area is free from obstacles. An obstacle-free clearance factor area influences the determination of antenna height. Usually, a clearance factor value is 60%. It can see in Figure 7 that the path between the Karangasem site and Mataram site has a clearance area of 0.6 from Fresnel Zone 1 (F1). The existence of an obstacle-free area will significantly affect the quality of the signal transmission between the transmitter and receiver. As present in Figure 8, the multipath fading did not occur in the communication from the Karangasem site to the Mataram site.

After adjusting antennas' heights, the next step was building the microwave communication system from its radio model, the channel used, feeder, to antenna specifications. For point to point microwave communication without space diversity techniques, the antenna configuration set was TR - TR. The TR - TR configuration is an antenna configuration mode using a single antenna. Therefore, a point to point microwave communication system design without space diversity technique was established. The Point to Point microwave communication system design is shown in Figure 9.

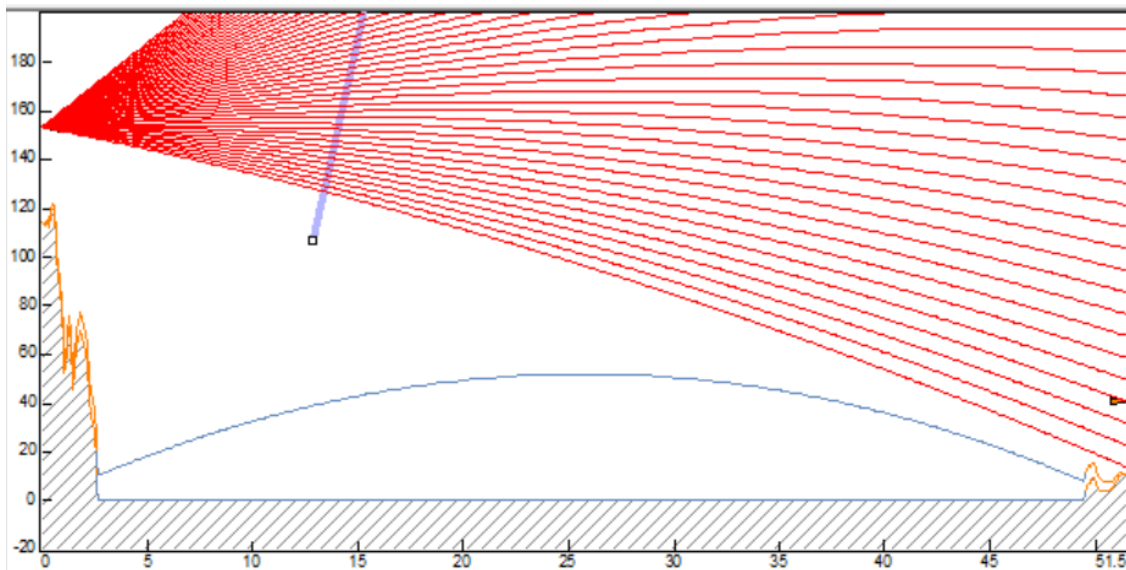


Figure 8. Transmission Direction on Microwave Communication Planning Without Space Diversity Technique

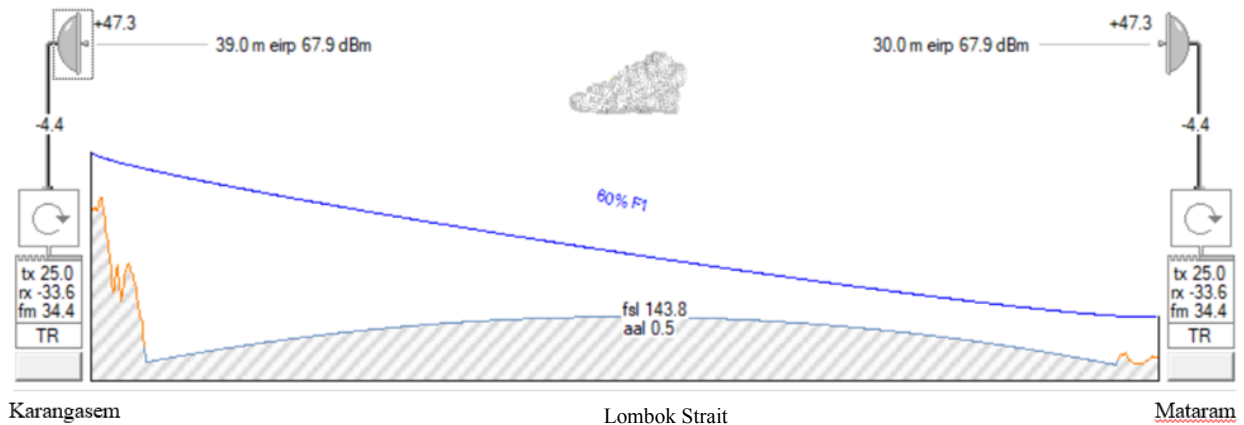


Figure 9. Microwave Communication Design Without Space Diversity Technique

After planning the point to point microwave communication pathway, the next step was analyzing the results of the communication path simulation. The analysis was conducted on the Point to Point microwave simulation. It comprised antenna height, radio models, Effective Isotropic Radiated Power (EIRP), Free Space Loss (FSL), Isotropic Received Level (IRL), Received Signal Level (RSL), threshold power level, thermal fade margin, threshold level, availability, and unavailability. The results of the simulation are presented in Table 4.

Table 4 shows that this planning used the frequency of 7.2 GHz, in which rain attenuation is assumed to be absent, or rain attenuation is considered not to affect the system. In terms of the Effective Isotropic Radiated Power (EIRP) parameter, the Karangasem site is at 67.87 dBm, while the Mataram site is at 67.87 dBm. Meanwhile, amounts of losses such as Free Space Loss (FSL) and atmospheric loss on the communication link are 143.83 dB and 0.50 dB.

To determine that the point-to-point microwave communication planning works appropriately, it is necessary to observe the Receive Signal Level (RSL) value. It can be seen that the RSL value on each link is -33.58 dBm, it can be concluded that the point to point microwave communication planning can work adequately, noting that the RSL value is above the threshold level value of -68.00 dBm.

Table 4. Results of the Simulation of Microwave Communication Planning Without Space Diversity Technique

Parameter	Value	
	Site Karangasem	Site Mataram
Antenna height (m)	39	30
Radio Model	Plus-XPIC-7GHz-128QAM-1	Plus-XPIC-7GHz-128QAM-1
EIRP (dBm)	67,87	67,87
FSL (dB)	143,83	143,83
Atmospheric Loss (dB)	0,50	0,50
IRL (dBm)	-75,96	-75,96
RSL (dBm)	-33,58	-33,58
Threshold Level (dBm)	-68,00	-68,0
Fade Margin (dB)	34,42	34,42
Availability (%)	99,99873	99,99667
Unavailability (%)	0,00333	0,00333

The next parameter is the fading margin; the value of the fading margin is very related to the availability value. The fading margin value at the Karangasem site is 34.42 dB, and at the Mataram, the site is 34.42 dBm, while the percentage availability for each location is 99.99667%.

4.2. Point to point microwave communication planning using Space Diversity technique

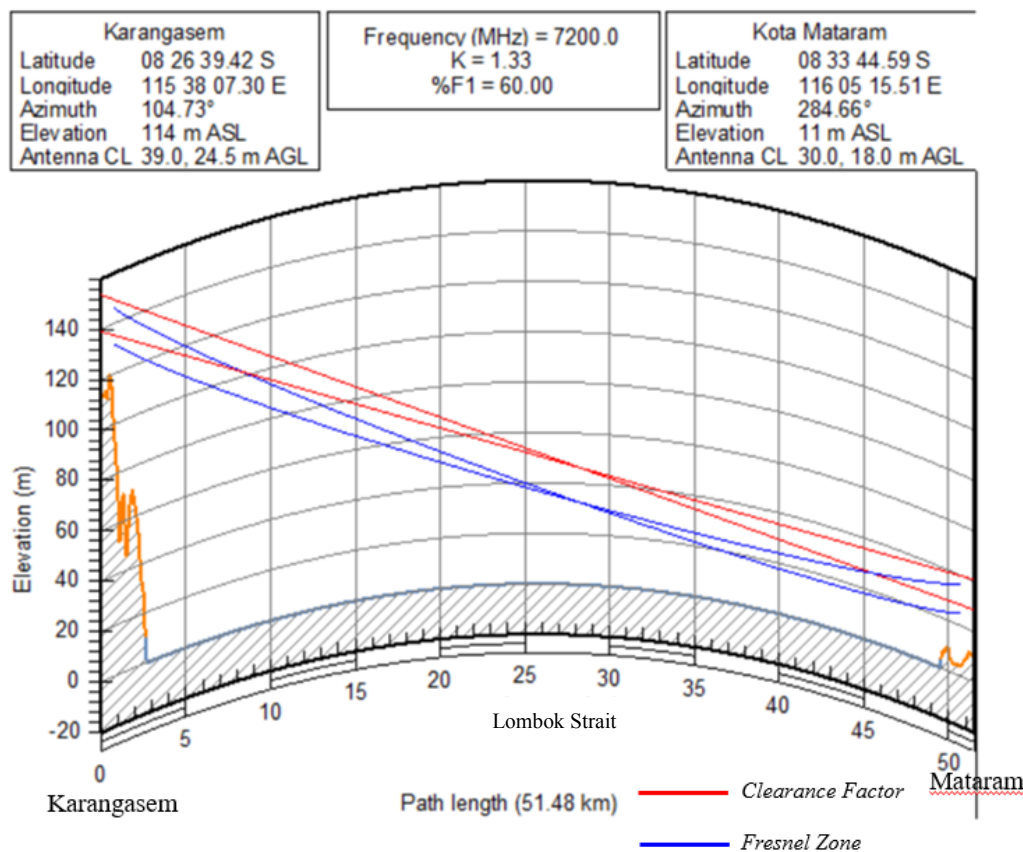


Figure 10. Path Profile on Planning With Space Diversity Technique

The second planning implements by simulating point-to-point microwave communication planning using space diversity technique by adjusting the number of transmitter and receiver antennas to two antennas in each Karangasem site and Mataram site. In this planning simulation, to achieve a Line of Sight (LOS) link between the Karangasem site and Mataram site, the path between the two sites must be free of obstacles or obstructions.

Therefore, the antenna height settings from both the transmitter and receiver need to be taken into account because they affect the clearance factor and fresnel zone. Unlike the first plan, the second plan includes two antenna heights, namely the height of the primary antenna and the height of the diversity antenna. In this point to point microwave communication planning, the height of the primary antenna at the Karangasem site is 39 m. In comparison, the height of the primary antenna at the Mataram site is 30 m. Meanwhile, the height of the diversity antennas at the Karangasem and Mataram sites are 24.5 m and 18.0 m, resulting in clearance factor and fresnel zone, as shown in Figure 10.

Figure 10 shows that the clearance factor area, which will influence the determination of antenna heights, is free from obstacles. The clearance factor value is usually at 60%, and it's present in Figure 10 that the path between the Karangasem - Mataram site has a clearance factor area of 0.6 from Fresnel Zone 1 (F1), both for the primary antenna and diversity antenna. The creation of a barrier-free area will significantly affect the quality of the signal transmission between the transmitter and receiver. Figure 11 shows that multipath fading did not occur on the communication from the Karangasem site to Mataram.

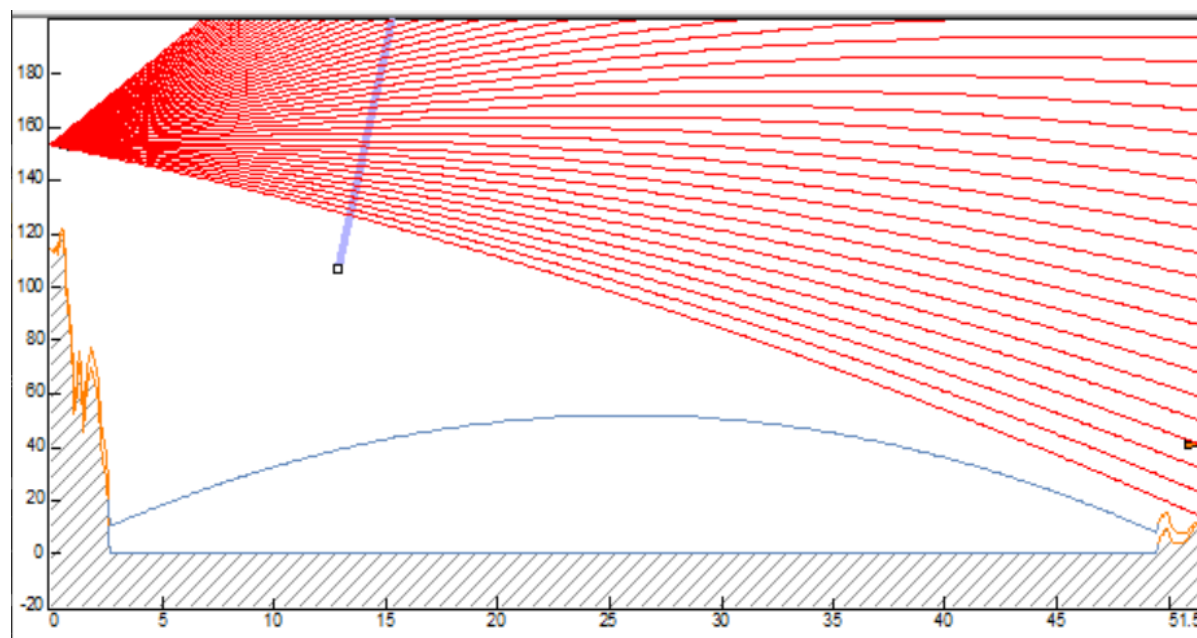


Figure 11. Transmission Direction on Microwave Communication Planning Using Space Diversity Technique

After adjusting the antenna height, the next step is to set the microwave communication system, including the radio model, the channel used, the feeder, and the antenna specifications. For point to point microwave communication using space diversity technique, the antenna configuration set used TRDR - TRDR.

In the Pathloss 5.0 simulator, space diversity planning applies for TRDR-TRDR antenna configurations, so a point to point microwave communication system design formed using a space diversity technique. The communication system design present in Figure 12.

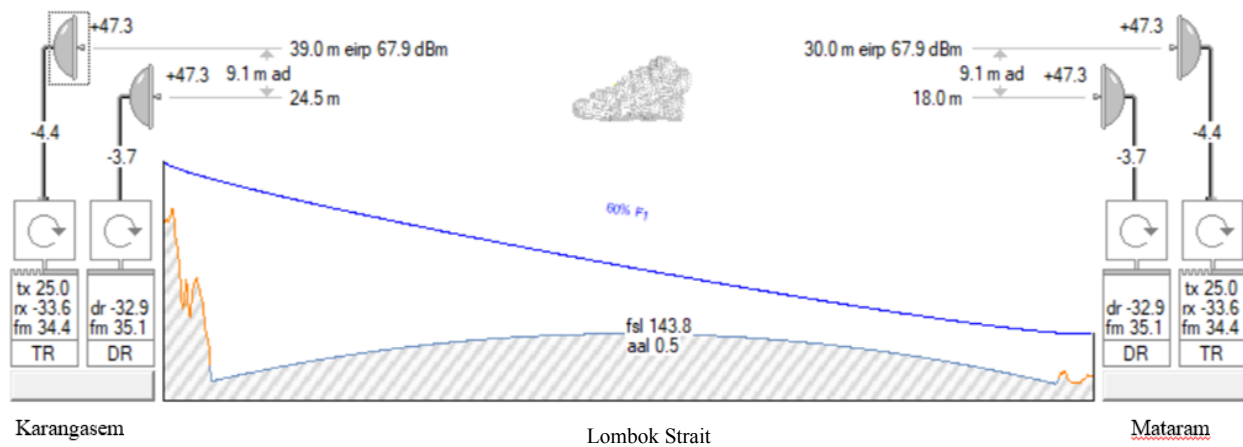


Figure 12. Microwave Communication Design With Space Diversity Technique

After planning the point to point microwave communication pathway, the next step is analyzing the results of the simulation of the communication path. The analysis was conducted on the simulation results, which involve some parameters. These include antenna height, radio models, Effective Isotropic Radiated Power (EIRP), Free Space Loss (FSL), Isotropic Received Level (IRL), Received Signal Level (RSL), threshold power level, thermal fade margin, threshold level, availability, and unavailability. The results of the simulation are presented in Table 5.

Table 5. Simulation Results of Microwave Communication Planning with Space Diversity Technique

Parameter	Value	
	Site Karangasem	Site Mataram
Antenna Heights (m)	39	30
Diversity Antenna Heights (m)	24,5	18
Radio Model	Plus-XPIC-7GHz-128QAM-1	Plus-XPIC-7GHz-128QAM-1
EIRP (dBm)	67,87	67,87
FSL (dB)	143,83	143,83
Atmospheric Loss (dB)	0,50	0,50
IRL (dBm)	-75,96	-75,96
Main RSL (dBm)	-33,58	-33,58
Diversity RSL (dBm)	-32,85	-32,85
Threshold Level (dBm)	-68,00	-68,0
Fade Margin (dB)	35,15	35,15
Availability (%)	99,99873	99,99873
Unavailability (%)	0,00127	0,00127

This simulation used the frequency of 7.2 GHz, with the assumption that rain attenuation is absent or rain attenuation does not affect the system. Based on Table 5, the Equivalent Isotropically Radiated Power (EIRP) parameter value at the Karangasem site is 67.87 dBm, and the Mataram site is 67.87 dBm. Meanwhile, the amount of attenuation or loss such as Free Space Loss (FSL) and atmospheric attenuation on the communication link are 143.83 dB and 0.50 dB.

Received Signal Level (RSL) is observed to determine the success of point to point microwave planning. It can be seen that the Receive Signal Level (RSL) at each site is -33.58 dBm. From the Receive Signal Level (RSL) value of each site, it can be said that the point to point microwave communication planning can work properly because the Receive Signal Level (RSL) value is above the threshold level value of -68.00 dBm. The next parameter is the fading margin; the amount of fading margin is closely related to the availability

value. The fading margin value at the Karangasem site is 34.42 dB, and at the Mataram, site is 34.42 dBm, while the percentage of availability for each section is 99.99873%.

4.3. Analysis of the Influence of Space diversity technique on availability

A comparison between plannings of point to point microwave communication linking Karangasem site-Mataram site using space diversity technique and without the space diversity is summarized in Table 6 below.

Table 6. Parameters Comparison of Microwave Communication Using and Without Space Diversity Technique

Parameter	Using Space Diversity		Without Space Diversity	
	Site Karangasem	Site Mataram	Site Karangasem	Site Mataram
EIRP (dBm)	67,87	67,87	67,87	67,87
FSL (dB)	143,83	143,83	143,83	143,813
IRL (dBm)	-75,96	-75,96	-75,96	-75,96
Main RSL (dBm)	-33,58	-33,58	-33,58	-33,58
Diversity RSL (dBm)	-32,85	-32,85	-	-
Threshold Level (dBm)	-68,00	-68,00	-68,00	-68,00
Fade Margin (dB)	35,15	35,15	34,42	34,42
Availability (%)	99,99873	99,99873	99,99667	99,99667
Unavailability (%)	0,00127	0,00127	0,00333	0,00333

Table 6 shows a striking difference in the values of the fading margin and the availability of both plannings. The amount of fading margin and the percentage of availability in the network planning without space diversity technique is 34.42 dB and 99.99667%. In comparison, the value of fading margin and availability in the network planning using space diversity technique is 35.15 dB and 99.99873%.

Communication planning using space diversity technique has a higher availability value than communication planning without space diversity technique. It indicates that the use of space diversity techniques can increase the percentage of availability and will affect the quality of signal transmission and reception.

5. Conclusions and Recommendations

5.1. Conclusions

Based on the planning and analysis, availability values of communication planning using space diversity technique and without space diversity technique is 99.99873% and 99.99667%. It can conclude that the point to point microwave communication planning linking Karangasem - Mataram sites using space diversity technology reached a higher value of reliability or availability percentage than that of the plan without space diversity technique.

From the simulation, it obtains that the microwave communication network planning on ocean topography in this study resulting in the availability of 99.99873% with space diversity and 99.99667% without space diversity. It has met the standardized availability quality recommended by the ITU-R G.827 availability performance parameters and objectives for end-to-end international constant bit-rate digital paths must obtain between 99.9966 % - 99.900 %. It also complies with the requirement by ITU-R F.1703 standards on the availability objectives for real digital fixed wireless links used in 27,500 km possible reference paths and connections with the best available value of 99.99873% using space diversity technique.

While observing the parameters of reliability or availability, it also found that the link budget value of the planning using space diversity technique has better results than that of the plan without space diversity technique. The results of this study indicate that the use of space diversity technique is proven to be able to increase the reliability value of the planned network. Therefore the method is recommended to be implemented by telecommunications network operators in Indonesia in accelerating the deployment of

telecommunications networks, especially in areas which include ocean topography, such as eastern Indonesia.

5.2. Recommendations

For further research, it recommends elaborating using other diversity techniques to improving system availability or reliability for microwave communication network planning on ocean topography, i.e., frequency diversity and time diversity techniques. It needed to find the best solutions for planning network systems in various conditions of Indonesian regions.

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References

- Andersen, J. (1964). Fresnel Zones for Ground-Based Antennas. *IEEE Transactions on Antennas and Propagation*, 12(4), 417–422.
- Attamimi, S., R. (2014). Perancangan Jaringan Transmisi Gelombang Mikro Pada Link Site Mranggen 2 Dengan Site Pucang Gading. *Jurnal Teknologi Elektro*, 5(2), 77–87.
- Freeman, L., R. (2007). *Radio System Design for Telecommunications*. New Jersey: John Wiley & Sons, Inc.
- Goktas, P., Topcu, S., Karasan, E., & Altintas, A. (2015). Multipath fading effect on terrestrial microwave LOS radio links. In *IEEE Antennas and Propagation Society, AP-S International Symposium (Digest)* (Vol. 2015-October, pp. 918–919). <https://doi.org/10.1109/APS.2015.7304846>
- Kristiadi, I. D., & Nashiruddin, M. I. (2019). Analisis Perencanaan Transmisi Microwave Link antara Semarang-Magelang untuk Radio Access Long Term Evolution (LTE). *Buletin Pos Dan Telekomunikasi*, 17(2), 95–110. <https://doi.org/10.17933/bpostel.2019.170202>
- Liu, D.B., Wahyudi, E., Nugraha, E. . (2017). Pengaruh Space Diversity Terhadap Peningkatan Availability Pada Jaringan Microwave Lintas Laut Dan Lintas Pegunungan. *Jurnal Elektro Telekomunikasi Terapan*. *Jurnal Elektro Telekomunikasi Terapan*, 4(2), 541–550. <https://doi.org/https://doi.org/10.25124/jett.v4i2.1107>
- Mahmud, R.A.MD., Khan, Z. . (2009). *Analysis and Planning Microwave link to Established Efficient Wireless Communications*. Blekinge Institute of Technology.
- Meitasari, D., Nugroho, R., Azman, N. (2016). Perancangan Jaringan Komunikasi Antara Manado dan Sofifi Menggunakan Radio Microwave. *Jurnal Ilmiah GIGA*, 19(2), 69–82.
- Mubarakah, L., Handayani, P. (2015). Karakteristik Redaman dan Shadowing dalam Ruang pada Kanal Radio 2,4 GHz. *Jurnal Teknik ITS*, 4(1), 25–30.
- Mulia, S.B., Hidayat, S. (2014). No Title Analisis Kekuatan Mekanis Dari Kabel Power Bawah Laut. *Electrans-Jurnal Teknik Elektro, Komputer Dan Informatika*, 13(2).
- Palle, A. V. (2013). SDH (Synchronous Digital Hierarchy) & Its Architecture. *IJSRD – International Journal for Scientific Research & Development*, 1(7), 1337–1381.
- Permenkominfo. (2015). No. 33 tentang Perencanaan Penggunaan Pita Frekuensi Radio Microwave Link Titik ke Titik (Point to Point).
- Ramadhan, C., Jambola, L., Hardiansyah, R. (2016). Analisis Kinerja Sistem Transport Pada Radio Microwave Digital. *Jurnal Reka Elkomika*, 4(1), 63–77.
- Rappaport, T. (1996). *Wireless Communications, Principle, and Practice*. New York: IEEE Press, Prentice-Hall.
- Rec. ITU-R F.1703. (2005). Availability objectives for real digital fixed wireless links used in 27.500 km hypothetical reference paths and connection.
- Rec. ITU-R G.827. (2003). Availability performance parameters and objectives for end-to-end international constant bit-rate digital paths.
- Rec. ITU-T G.707. (2007). Network node interfaces for the synchronous digital hierarchy (SDH).
- Triwibiwo, S.H., Wahyudi, E., Larasati, S. (2019). Perbandingan Penggunaan Teknik Diversity pada Jaringan Gelombang Mikro di Lingkungan Danau. *Jurnal Nasional Teknik Elektro Dan Teknologi Informasi*, 8(3), 290–299.
- UNCLOS. (1982). *United Nations Convention On The Law Of The Sea*.
- Utomo, A.B., Suni, A.F., A. (2016). Implementasi Multipath Fading Rayleigh Menggunakan TMS320C6713. *Jurnal Sains Dan Teknologi*, 14(1), 9–19.