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Cellular Communication Propagation at Drone around Building Environment with Single Knife Edge at 10 GHz

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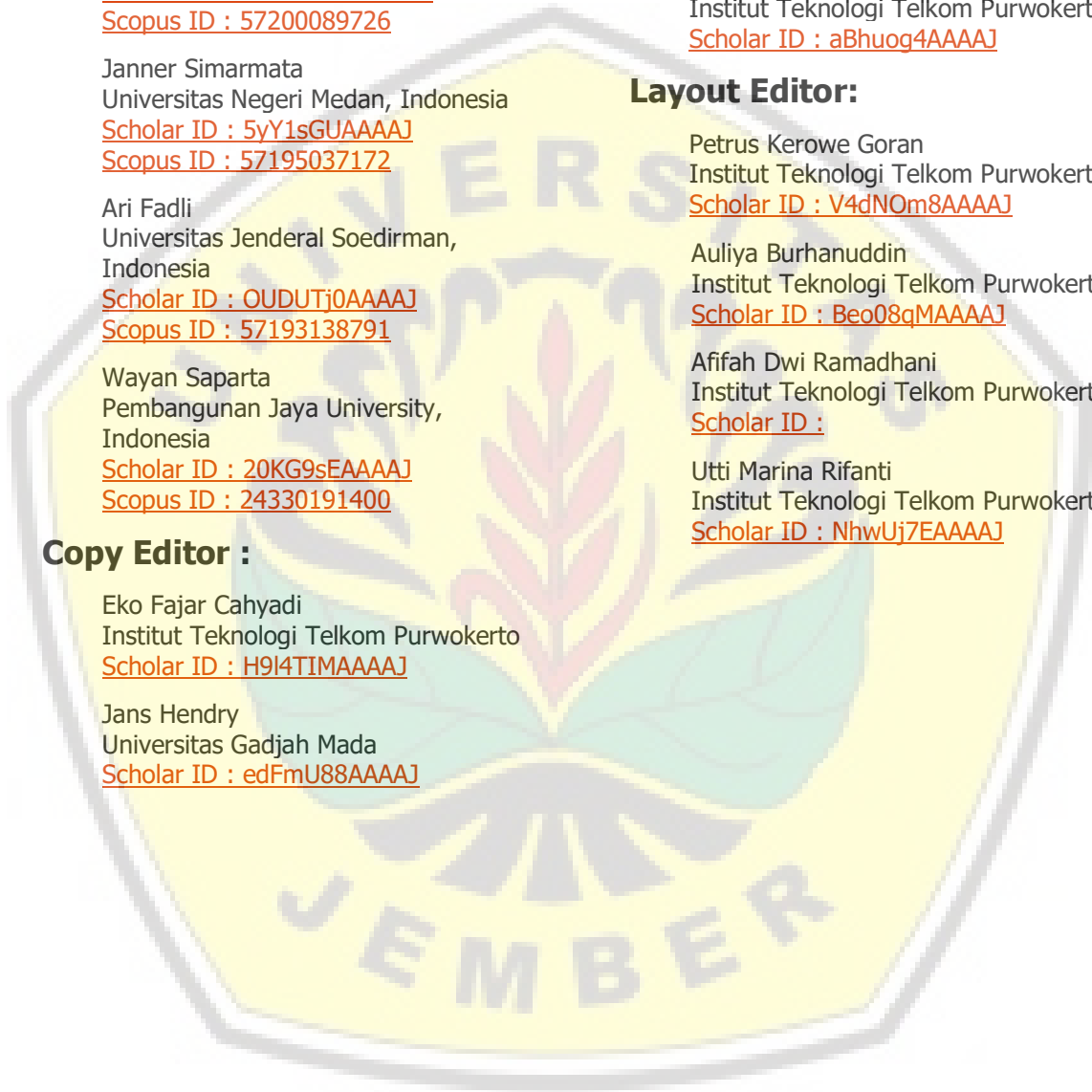
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Cellular Communication Propagation at Drone around Building Environment with Single Knife Edge at 10 GHz

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Abstract — The drone communication systems used a cellular network for controlling a drone from a long distance. That communication propagations between drone and base station were analyzed. The drone moved at the track around building environment. That environment used variations in building height. The communication propagation around building environment caused diffraction mechanism. Single knife edge method is used for that diffraction mechanism. The frequency of communication used 10 GHz. That frequency was influenced by atmospheric attenuation. This research was using some variations such as height of drone track location, transmitter power, and AMC (Adaptive Modulation Coding). MCS (Modulation Coding Scheme) was used AMC such as QPSK, 16 QAM, and 64 QAM. Some result was obtained at this research consist of LOS and NLOS distance, SNR, MCS probability, and percentage of drone coverage. NLOS propagation was caused by building height. The SNR value become increase when higher at drone position, such as drone was moving at 20 meters with height of flying drone 80 m and transmitter power 30 dBm obtained SNR 38.21 dBm. That SNR is affected AMC, so a higher SNR value increases AMC. The drone's coverage 100%, with a height of flying drone 80 meters and transmitter power of 30 dBm. That condition showed more increasing coverage percentage than 64.8% for height of flying drone 20 meters and transmitter power 30 dBm. That result showed that more drone height increased of coverage percentage, probability modulation, and SNR value.

Keywords – AMC, 10GHz, drone, building

I. INTRODUCTION

The drone was continually evolving, such as security, company, military, etc. This research is modeled with simulation for drone communication. That drone communication used a cellular network. Base Station (BS) location is placed everywhere. The cellular network was constantly evolving for communication. Some cellular communication researches related with super high frequency or too high frequency such as propagation for mobile communication around tree used OFDM-QAM at 10 GHz [1], propagation from outdoor to indoor with AMC using 10 GHz [2], and outdoor to indoor condition for path loss at picocell and femtocell [3]. Some researches related to millimeter-wave at femtocell, such as resource allocation schemes for cognitive LTE-A femtocells [4]. Femtocell enhanced multitarget spectrum allocation strategy in LTE-A Het

Nets [5], RBS femtocell propagation at street pole lamp used 10 GHz frequency [6]. communication systems influenced code rate at RBS femtocell at street pole lamp [7].

Some researches were related with millimeter wave communication propagation such as propagation measurement at indoor used millimeter-wave for wireless network 5G [8], determination location for mobile station around the building with AoA method at 47 GHz frequency [9], measurement at base station diversity for 5G using millimeter-wave with 73 GHz [10], the millimeter-wave network for self-backhauling relay nodes and centralized transmission coordination [11], millimeter-wave for 5G communication at small area [12], millimeter-wave communication of 5G at wireless network [13], propagation was depended with angle for cellular and wireless communication [14], self-backhauling with

flexible reuse of the resources for access and backhaul in street scenario with 5G network [15], multipath effect around the building environment for mobile communication was used 47 GHz frequency [16], and performance of in-band self-backhauling with integrated access and backhaul in a real-life street canyon scenario for 5G systems [17].

The researches of cellular communication about cellular frequency were constantly evolving more increase. This research was based on drone control from long distances. That communication propagations were analyzed between drone and base station. The communication between drone and cellular network is used for data transmission such as GPS, video, picture, sensors, etc. Base Station (BS) used some RBS (Radio Base Stations). SNR value can be obtained by drone communication with cellular network propagation, and the value affected AMC (Adaptive Modulation Coding) mechanism. This research used AMC, such as AMC, for mobile station communication at the train [18].

Some diffraction mechanisms are used such as the single knife-edge method, Epstein-Peterson diffraction method, Japanese method, Deygout method, Giovanelli Knife Edge, etc. That diffraction of propagation communication caused the SNR value more decrease. Some researches were related to that diffraction, such as mobile communication systems with diffraction propagation around the building environment [19] and mobile communication systems around the tree that used the Giovanelli Knife Edge method with 2.3 GHz frequency [20]. Some researches were related with OFDM at mobile communication systems such as OFDM and OFDMA with DFT based [21], edge windowing for communication systems with OFDM based [22], and algorithm allocation for OFDM systems [23].

This research modeled the communication propagation of drones with the cellular network around the building environment. The communication frequency used 10 GHz. Analysis with that frequency caused the development of spectrum frequency for cellular communication. The atmospheric attenuation affected communication. That frequency was influenced by atmospheric attenuation, such as water vapor and oxygen. The analysis of communication propagation for this research used the uplink condition. Uplink condition because of part of communication transmission. The effect of the building environment is modeled with a diffraction mechanism By using a single knife-edge method. SNR communication is obtained from LOS and NLOS propagation. NLOS condition was caused by building height. That SNR determined AMC that used MCS variation. That MCS used modulations such as QPSK, 16 QAM, and 64 QAM. Every modulation used code rate variation. This research is used parameter variation such as drone height, transmitter power, and AMC. The drone used various heights,

such as 40 meters, 60 meters, and 80 meters. The transmitter power that has been used 20 dBm and 30 dBm. This research showed LOS and NLOS effect, SNR communication, MCS probability for AMC, and coverage percentage at the drone. This research aimed to analyze drone communication propagation around building environments with the cellular network for a remote drone from a long distance. This research was important for the development of drone communication. This research is modeled with a simulation.

II. RESEARCH METHODS

A. Environment Model

The drone is moved around the building environment on the straight track. The flying drone uses various heights such as 40 meters, 60 meters, and 80 meters. Figure 1 shown communication propagation of drone at 40 meters with RBS. The communication propagation of drone at 60 meters with RBS is shown in Fig. 2. While Fig. 3 showed communication propagation of drone at 80 meters with RBS. That building environment is modeled with a high variation of building that shows NLOS propagation caused by their diffraction. Single knife edge method used for calculation of diffraction mechanism [24]. Figure 4 showed single knife-edge method [25].

Figure 4 showed block diagram communication from the transmitter to receiver. Drone used various heights such as 40 meters, 60 meters, and 80 meters. The building environment and atmospheric attenuation cause the communication propagation. The receiver used RBS (Radio Base Station) with a height of 30 meters.
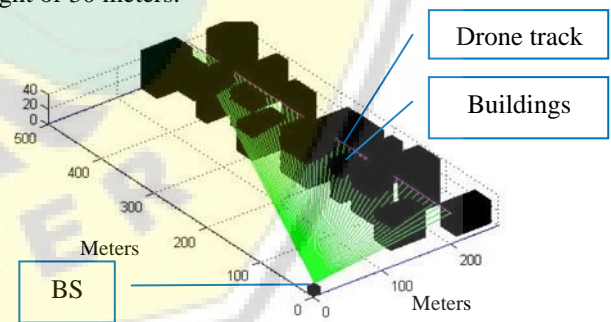

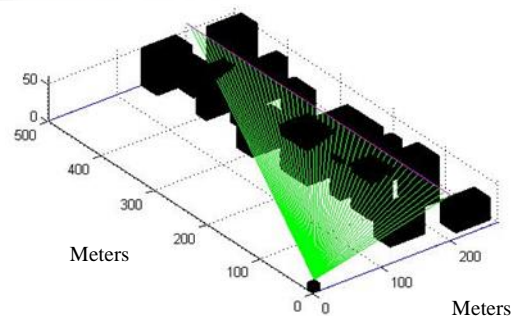Fig. 1. Drone propagation with a height of 40 meters

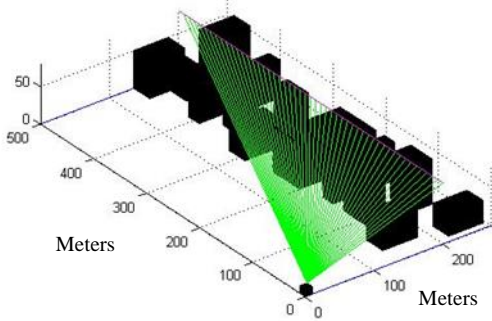Fig. 2. Drone propagation with a height of 60 meters

Fig. 3. Drone propagation with a height of 80 meters
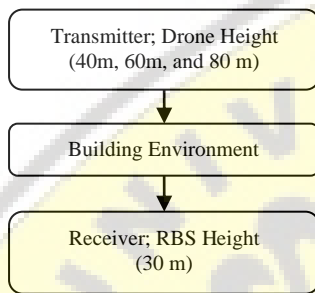
Fig. 4. Block Diagram from the transmitter to receiver

B. Single Knife Edge Method

A diffraction mechanism caused the building height. This research used a single knife-edge method for diffraction mechanism. Equation 1 showed single knife edge method. Parameter of λ, h, v, d_1, and d_2 was longwave (meters), high of diffraction (meters), Fresnel Kirchoff, transmitter distance through the node (meters), and receiver distance through the node (meters) [24].

$$v = h \sqrt{\frac{d(d_1+d_2)}{\lambda d_1 d_2}} = \alpha \sqrt{\frac{2d_1 d_2}{\lambda (d_1+d_2)}} \qquad (1)$$

Approximation to the diffraction used Fresnel Kirchoff diffraction at Fresnel Zone. Fresnel Zone is used between a transmitter and receiver. Diffraction with LOS condition, then *h* is negative and *v* also negative. Transmitter power variations used 20 dBm and 30 dBm. Parameter of s, N, and SNR was signal value, noise power, and signal to noise ratio [22].

$$SNR = \frac{S}{N} \qquad (2)$$

N parameter was showed on equation (3). Parameter of *K, B, NF, T* was Boltzman constant, bandwidth, noise Fig., and temperature (290ºK) [24]. Noise Fig. used 5 dB. Bandwidth used 5 MHz [25].

$$N = k\, T_o\, B + NF \qquad (3)$$

The attenuations of communication were caused by atmospheric attenuation. Atmospheric attenuations were influenced by oxygen, and water vapor could be observed int equation (4) [26]. γ and r_o parameters

were described with gaseous attenuation and path length (km).

AMC process based on modulation and coding scheme (MCS). MCS used modulations such as QPSK, 16 QAM, and 64 QAM [27]. The modulation of QPSK used some code rates such as 1/8, 1/5. 1/4, 1/3, 1/2, 2/3, 3/4, and 4/5. The modulation of 16 QAM used some code rates such as 1/2, 2/3, 3/4, and 4/5. Simultaneously, the modulation of 64 QAM used some code rates such as 2/3, 3/4, and 4/5. AMC process at communication propagation based on threshold modulation and coding scheme.

$$A = \gamma r_o \; dB \qquad (4)$$

Fig. 5. Single Knife Edge Diffraction Model

Fig. 6. The communication distance from the height of flying drones such as 40m, 60m, and 80m, shows more detail in Fig.7.

Fig. 7. Zoom in Fig. 6.

III. RESULTS

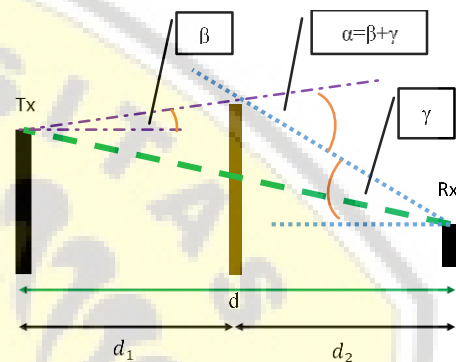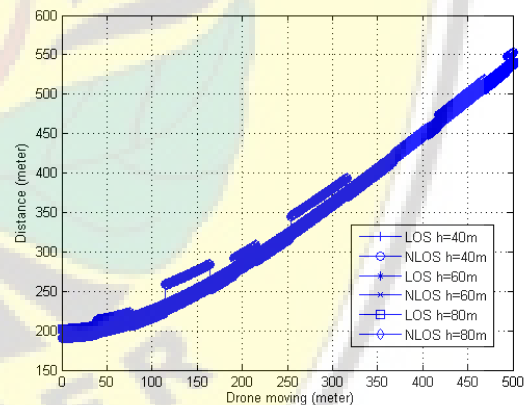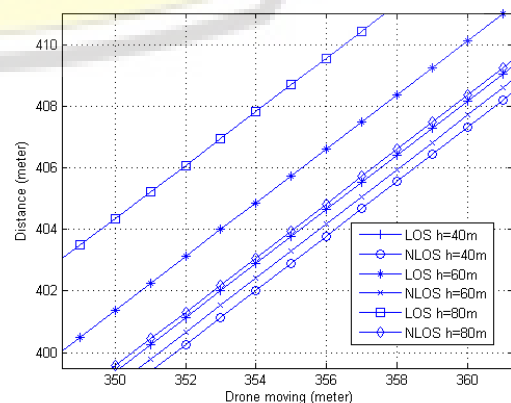This section describes the result based on the drone communication propagation. That drone communication system used a cellular network for a controlled drone from a long distance. That propagation analyzed communication between drone and base station. The communication frequency used 10 GHz. That frequency was influenced by oxygen and water vapor. The communication propagation of drone used uplink condition using various heights such as 40 meters, 60 meters, and 80 meters are used. Drone moved around the building environment on a straight track. The diffraction mechanism was caused by NLOS propagation around the building. Some analyze was used such as the height of flying drone variation, transmitter power variation, and MCS. The transmitter power used 20 dBm and 30 dBm. That MCS used modulations such as QPSK, 16 QAM, and 64 QAM.

Figure 6 showed communication propagation of drone with LOS and NLOS condition when used transmitter power 20 dBm, for more detail showed at Fig. 7. When a drone moving at 20 dBm is obtained, LOS distances 193.39 meters, some data, when the drone was moving at 50 meters, LOS distances obtained at 198.74 meters and NLOS distances 215.52 meters, and when the drone was moving at 400 meters, LOS distances were 433.84 meters and NLOS distances 451.52 meters.
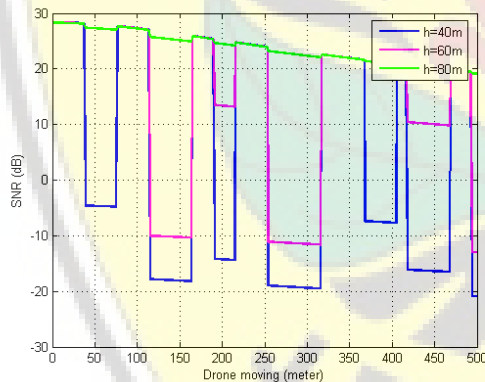
Fig. 8. The communication with transmitter power 20 dBm
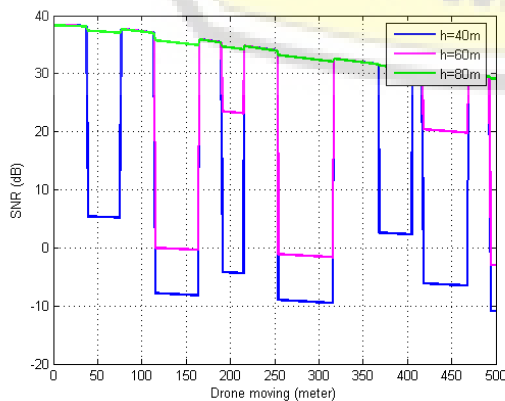
Fig. 9. The communication with transmitter power 30 dBm
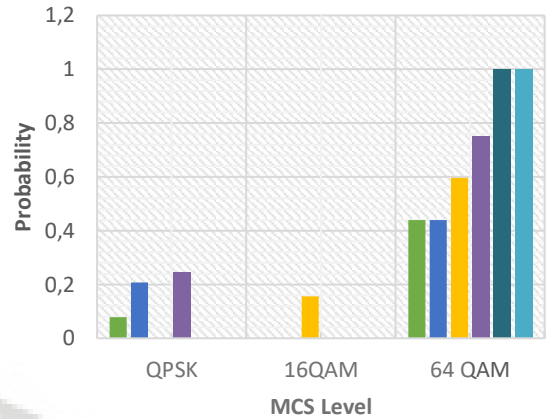
Fig. 10. AMC for drone communication at 10 GHz

Figure 8 showed SNR value for LOS and NLOS propagation with a height of flying drone variation for transmitter power 20 dBm. The drone used various height, such as 40 meters, 60 meters, and 80 meters. Some data resulted when the height of flying drone 40 meters and transmitter power 20 dBm such as drone location of 20 meters obtained SNR LOS 28.31 dBm that used AMC of 64 QAM code rate 3/4, drone location of 50 meters obtained SNR NLOS -4,6 dBm that used AMC of QPSK code rate 1/8. Drone location of 400 meters obtained SNR NLOS -7.64 dBm. Some data resulted when the height of flying drone 80 meters and transmitter power 20 dBm such as drone location of 20 meters obtained SNR LOS 28.31 dBm that used AMC of 64 QAM code rate 3/4, drone location of 50 meters obtained SNR LOS 27.29 dBm that used AMC of 64 QAM code rate 3/4. Drone location of 400 meters obtained SNR LOS 20.84 dBm that used AMC of 64 QAM code rate 3/4.

Figure 9 showed SNR values for LOS and NLOS with a height of flying drone variation at transmitter power 30 dBm. The drone used various heights, such as 40 meters, 60 meters, and 80 meters. Some data resulted when the height of flying drone 40 meters and transmitter power 30 dBm such as drone location of 20 meters obtained SNR LOS 38.21 dBm that used AMC of 64 QAM code rate 3/4, drone location of 50 meters obtained SNR NLOS 5.33 dBm that used AMC of QPSK code rate 2/3. Drone location of 400 meters obtained SNR NLOS 2.33 dBm that used AMC of QPSK code rate 1/2. Some data resulted when a height of flying drone 80 meters and transmitter power 30 dBm such as drone location of 20 meters obtained SNR LOS 38.21 dBm that used AMC of 64 QAM code rate 3/4, drone location of 50 meters obtained SNR NLOS 37.29 dBm that used AMC of 64 QAM code rate 3/4. Drone location of 400 meters obtained SNR NLOS 30.84 dBm that used AMC of 64 QAM code rate 3/4.

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Table 1. Detail for Fig.10

| | | Probability | | |
		QPSK	16QAM	64QAM
🟩	h=40m; pt=20dBm	0.078	0	0.441
🟦	h=60m; pt=20dBm	0.208	0	0.441
🟧	h=80m; pt=20dBm	0	0.156	0.597
🟪	h=40m; pt=30dBm	0.247	0	0.753
⬛	h=60m; pt=30dBm	0	0	1
🟦	h=80m; pt=30dBm	0	0	1

Figure 10 showed the MCS probability obtained from communication propagation between drone and RBS. Probability 1 indicates the communication occurred with the best condition. The exact value for Fig. 10 could see in Table 1. This research used MCS such as QPSK, 16 QAM, and 64 QAM. Some data resulted when the height of flying drone 40 meters with transmitter power 20 dBm obtained probability QPSK of 0.078 and 64 QAM of 0.44. When the flying drone's height 80 meters with a transmitter power of 20 dBm obtained, a probability of 16 QAM of 0.156 and 64 QAM of 0.597. Some data resulted when the height of flying drone 40 meters with a transmitter power 30 dBm obtained probability QPSK of 0.2 and 64 QAM of 0.753. When the flying drone's height 80 meters with a transmitter power of 30 dBm obtained a probability of 64 QAM of 1. The increase of height of flying drone could influence SNR value communication, so communication obstacle become decrease. The drone track resulted coverage percentages such as the height of flying drone 40 meters with transmitter power 20 dBm obtained 51.9%, height of flying drone 60 meters with a transmitter power of 20 dBm obtained 64.8%, the height of flying drone 80 meters with transmitter power 20 dBm obtained 75.3%, height of flying drone 40 meters, 60 meters, and 80 meters with transmitter power 30 dBm obtained 100%.

IV. DISCUSSION

The Research result of communication propagation analyzed communication between drone and base station. Figure 6 analyzed the drone communication propagation with LOS and NLOS conditions when used transmitter power 20 dBm. When the drone moving at 20 dBm obtained LOS distances 193.39 meters, some data, and when the drone was moving at 400 meters obtained LOS distances 433.84 meters and NLOS distances 451.52 meters. That NLOS propagation showed more increase of communication distance between drone and RBS. Figure 8 was analyzed about SNR value for

LOS and NLOS propagation when used transmitter power 20 dBm. Some data resulted when a drone with the height of flying drone 40 meters such as drone location of 20 meters obtained SNR LOS 28.31 dBm that used AMC of 64 QAM code rate 3/4, and drone location of 400 meters obtained SNR NLOS -7.64 dBm. Some data resulted when the height of flying drone 80 meters, such as drone location of 20 meters obtained SNR LOS 28.31 dBm that used AMC of 64 QAM code rate 3/4, and drone location of 400 meters obtained SNR LOS 20.84 dBm that used AMC of 64 QAM code rate 3/4. Figure 8 and 9 obtained a higher position of the flying drone. The more SNR will increase.

Figure 10 was analyzed about MCS probability from communication propagation. Some data resulted with transmitter 20 dBm when the height of flying drone 40 meters obtained probability QPSK of 0.078 and 64 QAM of 0.44, and when the height of flying drone 80 meters obtained probability 16QAM of 0.156 and 64 QAM of 0.597. Some data with transmitter 30 dBm resulted when the height of flying drone 40 meters obtained probability QPSK of 0.2 and 64 QAM of 0.753. When the height of the flying drone 80 meters obtained probability of 64 QAM of 1, the increase of height of the flying drone could influence SNR value communication, so communication obstacle become decrease. The track communication of drone analyzed coverage percentages of communication with 40 meters, 60 meters, and 80 meters. The coverage percentages of communication when used height of flying drone 40 meters, 60 meters, and 80 meters with transmitter power 30 dBm obtained 100%. The increase in the height of flying drones could influence the coverage percentage of communication.

V. CONCLUSION

This section described the research conclusion about communication propagation between drones and RBS. This research aimed to analyse drone communication propagation around a building environment with the cellular network for remote drone from a long distance. The communication frequency used 10 GHz. That frequency was influenced by attenuation atmospheric. The drone used various heights, such as 40 meters, 60 meters, and 80 meters. The transmitter power used 20 dBm and 30 dBm. The single knife-edge method is used for the diffraction mechanism. The communication propagation showed SNR value for the height of flying drone variation. Some data that resulted in more drone height obtained more coverage percentage, probability modulation, and SNR value. The necessity with drone communication used video, pictures, sensor data, etc. The height of the flying drone position is adjusted with location and necessity.

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