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# Identification and Analysis of 4G LTE Network Blind Spot Areas in the Papua Highlands Using Drive Test Method

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***Keywords***
*Blank Spot, Drive Test, Papua Mountains, 4G LTE, RSRP, SINR.*

**ABSTRACT**

The *Papua Pegunungan* region is one of the areas in Indonesia that still faces significant challenges in achieving equitable cellular network coverage, particularly for 4G LTE services. Its extreme geographical conditions, such as high mountains and limited infrastructure, are the main causes of blind spot areas that hinder communication and information access. This study aims to analyze the quality of the 4G LTE network and identify blind spot areas in the region using the Drive Test method. The technical parameters measured include RSRP (Reference Signal Received Power), SINR (Signal-to-Interference-plus-Noise Ratio), and throughput. Data collection was conducted using the G-NetTrack Pro application along predetermined routes. The results indicate several locations with very poor signal quality (categorized as Very Bad), particularly in areas far from base stations and obstructed by geographic features such as hills or dense forests. The collected data were mapped to visualize the signal strength distribution and delineate areas categorized as blind spots. This research is expected to serve as a basis for technical policy-making and network optimization planning by service providers to improve telecommunication access in remote and underserved regions.

## INTRODUCTION

Equitable access to communication networks remains a major challenge in the development of digital infrastructure in Indonesia, particularly in regions with extreme geographical conditions such as mountainous Papua (Kementerian Komunikasi dan Informatika, 2023; Putra & Ramadhan, 2021).

Geographical challenges, such as hilly terrain and dense vegetation, often hinder the stability of internet networks, which are critically needed to support coordination and information dissemination (Kaur & Nawani, 2025; Kumar, Duttagupta, Rangan, & Ramesh, 2020; Tarolli & Straffelini, 2020; Yaacoub & Alouini, 2020). Disadvantaged areas with difficult-to-access terrain require infrastructure solutions capable of ensuring reliable signal coverage despite various physical barriers. In addition, network towers must be designed to adapt to adverse weather conditions in order to maintain connectivity (Zukhal, 2025). Similar challenges related to network stability and connectivity disruptions have also been reported in local technical studies, indicating that environmental constraints and limited infrastructure significantly affect the reliability of internet services in remote and mountainous regions (Zukhal, 2025).

The highest elevation in Papua is located in Puncak Jaya Regency at approximately 2,980 meters above sea level, while the lowest elevation is found in Jayapura City with an average altitude of about 4 meters above sea level (Bappeda Papua, 2019). The dominant slope characteristics of Papua Province consist of gently sloping areas (0–8%) covering 45.9% of the region and very steep slopes (>40%) accounting for 43.3%, which are widely distributed across the Haanim, Meepago, Mamta, and Laapago regions (Bappeda Papua, 2019; Pemerintah Provinsi Papua, 2019). Although the 4G LTE network, as the main backbone of internet connectivity, has reached most regions of Indonesia (Kementerian Komunikasi dan Informatika, 2023), its deployment in Papua remains constrained by geographical conditions. There are at least 19 districts categorized as hard-to-reach due to mountainous and remote terrains (Pemerintah Provinsi Papua, 2019). Based on statistical data from 2018, out of 5,380 identified villages, approximately 80.22%, or about 4,316 villages, are located in mountainous and difficult-to-access areas, where nearly 80% of villages remain isolated from adequate transportation access (Direktorat Jenderal PPI, 2024). Consequently, the expansion of telecommunications infrastructure has not been able to fully reach geographically isolated regions, resulting in the persistence of blind spot areas that disrupt communication and limit access to information for local communities (Zukhal, 2025; Bappeda Papua, 2019).

Equitable access to communication networks is still a fundamental problem in the development of digital infrastructure in Indonesia (Putra & Ramadhan, 2021), especially in the mountainous Papua region, which has extreme geographical conditions, making building and maintaining internet networks challenging. The topography, with altitudes exceeding 3,000 meters above sea level and predominantly steep slopes, makes network deployment difficult. Furthermore, limited internet infrastructure often hinders villages from accessing network services (Mahendra, 2025).

The impact is evident in 19 districts that are hard-to-access areas, where most villages are located in mountainous areas and are still isolated from transportation networks. Although the 4G LTE network has become the backbone of national connectivity, its deployment has not been able to reach many mountainous areas in Papua. Data show that more than 80% of the 5,380 villages are in hard-to-reach areas, so blind spot areas are still often encountered. This condition hinders communication, public services, and access to information for the public. This situation emphasizes the need for proper identification and analysis because there are still many regions in Indonesia that do not have equal access to information and communication, which has the potential to result in blind spot areas (Kusumastuti et al., 2021), so that network expansion strategies can be carried out in a directed manner.

The drive test method is a relevant technical approach to map the quality of 4G LTE services directly in the field, so that the results can support the preparation of recommendations for strengthening telecommunication infrastructure in Highland Papua.

Drive test activities are technical steps taken by service providers to measure and evaluate signal quality in the field. One of the important findings of this activity is the blind spot. A blind spot is a condition in which an area is not reached by cellular signals due to the limited range of the Base Transceiver Station (BTS), signal interference, or topographic influences that inhibit the propagation of electromagnetic waves (Akram et al., 2023). Identification and analysis of blind spot areas are important to provide empirical data to service providers in determining network optimization strategies. Limited network access causes digital inequality (digital divide), which widens the gap between urban areas and 3T (Frontier, Outermost, Disadvantaged) areas. Therefore, efforts to identify and analyze blind spot areas are important to support planning and policy-making in the development of an equitable and inclusive telecommunication network (Aulia et al., 2022).

In a geographical context such as mountainous Papua, such research is still very limited. The characteristics of the region—consisting of steep mountains, dense forests, and limited basic infrastructure—cause network implementation to face many technical obstacles and high costs (Wibowo & Ramadhan, 2021). Some regions even rely only on radio communication as an alternative, which is clearly insufficient to support the digital needs of modern society (Lestari, 2023).

The drive test method is considered effective in providing a real picture of network performance on a certain route or region by utilizing technical parameters such as Reference Signal Received Power (RSRP) and Signal-to-Interference-plus-Noise Ratio (SINR) (Lintasarta, 2023). A study by Wibowo & Ramadhan (2021) demonstrated that this method was able to identify areas prone to weak signals in the West Kalimantan area with high accuracy, as well as support network optimization planning based on actual data (Direktorat Jenderal PPI, 2024). In addition, research by Lestari (2023) shows that spatial processing of drive test data through GIS can facilitate the identification of blind spots and the potential for network expansion (Farianto, 2021).

This study aims to identify and analyze blind spot areas of the 4G LTE network in the Papua Highlands region using the drive test method. By mapping signal quality parameters in real time and identifying points with weak or unavailable signals, this research is expected to serve as a technical foundation for the development of network infrastructure in the future. In addition, the results of this analysis are expected to help telecommunication service providers and local governments in developing communication infrastructure development strategies that are adaptive to extreme geographical challenges.

This study aims to analyze the quality of the 4G LTE network and identify blind spot areas in the Papua Pegunungan region using the drive test method. The study also seeks to measure technical parameters such as RSRP (Reference Signal Received Power), SINR (Signal-to-Interference-plus-Noise Ratio), and throughput to identify areas with poor signal quality. Additionally, this research aims to provide valid data that can be used as a basis for network optimization planning by service providers to improve telecommunication access in underserved and hard-to-reach areas. The study further aims to assist service providers and local governments in designing communication infrastructure development strategies that are responsive to the extreme geographical challenges in Papua.

This research provides the benefit of offering a clear picture of the 4G LTE network quality in the Papua Pegunungan region, along with identifying blind spot areas that hinder information access for local communities. The results of this study are expected to provide empirical data that can be used as a foundation for decision-making in the development and optimization of telecommunication infrastructure in remote areas. Furthermore, the research supports more efficient and effective network planning to reduce the digital divide, enhance connectivity, and strengthen communication systems that support key sectors such as education, health, and government in Papua. Finally, this research offers technical recommendations for telecommunication service providers and government policies to optimize frequency usage and Base Transceiver Station (BTS) installation in underserved areas.

## METHOD

This research used a field experiment method. The main focus of the study was on the measurement of 4G LTE network quality parameters directly in the field using the drive test method, which allowed researchers to obtain real-time data from existing network conditions. The drive test method was carried out by recording data directly in the field and moving from one point to another based on the route that had been determined for the analysis of this research.

The drive test method has been widely used in mobile network research to measure the performance and coverage of mobile networks (Akram et al., 2023; Wibowo & Ramadhan, 2021). The selection of this method aimed to accurately identify blind spot areas, particularly in regions with high geographical challenges such as Wamena, Papua Mountains. In addition, performance-based network evaluation is an important aspect in supporting effective network optimization and infrastructure planning. The analysis of key radio parameters obtained from field-based measurements provides accurate insights for identifying coverage limitations and improving network performance, especially in regions with extreme geographical conditions (Ahmadi et al., 2025).

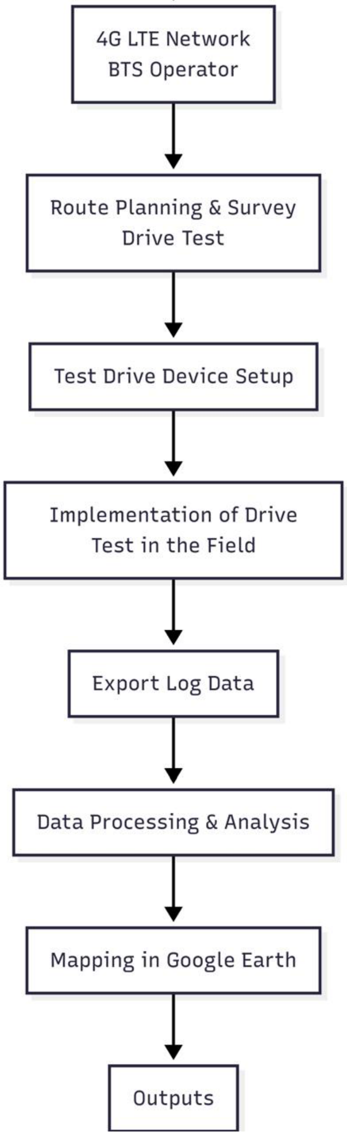


Figure 1. 4G LTE Network Drive Test Process Diagram Block
Source: G-NetTrack Pro Application Documentation

Figure 1 shows a block diagram of the process of implementing the 4G LTE network drive test, which was the basis for analyzing and optimizing signal coverage, especially for the identification of blind spot areas. This process consisted of several stages, starting from the planning stage to producing outputs in the form of blind spot maps and network optimization recommendations.

The initial stage began with the determination of the measurement object, namely the 4G LTE network provided by the mobile operator's BTS in the research area. This stage defined the scope of the measurement and ensured that the evaluation focused on the intended network infrastructure. At this stage, information about the configuration was needed as a basic reference so that field data collection could ensure that the measured parameters came from the appropriate cell sector.

The next stage was to draw up a drive test route plan, including the determination of paths representing coverage areas, the identification of points experiencing a blind spot, and the timing of implementation. This planning process was necessary to ensure that the collected data accurately represented real network coverage conditions in the research area.

Drive test device setup was then conducted. This stage focused on preparing the measurement system prior to field implementation. At this stage, the configuration of the equipment used was carried out, including a smartphone, the G-NetTrack Pro application, and the test carrier SIM card.

Implementation of the drive test in the field was the core stage of the process. During this stage, measurements were performed directly along the predefined routes to capture actual network performance. The main parameters recorded included RSRP (Reference Signal Received Power), RSRQ (Reference Signal Received Quality), SINR (Signal-to-Interference-plus-Noise Ratio), and throughput for both downlink and uplink.

Once data collection was complete, the log file was exported in KML (Keyhole Markup Language) format. This format was selected because it supports geographic visualization and spatial analysis of network performance. The KML data were then used for mapping in Google Earth.

At the data processing and analysis stage, the collected data were processed to extract meaningful information. This stage ensured that the measurement results were valid and suitable for further performance evaluation. The data were processed through several steps, including filtering to remove duplicate or invalid data, classification of signal levels based on KPI thresholds, and analysis of the drive test results.

The classified data were then mapped using Google Earth. This visualization stage provided a clear spatial representation of signal distribution and coverage conditions. The visualization yielded signal quality distribution maps, highlighted weak signal areas, and identified blind spot locations based on specific criteria, such as RSRP values less than or equal to −120 dBm and SINR values below 0 dB.

The final stage produced outputs in the form of blind spot maps, analysis reports, and network optimization recommendations to improve 4G LTE network performance in the research area, including the addition of new BTS, antenna tilt adjustments, power or PCI optimization, and handover parameter optimization.

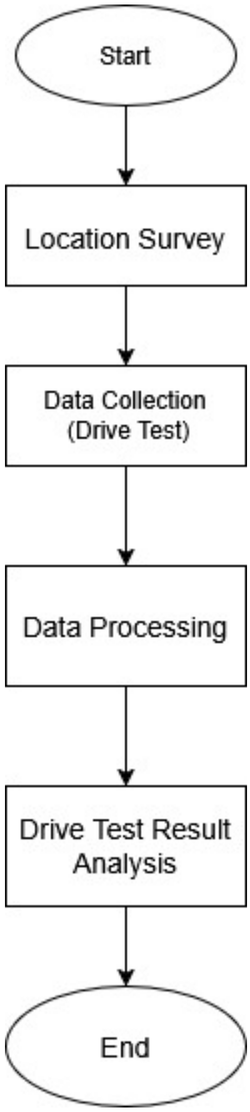


Figure 2. Research Flowchart for 4G LTE Blind Spot Analysis Using Drive Test
Source: G-NetTrack Pro Application Documentation

Figure 2 presented the research flowchart that outlined the systematic stages of the study, starting from location surveys to the analysis of drive test results.

Location surveys were conducted prior to the collection of drive test data to ensure that the research route was safe, accessible, and in accordance with the focus of the study area. Areas of focus included downtown Wamena as well as the main access roads that were frequently used. The survey also aimed to identify potential obstacles during data collection, such as road conditions and areas with weak signals.

Data capture was carried out using the drive test method with the G-NetTrack Pro application. The application recorded network parameters in real time, including RSRP, RSRQ, SINR, and throughput, along the research route. This process was carried out continuously to obtain representative data from the network conditions in the study area. After the data capture process was completed, the collected measurement data were prepared for further processing and visualization.

The drive test results were exported from the G-NetTrack Pro application in CSV and KML formats for each route taken. These data were then integrated with Google Earth to spatially visualize signal distribution and network performance in the research area. This visualization stage provided an initial overview of the spatial distribution of network performance across the study area.

The drive test results data were analyzed to evaluate and optimize network parameters, such as RSRP, RSRQ, SINR, and throughput. The analysis was carried out using the methods and features available in G-NetTrack Pro, so that areas with good signal quality could be identified alongside those that required improvement or optimization. This analysis stage represented the final step in evaluating overall network performance based on the collected drive test data.

## RESULT AND DISCUSSION

### Research Location

This research was carried out in Wamena City, Jayawijaya Regency, Mountainous Papua Province. Wamena City is the center of government, trade, and educational activities in the central mountainous region of Papua, so the need for telecommunication services is very high. making the selection of research in this location and the majority of the community's low digital literacy. Mountainous Papua Province is an expansion of Papua Province in 2022 with the number of districts: 8, namely Jayawijaya (Wamena), Pegunungan Bintang, Lanny Jaya, Nduga, Tolikara, Yahukimo, Yalimo, Central Mamberamo

The focus of the research taken is that the Wamena area can still be reached compared to other districts because the districts of Nduga, Yahukimo, Pegunungan Bintang, Lanny Jaya, Tolikara, and Central Mamberamo are still classified as vulnerable areas in conflict with the KKB. In addition, this location was chosen for the study because it reflects the topographic conditions of the valley surrounded by mountains with extreme topography and bad weather, low electricity support in the villages, satellite dependence with small bandwidth, remote, limited land access, heavily dependent on air transportation and satellite communication so that it greatly affects the quality of the 4G LTE signal. In addition, this region also represents a variety of user density, ranging from urban centers to suburban areas. Figure 3 presents the map of the research location in Wamena City, Jayawijaya Regency.

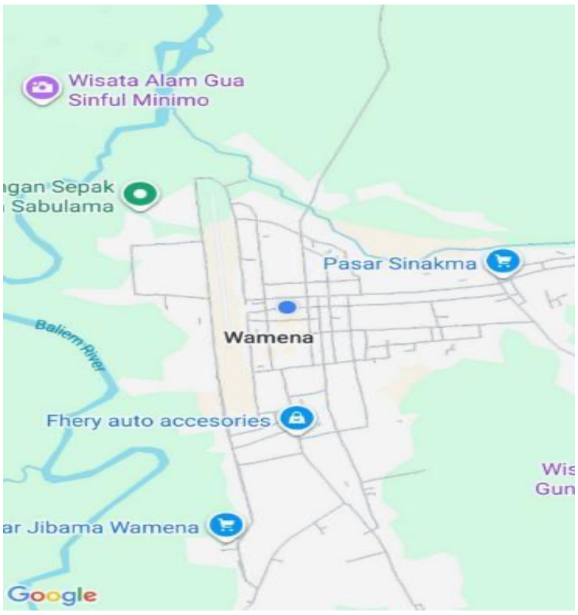


Figure 3. Map of the research location in Wamena City
Source: for the map in the image above is Google Maps

Based on the results of the drive test using the G-NetTrack Pro application combined with mapping in Google Earth, the position of several Base Transceiver Stations (BTS) serving the Wamena urban area can be identified. The following image shows the location of the BTS installed around the city center, marked with a red tower icon. This condition confirms that the limited number of BTS and the characteristics of the mountainous topography are the main factors causing uneven network coverage in Jayawijaya Regency.

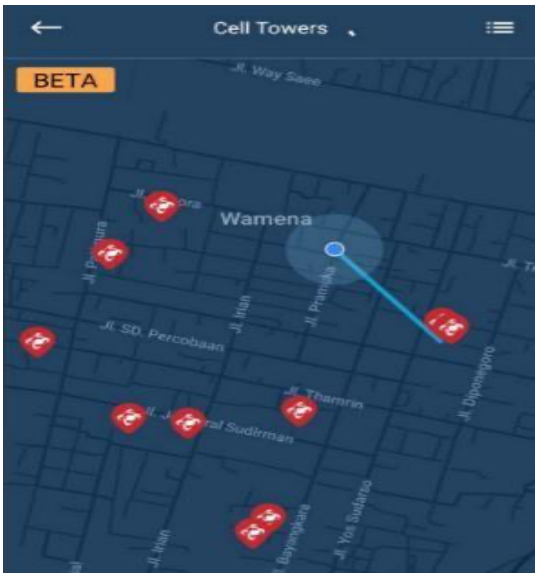


Figure 4. Base Transceiver Station Distribution Map in Wamena City
source: for the Base Transceiver Station distribution map in Wamena City is G-NetTrack Pro Application for mapping the distribution of BTS in the city area.

## Measurement Results Before Optimization

The measurement results using the G Net Track Pro application indicate that the distribution of network coverage in the Wamena area is uneven, some areas are well served, while others still experience limited mobile data access. From the results of the drive test, it can be seen that each travel point has a different color ranging from orange to gray.

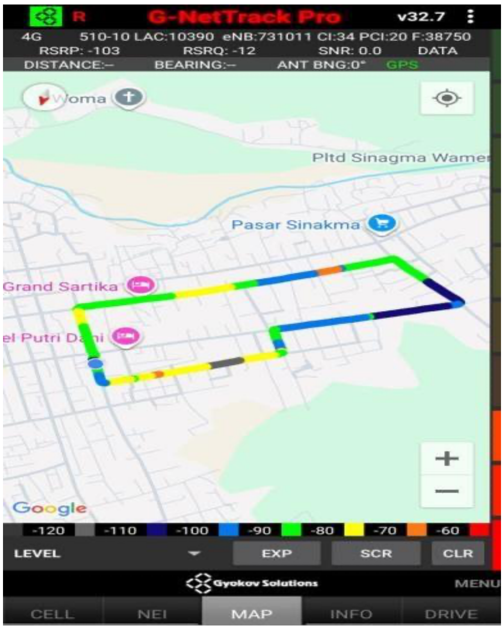


Figure 5. Drive Trails in the Wamena urban area
source for the Drive Trails map in the Wamena urban area is the G-NetTrack Pro Application

In figure 5, it can be seen that several segments, especially in the eastern and southern parts of the track, can be seen in dark blue-gray, which indicates weak signals and even blank spots. Segments with orange color are relatively rare, indicating that only a small percentage of the path has excellent signal quality.

**Table 1. Signal Quality Based on KPI ((Key Performance Indicators))**

| Color | RSRP Value Range | Signal Quality Description |
|---|---|---|
| (red) | (≤-60) x(-40) | Excellent |
| (orange) | (≤-70) x(-60) | Good |
| (yellow) | (≤-80) x(-70) | Enough |
| (green) | (≤-90) x(-80) | Keep |
| (light blue) | (≤-100) x(-90) | Bad |
| (dark blue) | (≤-110) x(-100) | Very Bad |
| (gray) | (≤-120) x(-110) | Unstable |

Source: for the Signal Quality table based on KPI (Key Performance Indicators) is derived from the G-NetTrack Pro Application Documentation

Table 1 presents the classification of signal quality based on Key Performance Indicators (KPI) using the Reference Signal Received Power (RSRP) parameter. The table correlates color indicators with specific RSRP value ranges to describe the quality of the received signal in the 4G LTE network.

Signal quality classified as Excellent is indicated by red color and corresponds to RSRP values higher than −60 dBm, representing areas with very strong signal reception. The Good category, shown in orange, corresponds to RSRP values between −60 dBm and −70 dBm, indicating reliable network performance with minimal degradation.

Signal quality categorized as Enough, represented by yellow color, covers RSRP values between −70 dBm and −80 dBm, which still provide acceptable service quality for standard data communication. The Keep category, shown in light green, represents RSRP values between −80 dBm and −90 dBm, indicating moderate signal conditions that may begin to affect user experience.

The Bad category, indicated by light blue, corresponds to RSRP values between −90 dBm and −100 dBm, where signal strength is weak and service quality may degrade noticeably. Furthermore, the Very Bad category, shown in dark blue, corresponds to RSRP values between −100 dBm and −110 dBm, indicating poor signal conditions that significantly impact network performance.

The lowest signal quality category, Unstable, is indicated by black color and corresponds to RSRP values below −120 dBm. This condition represents areas with extremely weak or unavailable signals and is typically identified as blank spot areas in the network coverage analysis.

**Table 2. 4G Drive Test Before Optimization**

| CELL ID | TECHNOLOGY | RSRP | RSRQ | SNR | DL Bitrate | UL Bitrate |
|---|---|---|---|---|---|---|
| **16** | 4G | -115 dBM | -9 | 0.0 | 0 kbps | 53 kbps |
| **14** | 4G | -101 dBm | -15 | 0..0 | 2 kbps | 7 kbps |
| **15** | 4G | -90 dBm | -13 | 0.0 | 0 kbps | 2 kbps |
| **13** | 4G | -90 dBm | -15 | 0.0 | I kbps | 0 kbps |
| **23** | 4G | -103 dBm | -14 | 0.0 | 4 kbps | 6 kbps |
| **25** | 4G | -100 dBm | -10 | 0.0 | 723 kbps | 14 kbps |
| **21** | 4G | -97 dBm | -19 | 0.0 | 0 kbps | 0 kbps |

source for the 4G Drive Test data table before optimization is based on the G-NetTrack Pro Application

Based on the results in Table 2, the drive test measurements before optimization indicate that several areas in the Papua Highlands experience poor 4G LTE network performance, which can be categorized as blind spot or weak coverage areas. This condition is primarily reflected by low RSRP values, ranging from –90 dBm to –115 dBm, where most cells fall below the recommended threshold for good signal strength. The weakest signal is observed at Cell ID 16 (–115 dBm), indicating severe signal attenuation and limited coverage.

In addition to low signal strength, the RSRQ values, which range from –9 dB to –19 dB, indicate poor signal quality caused by interference, noise, or network congestion. Several cells, such as Cell ID 21 (–19 dB) and Cell ID 14 (–15 dB), show degraded quality that negatively impacts data transmission performance. Furthermore, the SNR values consistently recorded at 0.0 dB across all cells suggest that the received signal is highly affected by noise, making reliable communication difficult.

This poor radio condition is directly reflected in the data throughput performance, where most cells show extremely low downlink (DL) and uplink (UL) bitrates, often close to 0 kbps. For example, Cell IDs 16, 15, 21, and 13 demonstrate almost no effective data transmission, indicating that users in these areas are likely unable to access data services properly. Although Cell ID 25 shows a relatively higher downlink bitrate (723 kbps), the overall performance remains inadequate for stable LTE services.


Figure 6. Google Earth Visualization Before Optimization

Through research using the drive test method using the G-NetTrack Pro application in the Wamena urban line, 4G LTE network quality data was obtained which was then visualized using Google Earth. The measurement results using the drive test method with the G-NetTrack Pro application showed the network performance of Cell ID 16 in the urban area of Wamena. The technical parameters obtained include RSRP −115 dBm, RSRQ −9 dB, SNR 0 dB, with a downlink throughput value of 0 kbps and an uplink of 53 kbps.

Signal strength with RSRP −115 dBm is in the poor category even close to the blank spot, as it is below the LTE acceptance threshold (−110 dBm). An RSRQ value of −9 dB indicates low signal quality due to possible interference or limited network capacity, while an SNR of 0 dB indicates the absence of usable channel quality.

From the service side, a downlink throughput of 0 kbps indicates that there is no internet access available, while a 53-kbps uplink is only capable of generating very low traffic and is inadequate for standard data communication needs. With these conditions, the areas served by Cell ID 16 can be categorized as blank spots that require network optimization, either through adjustments to radio parameters (e.g. antenna tilt and transmit power), as well as the construction of additional sites to expand signal coverage. To provide an overview of the existing communication infrastructure supporting internet access in the study area, the classification of communication and network technologies is presented in Table 3.

**Table 3. Classification Table of Communication and Network Technology.**

| Technology | Information |
|---|---|
| VSAT | Used in government offices and schools for basic internet access |
| Microwave Link | Used between small towns for signal relay from major BTS towers |
| Palapa Ring Timur (PRT) | The main backbone is through BAKTI's satellite network, very limited capacity |
| Fiber Optics | Not yet available, land connection from Timika – Wamena is being planned |

Table 3 shows that internet access in the Papua mountainous region is still dominated by satellite-based technologies such as VSAT and the Palapa Ring Timur, which have limited capacity and relatively low transmission speed. The absence of fiber optic infrastructure reflects geographical challenges that contribute to network performance limitations and potential blind spot areas. Based on the communication technologies described in Table 3, Table 4 presents the estimated bandwidth capacity and general internet speed across mountainous regencies in Papua.

**Table 4. Bandwidth & Internet Speed in Papua Mountainous Regency by 2025**

| Regency | Estimated Bandwidth | General Internet Speed | Dominant Sources |
|---|---|---|---|
| Jayawijaya(Wamena) | ±700 Mbps | 2–5 Mbps | Palapa Ring + VSAT |
| Pegunungan Bintang | ±300 Mbps | 1–3 Mbps | VSAT BAKTI |
| Yahukimo | ±200 Mbps | 1 Mbps | VSAT + Microwave |
| Other | <100 Mbps | 0.5–1 Mbps | VSAT portable / minim |

Table 4 shows the estimated bandwidth capacity and general internet speed across mountainous regencies in Papua. The data indicate significant disparities in network capacity and service performance, with Jayawijaya Regency exhibiting the highest estimated bandwidth and relatively better internet speeds compared to other regions. In contrast, regencies such as Pegunungan Bintang and Yahukimo rely predominantly on VSAT-based connectivity, resulting in lower bandwidth availability and reduced internet speeds.

Overall, the limited bandwidth capacity and dependence on satellite-based infrastructure contribute to uneven service quality and constrain network performance, particularly in geographically challenging mountainous areas

**Analisa OPTIMASI interference & neighbor relation**

The measurement results in Figure 7 show the presence of badspots on the antenna in the central mountainous region of Papua sector 3 with an azimuth direction of 240o due to interference from neighboring cells and suboptimal antenna orientation. Some neighboring cells use the same ARFCN, lowering RSRQ and SINR in certain areas.

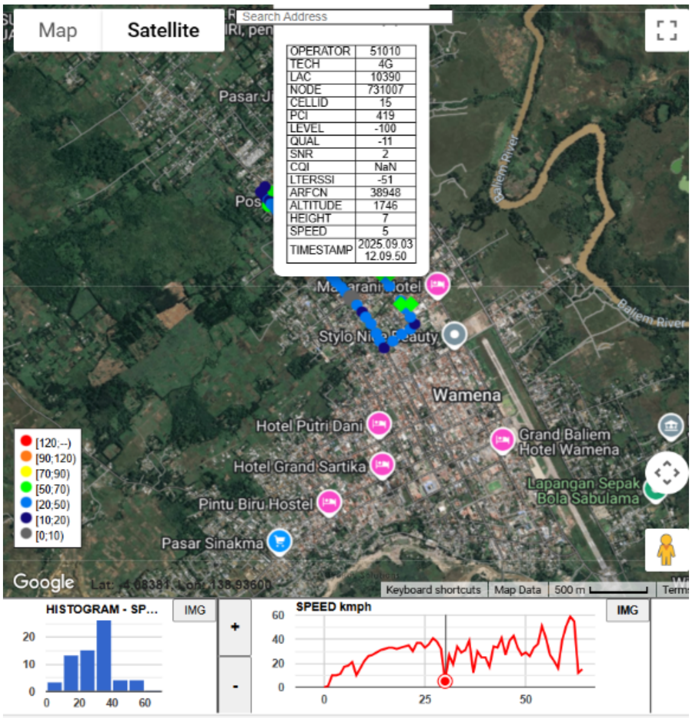


Figure 7. Badspot area due to interference in the mountainous region of Papua

G-netTrack Pro Optimization Simulation Results

1. RSRP and SINR Results After Optimization

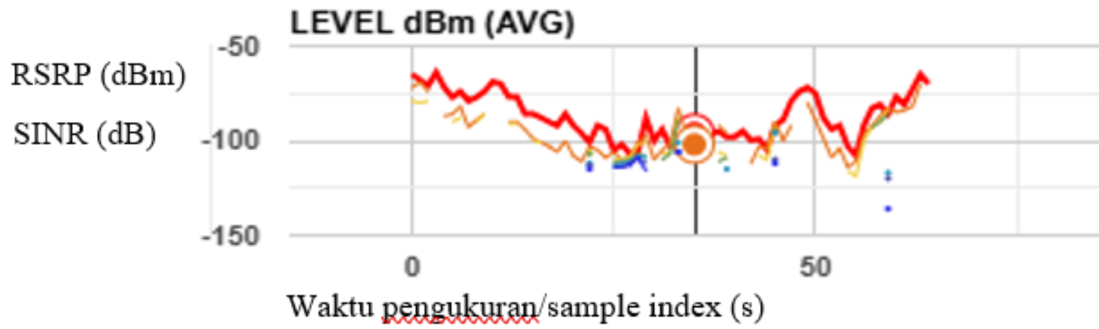


Figure 8. Chart Level Results

After network optimization, the Level Chart graph on G-NetTrack Pro shows an improvement in signal quality. On the X-axis representing the time or sequence of the measurement sample, there is a change in signal pattern along the test drive path. On the Y-axis, the RSRP value that was originally in the range of -110 to -100 dBm increases to -85 to -75 dBm in most segments. Meanwhile, the SINR value increased from < 5 dB to > 10 dB at many points, indicating a more stable channel quality and reduced interference.

Table 5. RSRP levels before and after Network Repair

| RSRP level | Range dBm | Before | After |
|---|---|---|---|
| Excellent | 75 ≤ RSRP <- 0 | 1,62 % | 4.10% |
| Very Good | 85 ≤ RSRP <- 75 | 7.43% | 12.20% |
| Good | 110 ≤ RSRP <- 85 | 45,41% | 48,7% |
| Fair | 110 ≤ RSRP <- 110 | 36,14% | 29% |
| Poor | RSRP<110 | 9,39% | 6,1% |

Based on the CELLID 23 drive test data in the Wamena area, information was obtained that the average RSRP value of the main cell was at -92 dBm, with an RSRQ of -9 dB and a SINR of 13 dB. This value indicates that the signal quality is still suboptimal, mainly due to interference from neighboring cells, namely NCELL1 = 190 and NCELL2 = 189, which have the same ARFCN (500 MHz) and weak signal levels (-89 dBm and -90 dBm). In addition, the measurement area is located on the topography of mountains with an altitude of 1744 m, so environmental factors also affect the signal quality. Neighbor relations show that neighbor signals cause a decrease in RSRQ and SINR in the main cell, although RSRP is still quite good.

2. Throughput Results After Optimization

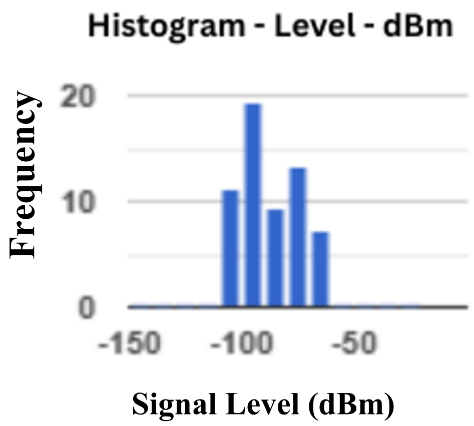


Figure 9. Histogram of Throughput Distribution after network optimization in badspot area

While Figure 9 is a histogram display, you can see the percentage of throughput parameters in the excellent and good categories in the throughput area in the badspot area, indicating that there is an improvement in quality that occurs because the speed of throughput data transfer increases so that the quality of service will be good, with good service quality and data transfer speed will be able to increase the system capacity of the cell so that it can serve a greater traffic load. This indicates an improvement in good service quality, and the speed of data transfer will be able to increase the system capacity of the cell. To further clarify and quantitatively support the throughput improvement observed in Figure 9, the comparison of throughput performance levels before and after network optimization is presented in Table 6.

**Table 6. Level Throughput**

| | Throughput | Percentage | |
|---|---|---|---|
| Level | Range (Kbps) | Before | After |
| Excellent | Throughput ≥ 14.000 | 45,8% | 17,8% |
| Very Good | 7.000≤ Throughput < 14.000 | 42,5% | 60,7% |
| Good | 1.000≤ Throughput <7.000 | 11,7% | 21,5% |
| Fair | 512≤ Throughput <1.000 | 0% | 0% |
| Poor | Throughput | 0% | 0% |

## CONCLUSION

The BTS location map revealed that infrastructure distribution in the Wamena area was suboptimal, with concentration in the city center resulting in adequate coverage in the core area but notable weaknesses in the suburbs and along major transportation routes. Drive test measurements conducted using the G-NetTrack Pro application and visualized in Google Earth confirmed that 4G LTE network quality across urban Wamena varied considerably; while some city center segments demonstrated acceptable signal quality, suburban areas frequently recorded RSRP values of ≤ −110 dBm, placing them in the poor to blind spot category. These findings indicated that network coverage distribution was uneven and service capacity remained below optimal, necessitating immediate optimization measures such as the addition of new BTS in underserved areas, antenna tilt and azimuth adjustments, and ongoing handover parameter re-optimization. To maintain long-term network reliability, regular signal quality monitoring, periodic radio simulations benchmarked against field conditions, and thorough performance evaluations following any environmental changes or increases in user activity were recommended. For future research, it is suggested that efforts be directed toward deploying mini portable BTS units and distributing VSAT terminals in blind spot districts, accelerating the Wamena–Timika fiber optic project, conducting real-time blind spot mapping using drones or IoT-based systems, and strengthening cross-agency coordination between local governments, Kominfo, and BAKTI, alongside community-based digital literacy programs facilitated through religious and customary leaders to ensure that improved network infrastructure translates into meaningful and equitable access for the broader population.

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