OUTDOOR LONG TERM EVOLUTION (LTE) NETWORK PLANNING AT 1880 MHz FREQUENCY IN CICALENGKA SUBDISTRICT, BANDUNG REGENCY

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Abstract— **LTE networks have become the dominant wireless data access technology worldwide, including in Indonesia. In Bandung Regency, the demand for LTE data services continues to increase, especially in rural areas such as Cicalengka Subdistrict. This study aims to design an outdoor LTE network in Cicalengka District using the 1880 MHz frequency. This planning is carried out to overcome the digital divide and improve the quality of data services for the community in the Cicalengka Subdistrict.**

This study uses the Capacity Planning and Coverage Planning calculation methods and simulation with Atoll Radio Planning software. The parameters analyzed include RSRP, RSRQ, SINR, Signal Level, and Throughput. The calculation and simulation results show that 10 sites are needed with a cell radius of 1.35 km. Then the signal quality is obtained from the simulation results using Atoll in Cicalengka District with an average RSRP of -113.19 dBm, an average RSRQ of 0.02, an average SINR of 7.15 dBm, an average Signal Level of -75 dBm, and an average Throughput of 18 Mbps. This shows that the designed LTE network is capable of providing good signal coverage with sufficient network capacity to serve the community's data needs. However, there are still blind spots because the Cicalengka area consists of many mountains with hilly and winding topographies. This causes radio signals from BTS to have difficulty reaching areas blocked by hills or valleys. This research is expected to provide a solution to improve the quality of network services in the Cicalengka Subdistrict.

Keywords— **LTE, Capacity Planning, Coverage Planning, 1880 MHz Frequency, Cicalengka, Atoll Radio Planning**

I. INTRODUCTION

LTE technology has become the dominant wireless data access technology worldwide, including in Indonesia. In Bandung Regency, the demand for LTE data services continues to increase, including in rural areas such as Cicalengka District. Cicalengka Subdistrict is one of the Subdistricts in Bandung Regency, West Java Province. This Subdistrict is located in the eastern part of the regency. Cicalengka Subdistrict has an area of 35.99 km2 and is inhabited by approximately 127,514 people with a population density of 3,543 as stated in the 2022 data from the Cicalengka Subdistrict Central Statistics Agency [1].

Geographically, the Cicalengka Subdistrict is located at an altitude of between 500-1,000 meters above sea level.

Fig. 1 Cicalengka Subdistrict Area Map

Figure 1 is a map of the Cicalengka Subdistrict. Cicalengka Subdistrict is one of the Subdistricts in Bandung Regency, consisting of 12 urban villages, namely Nagong, Narwita, Margaasih, Cicalengka Wetan, Cikuya, Waluya, Panenjoan, Tenjolaya, Cicalengka Kulon, Babakan Peuteuy, Dampit, and Tanjungwangi. The administrative boundaries of Cicalengka Subdistrict are as follows, north is Paseh Subdistrict, south is Nagreg Subdistrict, east is Garut Regency, and west is Rancaekek Subdistrict.

Based on the data from the Central Bureau of Statistics (BPS) on the Cicalengka Subdistrict in numbers, the data for 2022 includes data on the area, total population, population density, population groups by age, and the potential population for the prediction of the next 5 years using the growth factor.

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Table 1. Data Area and Population Density of Cicalengka Subdistrict

No	Village Name	Size Area (km^2)	Population Count	
			Total Population	Population Density
1	Nagong	4,17	13.483	3.233
2	Narwita	3,02	7.014	2.323
3	Margaasih	3,29	9.659	2.936

4	Cicalengka Wetan	0,84	14.909	17.749
5	Cikuya	4,5	12.498	2.777
6	Waluya	1,26	12.499	9.920
7	Panenjoan	2,28	14.567	6.389
8	Tenjolaya	1,89	10.623	5.621
9	Cicalengka Kulon	0,7	7.444	10.634
10	Babakan Peuteuy	4,2	12.220	2.910
11	Dampit	3,47	6.112	1.761
12	Tanjungwangi	6,37	6.486	1.018
TOTAL		35,99	127.514	3.543

Table 1 This is a table that contains the area of the Cicalengka Subdistrict, which is divided into 12 villages/urban villages, each with its own total population and population density to determine the type of region category.

After determining the type of region category, to conduct network planning, it is necessary to have data on the number of productive age population that is in the age range of 15-55 years. The following is a table of the number of productive ages in 2022 in numbers:

Table 2. Number of Productive Age Population (15-55 years)

Age Group	Gender		
	Male	Female	Total
15-19	5.663	5.466	11.129
20-24	6.204	5.759	11.963
25-29	5.635	5.118	10.753
30-34	4.564	4.435	8.999
35-39	4.686	4.306	8.992
40-44	5.001	5.066	10.067
45-49	4.495	4.505	9.000
50-54	3.890	3.878	7.768
TOTAL	40.138	38.533	78.671

Currently, the coverage of LTE data services in the Cicalengka District is not optimal. This causes several problems, such as poor data service quality, such as weak signal and low throughput, and a digital divide between rural and urban communities.

This outdoor LTE network planning combines several techniques, namely Capacity Planning and Coverage Planning calculation techniques, and simulations using Atoll. This research is expected to produce a more optimal LTE network with wider signal coverage and better service quality, thus improving data service quality in the Cicalengka District.

II. METHOD

The flowchart below shows the steps in conducting long-term evolution (LTE) outdoor network planning at 1880 MHz frequency in the Cicalengka Subdistrict, Bandung.

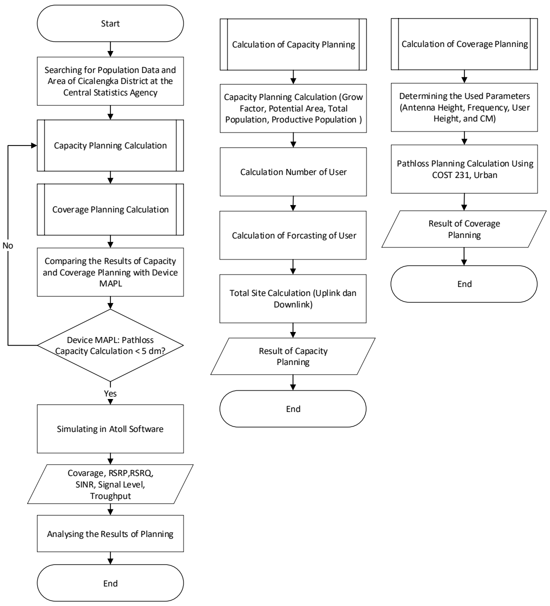

Fig. 2 Flowchart of LTE Network Design Procedure in Cicalengka Subdistrict

The flowchart above shows the planning process, which begins with the search for population data and the area of Cicalengka Subdistrict on the official website of the Central Bureau of Statistics (BPS). Next, the capacity planning calculation is carried out by determining parameters such as growth factor, Potential Area, total population, and productive population. The next stage involves the calculation of the number of users, forecasting of users, and total site calculation, which includes uplink and downlink. After that, the results of the capacity planning calculation are obtained.

The next step is the coverage planning calculation by determining parameters such as Antenna Height, Frequency, User Height, and CM. Then, the path loss planning calculation is carried out using COST 231, Urban to obtain the path loss value. After that, the results of the coverage planning calculation are compared with the MAPL Device value. If the MAPL Device value is < 5 dBm, then the calculation is considered successful. However, if the result is > 5 dBm, the calculation is considered failed, and a recalculation or change in the design parameters is required.

Next, after successfully performing the calculation, simulation can be carried out using the ATOLL software. This simulation produces RSRP, RSRQ, SINR, Signal Level, and Throughput values. The results of this simulation will be used to evaluate the success and feasibility of the implementation of the design. Next, an analysis of the design results is carried out to determine whether the design meets the requirements or requires further adjustments.

A. Parameter Planning

The general parameters used in this design are as follows:

1. The design is for the needs of the LTE network for the next 5 years, until 2028, with a growth factor of 1.2% for the Cicalengka Subdistrict in 2023. [1]
2. The UE height is 1.75 m.
3. The antenna height used is 30 m, according to the antenna height criteria for urban areas.

4. The provider used is Telkomsel.
5. The number of cellular service users of Indosat operator (market share), according to the company's annual report in 2022, was recorded at 58.9% of all cellular users. [2]
6. The number of 4G LTE service users (LTE penetration), based on data from the company's annual report, shows a figure of 60% of Telkomsel's total customers. [3]
7. The allocation of frequency bands for Indonesian cellular operators has been established. Here is the
8. Allocation of frequency bands for some of these operators.

Fig. 3 Spectrum Frequency Allocation

9. Category of regions based on population density

Table 3. Category of Regions Based on Population Density

User Behavior	Dense Urban		Urban		Sub Urban		Rural	
	Penetration Ratio %	BHSA	Penetration Ratio %	BHSA	Penetration Ratio %	BHSA	Penetration Ratio %	BHSA
VoIP	100	1.4	100	1.3	50	1.0	50	0.9
Video Conference	20	0.2	15	0.15	10	0.1	5	0.05
Gaming	30	0.2	20	0.2	10	0.1	5	0.1
Streaming Media	15	0.2	15	0.15	5	0.1	5	0.1
IMS Signalling	40	5.0	30	4	25	3.0	20	3
Web Browsing	100	0.6	100	0.4	40	0.3	30	0.2
FTP	20	0.3	20	0.2	20	0.2	10	0.2
Video Phone	20	0.2	20	0.16	10	0.1	5	0.05
Email	10	0.4	10	0.3	10	0.2	5	0.1
P2P File Sharing	20	0.2	20	0.3	20	0.2	5	0.1

10. Determining the per-user throughput needs

Table 4. Per-User Throughput Needs

Traffic Parameter	DENSE URBAN		URBAN	
	UL(Kbit)	DL(Kbit)	UL(Kbit)	DL(Kbit)
VoIP	1704.210101	1704.210101	1356.412121	1356.41212
Video Conference	6366.690909	6366.690909	3069.654545	3069.65455
Gaming	954.8509091	7640.029091	545.6290909	4365.73091
Streaming Media	238.7127273	36288.68727	153.4581818	23328.4418
IMS Signaling	61.88848485	61.88848485	31.82836364	31.8283636
Web Browsing	4775.018182	19099.30909	2728.581818	10913.8909
FTP	7162.4	38199.12727	4092.8	21828.0727
Video Phone	247.5935354	247.5935354	169.7784242	169.778424
Email	397.9111111	636.6521212	255.8	409.276364
P2P File Sharing	16977.16364	50936.24242	21827.78182	65489.4545
Total	38886.4396	161180.4303	34231.72436	130962.541
Single User Throughput in Busy Hour (IP)(Kbps)	10.80178878	44.77234175	9.508812323	36.3784835

11. eNodeB modulation capacity versus bandwidth

Table 5. eNodeB Modulation Capacity versus Bandwidth

Bandwidth (MHz)	Modulation		
	QPSK	16 QAM	64 QAM
1.4	2.016 Mbps	4.032 Mbps	6.048 Mbps
3	5.04 Mbps	10.08 Mbps	15.12 Mbps
5	8.4 Mbps	16.8 Mbps	25.2 Mbps
10	16.8 Mbps	33.6 Mbps	50.4 Mbps
15	25.2 Mbps	50.4 Mbps	75.6 Mbps
20	33.6 Mbps	67.2 Mbps	100.8 Mbps

12. Average SINR 1880 MHz Distribution

Table 6. Average SINR 1880 MHz Distribution

6. AVERAGE SINR 1800 MHz DISTRIBUTION >>> Channel BW 20 MHz, MIMO 2X2								
Modulasi	Code Bit	Coding Rate	SINR (min) dB	SINR Prob	DL Cell TP (Mbps)	DL Cell Avg TP	UL Cell TP (Mbps)	UL Cell Avg TP
QPSK 1/3	2	0,333333333	-0,75	0,28	15,999976	4,47999328	19,199976	5,37599328
QPSK 1/2	2	0,5	1,5	0,25	23,999976	5,999994	28,799976	7,199994
QPSK 2/3	2	0,666666667	3,5	0,17	31,999976	5,43999592	38,399976	6,52799592
16 QAM 1/2	4	0,5	7	0,13	47,999976	6,23999688	57,599976	7,48799688
16 QAM 2/3	4	0,666666667	9,5	0,1	63,999976	6,3999976	76,799976	7,6799976
16 QAM 4/5	4	0,8	11,5	0,05	76,799976	3,8399988	92,159976	4,6079988
64 QAM 1/2	6	0,5	12,6	0,01	71,999976	0,71999976	86,399976	0,86399976
64 QAM 2/3	6	0,666666667	14,5	0,01	95,999976	0,95999976	115,199976	1,15199976
Cell Avg TP (MAC) (Mbps)					34,079976		40,895976	

13. Link Budget Downlink Device (Huawei)

Table 7. Huawei Downlink MAPL Device

2. LINK BUDGET (DOWNLINK)		
Transmitter	Value	Calculation
eNb TX Power (dBm)	43	A
eNb Gain (dBi)	18	B
Feeder Loss (dB)	2	C
EIRP (dBm)	59	D = A+B-C
Total Resource Block	100	
Receiver	Value	Calculation
UE Noise Figure (dB)	7	E
Thermal Noise (dBm)	-100,8196966	F = k*T*BW
SINR (dB)	-9	G
Receiver Sensitivity (dBm)	-102,8196966	H = E+F+G
Interference Margin (dB)	3	I
Fading Margin (dB)	3	J
Penetration Loss (dB)	12	K
Body Loss (dB)	0	L
UE Gain (dBi)	0	M
MAPL (DL)	143,8196966	O = D-H-I-J-K-L+M

B. Capacity Planning

Parameters

Growth Factor	1,2%
Area (km^2)	35,99 km^2
Potential Area (km^2)	35,99 km^2
Total Population (2022)	127.514 people
Productive Population	78.671 people

1) Number of User Calculations

Table 8. Table Number of Users in Cicalengka Subdistrict

Years	2023	2024	2025	2026	2027	2028
Total Population	127.514	129.044	130.592	132.159	133.744	135.348
Growth Factor	0.012	0.012	0.012	0.012	0.012	0.012
Productive Population (15-55 th)	78.671	77.426	78.355	79.295	80.246	81.208
Market share Telkomsel 2022	0.589	0.589	0.589	0.589	0.589	0.589
Market share Customer Telkomsel	46338	45604	46152	46705	47265	49186
LTE Penetration	0.6	0.6	0.6	0.6	0.6	0.6
LTE Customer	27803	27363	27692	28023	28359	29512
LTE-A Provider Penetration	0.8	0.8	0.8	0.8	0.8	0.8
Potential LTE User	22242	21890	22153	22418	22687	23609

2) Forecasting Number of User

Table 9. Forcasting Number of User in Cicalengka Subdistrict

Forecasting Number of Users (Kec Cicalengka)	
Total Population (2023)	127.514
Growth Factor	0,012
Estimated Prediction Time	5 Years
Total Prediction Population (2028)	135.351
Percentage of Productive Age Population	0,616959706
Estimated Productive Age Population (2028)	83.507
Market Share Percentage	0,589
Estimated Celuller Customer (Telkomsel)	49.186
LTE Penetration Percentage	0,6
Telkomsel LTE Subscriber Estimates (Target Potential User)	26.560,8

- From the table above, the population increase each year is obtained using the formula:
  $P_N = P_o(1 + GF)^n$
  P_o = Initial Population
  P_N = Future Population
  GF = Growth Factor
  n = Number of Predicted Years
- Calculation of Population Estimates for the Next 5 Years (2028)
  $= \text{Total Population} \times (1 + Grow\ Factor)^{Design\ Period}$
  $= 127.514 \times (1 + 0{,}012)^5$
  = 135.351 population
- Calculation of Estimated Productive Age Population (Percentage)
  $= \frac{Number\ of\ Productive\ Age\ Population}{Total\ Population}$
  $= \frac{78.671}{127.514}$
  = 0,616959706 = 61%
- Calculation of Estimated Production Age Population (Number)
  $= Estimated\ Percentage\ of\ Productive\ Age \times Estimated\ Total\ Population$
  = 61% × 135.351
  = 83.507 population
- Estimated Market Share Calculation (Telkomsel)
  $= Operator\ Market\ Share\ Operator\ Percentage \times Estimated\ Number\ of\ Productive\ Age\ Population \times 0{,}9$
  = 58,9% ×83.507
  = 49.186 population
- Calculation of Telkomsel LTE Subscriber Estimation (Target User Potential)
  $= Operator\ LTE\ Subscriber\ Percentage \times Operator\ Market\ Share\ Estimation \times 0{,}9$
  = 60% × 49.186 × 0,9
  = 26.560 population

3) Total Site Calculation Uplink and Downlink

Table 10. Results of the Total Site Calculation

TOTAL SITE CALCULATION		
Item	UL	DL
Area (km^2)	35,99	
Target User	26560	
Network TP (MAC) (Mbps)	257,7117386	969,4025571
Cell Avg TP (Mbps)	40,895976	34,079976
Site Capacity (Mbps)	122,687928	102,239928
Total Site	2	10
LTE Users per Site	13280	2656
Coverage per Site (km^2)	11,99666667	3,599
Coverage per Cell (km^2)	3,998888889	1,199666667
Cell Radius (km)	1,432030813	1,358543715
REUSE DISTANCE (CLUSTERING 3 SEL) (Km)	4,075631145	

Uplink

- Network Throughput UL MAC (Mbps)

$$= \frac{\text{Network Throughput IP UL (Kbps)}}{0.98} \times \frac{1}{1000}$$
$$= \frac{\text{Target user Potensial} \times \text{SU Troughput}}{0.98} \times \frac{1}{1000}$$
$$= \frac{252557{,}593}{0.98} \times \frac{1}{1000}$$
$$= 257{,}711 \text{ Mbps}$$

- UL Cell Avg Throughput (Mbps)
  $= Total\ UL\ Cell\ Avg = 40{,}895976$
- Site Capacity UL (Mbps)
  $= UL\ Cell\ Throughput \times 3$
  = 40,895976 × 3
  = 122,687928
- Total Site UL
  $$= \frac{\text{Network Throughput UL (Mbps)}}{\text{Site Capacity UL (Mbps)}}$$
  $$= \frac{257{,}711}{122{,}687} \approx 2$$
- LTE User
  $$= \frac{Target\ User}{Total\ Site\ UL}$$
  $$= \frac{26560}{2} = 13280 \text{ user}$$
- Coverage per Site UL (km^2)
  $$= \frac{\text{Area (km}^2)}{\text{Total Site UL}}$$
  $$= \frac{35{,}99}{2} = 19{,}775 \text{ km}^2$$
- Coverage per Cell (km^2)
  $$= \frac{\text{Coverage per site UL(km}^2)}{3}$$
  $$= \frac{11{,}99}{3} = 3{,}99 \text{ km}^2$$
- Cell Radius (km)
  $$= \sqrt{\frac{\text{Coverage per Cell UL (km)}}{1{,}95}}$$
  $$= \sqrt{\frac{3.99}{1{,}95}} = 1{,}43 \text{ km}$$

Downlink

- Network Throughput DL MAC (Mbps)
  $$= \frac{\text{Network Throughput IP DL (Kbps)}}{0.98} \times \frac{1}{1000}$$
  $$= \frac{\text{T arg e t user Potensial} \times \text{SU Troughput}}{0.98} \times \frac{1}{1000}$$
  $$= \frac{950014{,}505}{0.98} \times \frac{1}{1000} = 969{,}402 \text{ Mbps}$$
- DL Cell Avg Throughput (Mbps)
  $= Total\ DL\ Cell\ Avg\ Throughput$
  = 34,079976 Mbps
- Site Capacity DL (Mbps)
  $= DL\ Cell\ Throughput \times 3$
  = 34,079976 × 3 = 102,239 Mbps
- Total Site DL
  $$= \frac{\text{Network Throughput DL (Mbps)}}{\text{Site Capacity DL (Mbps)}}$$
  $$= \frac{969{,}402}{102{,}239} \approx 10$$
- LTE User
  $$= \frac{\text{T arg e t User}}{\text{Total Site DL}}$$
  $$= \frac{26560}{10} = 2656 \text{ user}$$
- Coverage per Site UL (km^2)
  $$= \frac{\text{Area (km}^2)}{\text{Total Site DL}}$$

$$= \frac{35{,}99}{10} = 3{,}59 \text{ km}^2$$

- Coverage per Cell (km^2)

$$= \frac{\text{Coverage per site DL(km}^2)}{3}$$

$$= \frac{3{,}599}{3} = 1{,}19$$

- Cell Radius (km)

$$= \sqrt{\frac{\text{Coverage per Cell DL (km)}}{1{,}95}}$$

$$= \sqrt{\frac{1{,}19}{1{,}95}} = 1{,}35 \text{ km}$$

The customer comes from the site. This transmission model is called downlink communication, so the link budget calculation for coverage planning will use the maximum allowed path loss (MAPL) in the downlink direction.

Table 11. Table of Total Site Calculation Results on the Device

PATH LOSS (COST 231, URBAN) (f>300 MHz ~1800 MHz)	
a(hm) >> MS Height Antenna Factor	0,54733875
Frekuensi (MHz)	1880
hT >> Enb Antenna Height(30-200 m)	30
hm >> UE height (1-10 m)	1,75
D >> Link Distance (1-20 km)	1,35
CM (Urban, Large City) (dB)	3
PATH LOSS (dB) (Capacity)	143,9237848

4) Pathloss Planning

- $a(hm)_{Urban}$ $= 3{,}2\,[log(11{,}75 \times h_m)]^2 - 4{,}97$

  $= 3{,}2\,[log(11{,}75 \times 1{,}75)]^2 - 4{,}97$

  $= 0{,}54733875$

- Lp (Cost-231) $= 46{,}3 + 33{,}9\,log(fc) - 13{,}82\,log(h_m) + a(h_m) + [44{,}9 - 6{,}55\,log(h_t)]\,log\,(D) + CM$

  $= 46{,}3 + 33{,}9\,log(1880) - 13{,}82\,log(1{,}75) + 0{,}5 + [44{,}9 - 6{,}55\,log(30)]\,log\,(1{,}35) + 3$

  $= 143{,}92\ dB$

5) Device Calculation

Table 12. Total Site Calculation Results on the Device

TOTAL SITE CALCULATION	
Parameter	**Value**
Area (Km^2)	35,99
Coverage per Site (3-SECTORAL) (Km^q)	5,082542724
Total Site (3-SECTORAL)	8
Frequency Reuse Distance (CLUSTERING 3 SEL) (Km)	4,194450753
COST 231 OUTDOOR	

- *MAPL (Cost-231)* $= 46{,}3 + 33{,}9\,log(fc) - 13{,}82\,log(h_m) + a(h_m) + [44{,}9 - 6{,}55\,log(h_t)]\,log\,(D) + CM$
  143,819 $= 46{,}3 + 33{,}9\,log(1880) - 13{,}82\,log(1{,}75) + 0{,}5 + [44{,}9 - 6{,}55\,log(30)]\,log\,(D) + 3$
- D (Cell Radius) = 1,398 Km
- Coverage per Site (3-Sectoral) = $2{,}6 \times$ Cell Radius
  $= 2{,}6 \times 1{,}389$
  $= 5\ Km^2$
- Total Site (3-Sectoral) $= \frac{\text{Luas Area}}{\text{Cell Radius}}$
  $= \frac{35{,}99}{5}$
  = 8 site
- Frekuensi Reuse Distace (Clustering 3 Sel) $= \sqrt{3 \times 3} \times$ Cell Radius
  = 4,194 Km

III. RESULT AND DISCUSSION

A. Comparison of Capacity and Coverage Planning

In the capacity planning stage, the cell capacity, number of cells, and cell radius required to serve all users in the Subdistrict are obtained. From these results, the MAPL (Mean Access Point Level) of the capacity planning is calculated, and compared with the MAPL of the coverage planning to determine whether the path loss value already meets the standard.

Table 13. MAPL Device and Calculation Comparison

MAPL (Coverage) Device	143,8196966
PATH LOSS (Cost-231, Urban) [Utk D =5] Planning	143,9237848

Pathloss Capacity is calculated using COST-231, for urban areas with a frequency of 1880 MHz, while the MAPL coverage is obtained from the Huawei vendor datasheet with a value of 143.8196966. From the results of the comparison of the planning value and the device value, a difference of 0.104 dB was obtained, so the capacity calculation is considered to meet the device standard used because it has a difference of < 5 dB.

B. Simulation on Atoll Software

In the simulation on the Atoll software in the Cicalengka Subdistrict, Bandung Regency, the planning results were obtained based on the calculations that had been carried out in the planning. Several parameters can be measured in the Atoll simulation, including RSRP, RSRQ, SINR, Throughput, and Signal Level, to determine the quality of the planning that has been made. The following is a picture of the coverage and site in the Cicalengka Subdistrict.

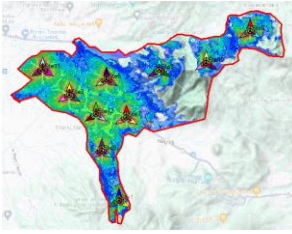

Fig. 4 Coverage Map of Cicalengka Subdistrict in Atoll Software

Above is the map of the Cicalengka Subdistrict equipped with 10 sites according to the results of the planning calculation that has been carried out, but the result still has areas that are white (blind spot). This is because the Cicalengka area consists of many mountains that have hilly and winding topography. This causes radio signals from BTS to be difficult to reach areas that are blocked by hills or valleys.

1) RSRP

RSRP stands for Reference Signal Received Power, which means received reference signal power. RSRP is a measure of the received signal power level from the reference signal on an LTE cellular network. Reference signals are used to help mobile devices determine cell location and adjust signal settings. RSRP values are measured in decibels milliwatt (dBm). The image below is a map of RSRP in the Cicalengka

Subdistrict. Higher RSRP values indicate stronger signal strength. Lower RSRP values indicate weaker signal strength. The map shows the RSRP in the Cicalengka Subdistrict.

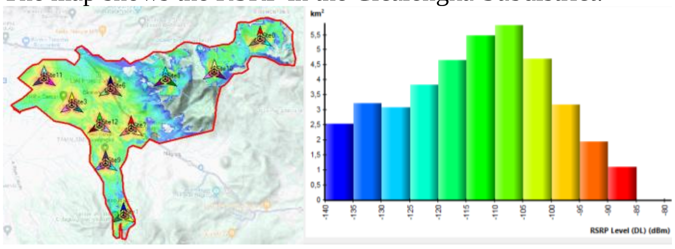

Fig. 5 RSRP Map and Histogram on Atoll

Based on the histogram above, which is the result of RSRP from simulation using Atoll software, it can be concluded that the LTE network in the planning that has been carried out in the Cicalengka Subdistrict has poor results because it has an average RSRP value of -113.19 dBm.

2) RSRQ

RSRQ stands for Reference Signal Received Quality, which means received reference signal quality. It is an important parameter used to measure the quality of the LTE connection. RSRQ is measured in decibels (dB). Higher RSRQ values indicate better signal quality. Lower RSRQ values indicate worse signal quality. The map shows the RSRQ in the Cicalengka Subdistrict.

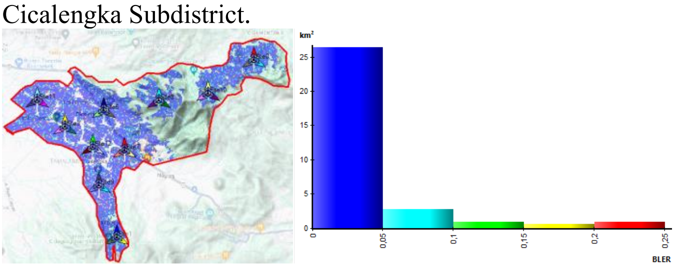

Fig. 6 RSRQ Map and Histogram on Atoll

Based on the histogram above, which is the result of RSRQ from the simulation using Atoll software, it can be concluded that the LTE network in the planning that has been carried out in the Cicalengka Subdistrict has a good result because it has an average RSRQ value of 0.02 or 2% BLER (Block Error Ratio). After all, a good BLER value is below 5% so more data is corrupted during transmission.

3) SINR

SINR (Signal-to-interference-plus-noise ratio) is an important parameter in wireless communication systems, especially those operating on radio frequencies such as cellular (GSM, LTE, 5G), WiFi, and satellite. SINR measures the strength of the desired signal (carrier signal) relative to the combined strength of unwanted interference and noise. Higher SINR values indicate better signal quality and more reliable data transmission. The map below shows the SINR in the Cicalengka Subdistrict.

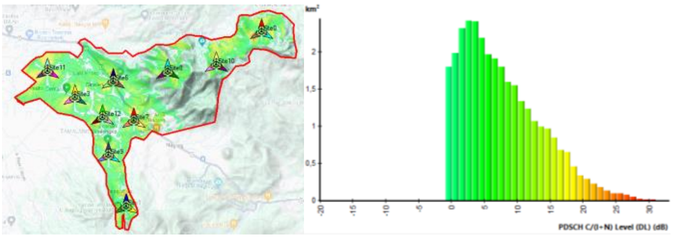

Fig. 7 SINR Map and Historam on Atoll

Based on the histogram above, which is the result of SINR from the simulation using the Atoll software, it can be concluded that the LTE network in the planning that has been carried out in the Cicalengka Subdistrict has poor results because it has an average SINR value of 7.15 dB, where the good SINR value is above 13 dB.

4) Signal Level

Signal level, or signal level, is a measure of the strength of the signal received by the receiving device. The signal level is measured in decibels (dBm), and the higher the value, the better the signal strength. The image below shows the Signal Level in the Cicalengka Subdistrict.

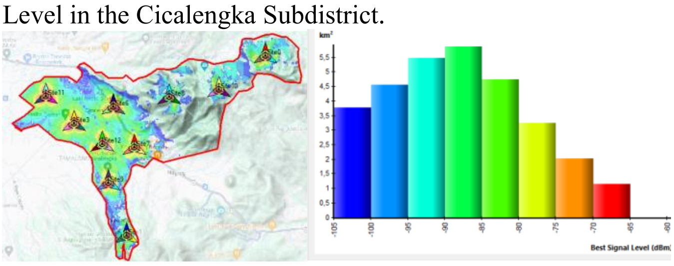

Fig. 8 Signal Level Map and Histogram on Atoll

Based on the histogram above, which is the result of the signal level from the simulation using the Atoll software, it can be concluded that the LTE network in the planning that has been carried out in the Cicalengka Subdistrict has a fairly good result because it has an average Signal Level value of -75 dBm.

5) Throughput

Actual bandwidth or actual bandwidth that is measured at a certain time interval in a day using a specific internet route when downloading a file. The map image shows the Throughput in the Cicalengka Subdistrict.

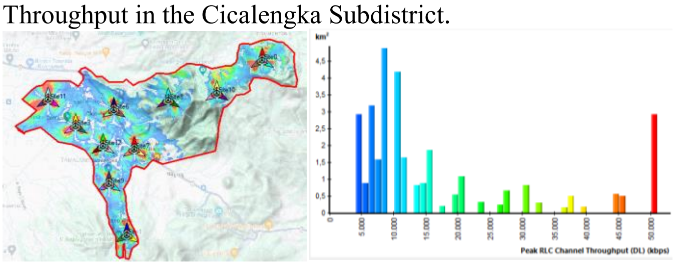

Fig. 9 Throughout Map and Histogram on Atoll

Based on the histogram above, which is the result of the throughput from the simulation using the Atoll software, it can be concluded that the LTE network in the planning that has been carried out in the Cicalengka Subdistrict has quite good results because it has an average throughput value of 18 Mbps.

Table 14. Calculation comparasion with Standart KPI

No	LTE Measurement	Calculation	Standard KPI
1	RSRP	-113.19 dBm	Poor
2	RSRQ	2% BLER	Excellent
3	SINR	7.15	Good
4	Signal Level	-75	Excellent
5	Throughput	18 Mbps	Fair

The table above is a comparison table of the simulation results with the KPI standards used. The results of the simulation can be said to meet the standards because several measurements have met them. The results of this simulation can still be maximized if using antennas with certain tilts because the planning area used is in an area with uneven surfaces, which is what affects the values of each measurement. [8]

IV. Conclusions

Based on the Long Term Evolution (LTE) outdoor network planning at frequency of 1880 Mhz In The Cicalengka Subdistrict, Bandung Regency, It can be concluded that :

1. After Comparing The MAPL planning values with the equipment used, there is a difference of 0.104 dB. Therefore, the capacity calculation is considered to meet the standards of the equipment used, as the difference is below 5 dB.
2. Through manual planning, an estimated number of 10 sites with a cell radius of 1.35 km were obtained for the Cicalengka District, which was then simulated using Atoll software to analyze parameters such as RSRP, RSRQ, SINR, Throughput, and Signal Level.
3. From the simulation results in the Atoll software, there are still areas marked as white (blind spots), caused by the hilly and winding topography in most of the Cicalengka area, particularly in mountainous regions. This makes it challenging for radio signals from the BTS to reach areas obstructed by hills or valleys.
4. Although the parameters of RSRP, RSRQ, SINR, Throughput, and Signal Level reach satisfactory levels, there is a less-than-optimal average RSRP value due to the presence of mountains in the Cicalengka Subdistrict.

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