

5G Indoor Solution Deployment Using LEO Satellite Backhaul for Rapid Network Connectivity

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Abstract—Reliable backhaul connectivity remains one of the primary challenges for deploying mobile networks in remote, temporary, and disaster-affected areas where terrestrial transmission infrastructure is unavailable or economically impractical. Recent advancements in Low Earth Orbit (LEO) satellite communications provide a promising alternative by offering significantly lower latency and higher throughput than traditional geostationary satellite systems. This paper presents the deployment and validation of a 5G Indoor Solution integrated with OneWeb LEO satellite backhaul in a live commercial network environment. The proposed solution combines a compact radio access network with a rapidly deployable LEO satellite connection to enable broadband LTE and 5G services in isolated locations. The trial evaluates end-to-end network performance through multiple time field measurements, including downlink and uplink throughput, latency, jitter, and overall system stability. The measured results demonstrate downlink and uplink throughputs in the range of 90-100 Mbps and 10-15Mbps, respectively, with latency nearly between 80-96 ms and stable connectivity throughout the trial. Compared with conventional GEO satellite systems, the LEO-based solution achieved substantially lower latency while providing reliable broadband access suitable for voice and data services. The study also identifies practical deployment considerations related to network integration, thermal performance, and IP addressing constraints. Overall, the proposed architecture demonstrates that LEO satellite backhaul is a practical and scalable solution for rapidly deploying LTE and 5G networks in remote areas, emergency response scenarios, temporary events, and mission-critical communication environments.

Index Terms—5G, Base Station, Indoor Small Cell Solution, Low Earth Orbit (LEO) Satellite, Satellite Backhaul, Rapid Network Deployment, Remote Connectivity, LTE, NonTerrestrial Networks (NTN), Emergency Communications.

I. INTRODUCTION

The rapid expansion of fifth-generation (5G) mobile networks has created an increasing demand for reliable broadband connectivity in areas where terrestrial transmission infrastructure is unavailable or difficult to deploy. While fiber optics and microwave links remain the preferred backhaul technologies for conventional cellular networks, their deployment is often impractical in remote regions, oil and gas facilities, mining sites, disaster-affected areas, temporary events, and emergency response scenarios. In such environments, establishing a reliable and rapidly deployable backhaul solution is essential for extending mobile network coverage and ensuring uninterrupted communication services.

Recent advancements in Low Earth Orbit (LEO) satellite technology have emerged as a promising alternative to conventional satellite communications. Unlike Geostationary Earth Orbit (GEO) satellites, which typically introduce roundtrip latencies exceeding 500 ms, LEO satellite constellations operate at significantly lower orbital altitudes, enabling substantially lower latency, improved throughput, and enhanced

communication reliability. These characteristics make LEO satellite backhaul well suited for supporting LTE and 5G radio access networks, particularly in applications where rapid deployment and flexible connectivity are required.

base station solutions have also gained considerable attention as an effective approach for providing temporary or on-demand mobile coverage. Huawei's Indoor Solution integrates a compact baseband unit, remote radio units, and flexible backhaul interfaces into a lightweight and trans platform that can be deployed within a short period of time. By supporting multiple backhaul technologies, including fiber, microwave, VSAT, and LEO satellite communications, the solution provides operators with a versatile platform capable of delivering broadband connectivity across a wide range of deployment scenarios.

Although several studies have investigated satellite-based mobile backhaul, practical field evaluations of LTE and 5G radio access networks operating over LEO satellite links remain limited. Most existing research focuses on theoretical analysis or simulation-based evaluations, with relatively few studies reporting the operational challenges and performance of live commercial deployments. Therefore, further investigation is required to validate the feasibility of integrating radio access networks with LEO satellite backhaul under real operating conditions.

This paper presents the deployment and validation of a 5G Indoor Solution integrated with LEO satellite backhaul in a live commercial network environment. The study evaluates the solution through field measurements of throughput, latency, jitter, and network stability while assessing its suitability for remote connectivity, emergency communications, temporary events, and disaster recovery applications. The findings provide practical insights into the capabilities and deployment considerations of LEO-enabled mobile networks and demonstrate their potential as a scalable solution for future non-terrestrial network (NTN) deployments.

II. OBJECTIVE AND TRIAL SETUP

A. Objective

The primary objective of this study is to validate the feasibility of deploying LTE and 5G radio access networks

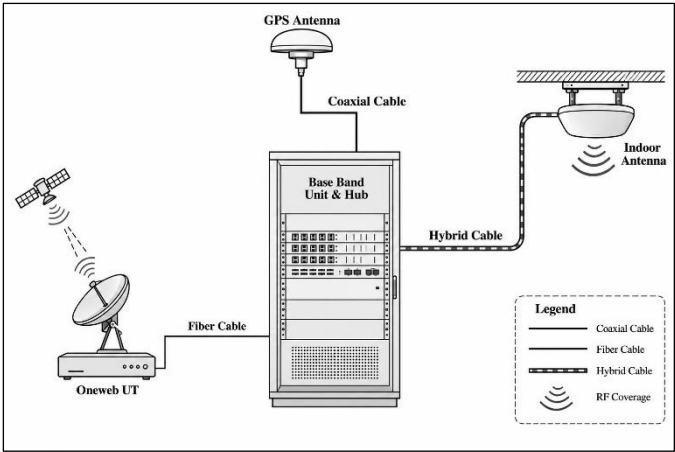


Fig. 1: Indoor Solution architecture with LEO satellite backhaul.

using a Indoor Solution integrated with Low Earth Orbit (LEO) satellite backhaul in a live commercial network environment. The study investigates whether LEO satellite technology can provide a reliable alternative to conventional terrestrial backhaul solutions while maintaining acceptable network performance for broadband mobile services.

The evaluation focuses on key network performance indicators, including end-to-end latency, jitter, downlink throughput, uplink throughput, and overall link stability. In addition, the study assesses the integration of the LEO satellite backhaul with the existing LTE and 5G radio access network to ensure seamless interoperability and stable service delivery under practical deployment conditions.

Furthermore, the trial aims to identify operational challenges associated with network deployment, including equipment installation, satellite terminal alignment, environmental considerations, and network configuration. The overall objective is to demonstrate the suitability of LEO satellite backhaul as a flexible and rapidly deployable solution for providing mobile broadband connectivity in remote locations, temporary events, disaster recovery operations, and missioncritical communication scenarios.

B. Trial Setup

The proof-of-concept (PoC) trial was conducted using a single Indoor Solution connected through a OneWeb Low Earth Orbit (LEO) satellite backhaul within a live commercial network environment. The trial was designed to evaluate the operational performance of LTE and 5G services over satellite backhaul while maintaining compatibility with the existing mobile network infrastructure. The Indoor Solution served as the radio access node, whereas the LEO satellite terminal provided the transport connectivity between the radio site and the core network.

The deployed radio configuration supported both LTE and 5G services simultaneously. LTE operated on B1 and B3 with a combined bandwidth of 55MHz using a 2×2 MIMO configuration, while the 5G NR carrier operated on C-Band with 100 MHz bandwidth using a 4×4 MIMO configuration. This configuration enabled the evaluation of both technologies under

identical backhaul conditions while representing a realistic commercial deployment scenario.

Field validation included throughput measurements, latency analysis, jitter evaluation, and end-to-end connectivity verification using commercial user equipment. The collected results were compared against typical terrestrial backhaul performance to assess the suitability of LEO satellite technology for LTE and 5G deployments. The trial also evaluated deployment simplicity, operational stability, and practical implementation considerations under real network conditions.

C. Tools Used

The performance evaluation was carried out using a combination of field measurement tools and network monitoring systems to provide a comprehensive assessment of the proposed Indoor Solution. Commercial LTE and 5G user equipment (UE) was used to perform end-to-end connectivity tests and measure user-experienced performance under live network conditions. Throughput measurements were conducted using Ookla Speedtest, while latency and jitter were evaluated through continuous ping tests to assess the quality and stability of the LEO satellite backhaul. Network-level performance was monitored using the operator's Operation Support System (OSS), which provided real-time information on radio connectivity, service availability, and network status throughout the trial. The OSS data was used to verify the successful integration of the Indoor Solution with the existing LTE and 5G infrastructure and to ensure stable operation during the testing period.

The OneWeb User Terminal (UT) served as the satellite communication gateway, establishing the LEO backhaul connection between the Indoor Solution and the mobile core network. A GPS receiver was used to provide synchronization for the radio access network, while the Indoor Solution hardware was deployed using a lightweight tripod and pre-configured cabling to simplify field installation. This combination of field measurements, OSS monitoring, and satellite communication equipment enabled a comprehensive evaluation of the proposed solution under real commercial deployment conditions.

III. NETWORK CONFIGURATION

The trial network was configured to provide simultaneous LTE and 5G services through a Indoor Solution using a OneWeb Low Earth Orbit (LEO) satellite as the backhaul transmission medium. The Indoor Solution acted as the radio access node, while the OneWeb User Terminal (UT) established the satellite communication link to the transport network. This architecture eliminated the need for conventional terrestrial backhaul such as fiber or microwave, enabling rapid deployment in locations where transmission infrastructure was unavailable. The overall network architecture is illustrated in Fig. 1. The LTE network operated on B1 and B3 frequency bands with combined

TABLE I: Indoor Solution Throughput Performance Summary

Parameter	Range
Downlink Throughput (Mbps)	90-100
Uplink Throughput (Mbps)	10-15

TABLE II: Latency and Jitter Performance

Parameter	Range
Ping (Latency) (ms)	80-96
Jitter (ms)	5-11

bandwidth of 55 MHz using a 2×2 MIMO configuration, whereas the 5G NR network operated on C-Band with a bandwidth of 100 MHz using a 4×4 MIMO configuration. The radio access network was processed by the eNode B and gNode B and distributed to the active antenna through the HUB using optical interfaces. This configuration enabled simultaneous LTE and NR operation while maintaining compatibility with the existing mobile core network.

The Indoor Solution was designed with a pre-configured architecture to simplify installation and reduce deployment time. All radio, power, and synchronization interfaces were integrated within a trans equipment box, while the Active Antenna was mounted on a tripod to provide radio coverage. GPS synchronization ensured accurate timing for LTE and NR operation, and the satellite user terminal provided continuous connectivity between the radio access network and the core network throughout the trial. This integrated design significantly reduced installation complexity compared with conventional macro base station deployments.

To validate the proposed architecture, end-to-end connectivity was verified through continuous service testing, including user registration, voice and data session establishment, throughput measurements, and latency evaluation. The network remained stable during the trial, demonstrating that the Indoor Solution and LEO satellite backhaul can operate together as an integrated solution capable of delivering reliable LTE and 5G services under live commercial network conditions

IV. THEORETICAL BACKGROUND

Low Earth Orbit (LEO) satellite communication has emerged as a promising backhaul solution for next-generation mobile networks by providing significantly lower latency and higher throughput than conventional Geostationary Earth Orbit (GEO) satellite systems. Due to their lower orbital altitude, typically between 500 km and 2,000 km, LEO satellites reduce signal propagation delay while maintaining continuous broadband connectivity through satellite constellations. These characteristics make LEO backhaul suitable for supporting LTE and 5G radio access networks in remote and temporary deployment scenarios.

The end-to-end latency experienced in a satellite communication system is primarily determined by the signal propagation delay between the ground terminal and the satellite. The one-way propagation delay can be approximated as

$$T = \frac{d}{c} \quad (1)$$

where d is the propagation distance between the ground station and the satellite, and c is the speed of light (3×10^8 m/s). Since LEO satellites operate at much lower altitudes than GEO satellites, the propagation delay is significantly reduced, resulting in improved user experience for real-time applications.

The theoretical maximum channel capacity is governed by Shannon's Capacity Theorem,

$$C = B \log_2(1 + SNR) \quad (2)$$

where C represents the channel capacity, B is the available bandwidth, and SNR denotes the signal-to-noise ratio. The higher bandwidth available for the deployed LTE and 5G carriers enables the Indoor Solution to deliver broadband services despite the additional delay introduced by the satellite backhaul.

Another important parameter affecting satellite communication performance is the Free Space Path Loss (FSPL), which can be expressed as

$$FSPL = 20\log_{10}(d) + 20\log_{10}(f) + 32.44 \quad (3)$$

where d is the transmission distance in kilometers and f is the carrier frequency in MHz. Although satellite links experience higher propagation losses than terrestrial microwave links, modern LEO satellite systems compensate through advanced antenna technologies, adaptive coding and modulation, and efficient resource management.

These theoretical principles explain the measured throughput, latency, and network stability observed during the field trial and provide the engineering foundation for evaluating LEO satellite backhaul as an alternative transmission solution for LTE and 5G deployments.

V. TRIAL RESULTS

The proposed Indoor Solution integrated with the OneWeb LEO satellite backhaul was successfully deployed and validated under live commercial network conditions. The trial confirmed stable end-to-end connectivity for both LTE and 5G services throughout the evaluation period. Network performance was assessed using field measurements of downlink throughput, uplink throughput, latency, and jitter to determine the suitability of LEO satellite backhaul for mobile network deployments.

The measured performance results are summarized in Table I. The Indoor Solution achieved downlink throughput between 90-100 Mbps and uplink throughput between 10-15 Mbps, while the best observed downlink and uplink throughputs reached near to 100 Mbps and 16 Mbps, respectively. Although these values are lower than those typically achieved using GPON backhaul, they are sufficient to support broadband LTE and 5G services in remote and

TABLE III: Comparison Between LEO Satellite and Typical GPON Backhaul

Performance Metric	LEO Satellite Range	Typical GPON Backhaul Range
Downlink Throughput (Mbps)	90-100	1200-1600
Uplink Throughput (Mbps)	10-15	140-160
Latency (ms)	80-96	10-15
Jitter (ms)	5-11	0-4

TABLE IV: Deployment Observations and Recommendations

Observation	Remarks
LEO Satellite Latency	Significantly lower than GEO satellite, achieving approximately 80-96 ms during the trial.
Network Integration	LTE and 5G services successfully operated using a shared subnet due to OneWeb VRF limitations.
Deployment Flexibility	Indoor Solution enabled rapid installation with minimal infrastructure requirements.
Thermal Performance	Elevated equipment temperature observed during prolonged operation; outdoor deployment requires additional cooling consideration.
Recommended Applications	Remote villages, oil fields, temporary events, disaster recovery, and emergency communications.

temporary deployment scenarios. The results demonstrate that the LEO satellite link provides reliable bandwidth for voice, video streaming, web browsing, and other mobile broadband applications.

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The measured performance results are summarized in Table I. The Indoor Solution achieved downlink throughput between 90-100 Mbps and an uplink throughput between 10-15 Mbps. Although these values are lower than those typically achieved using GPON backhaul, they are sufficient to support broadband LTE and 5G services in remote and temporary deployment scenarios. The results demonstrate that the LEO satellite link provides reliable bandwidth for voice, video streaming, web browsing, and other mobile broadband applications.

The latency and jitter performance of the proposed LEO satellite backhaul solution is summarized in Table II. The end-to-end latency measured during the trial was between 80-96 ms. Similarly, the jitter was measured between 5-11 ms with a minimum value near to 6 ms. These results demonstrate that the LEO satellite link provides significantly lower latency than conventional GEO satellite systems, making it suitable for real-time services such as voice, video conferencing, and interactive data applications.

Although the measured latency remains higher than that of terrestrial fiber-based networks, the achieved values are well within acceptable limits for LTE and 5G deployments. The stable latency and low jitter observed throughout the trial further confirm the reliability of the proposed satellite backhaul solution for mission-critical and temporary communication scenarios.

Table III compares the measured LEO satellite backhaul performance with the typical performance of GPON-based terrestrial backhaul. As expected, GPON provides significantly higher throughput and lower latency due to its fiber-optic

transmission medium. However, the proposed LEO satellite solution offers an important advantage by enabling broadband connectivity in locations where terrestrial transmission infrastructure is unavailable.

Despite the performance gap, the achieved throughput of approximately between 90-100 Mbps and latency below 100 ms are sufficient to support most LTE and 5G mobile broadband services. Therefore, LEO satellite backhaul represents a practical alternative for rapid deployment in remote villages, oil fields, temporary events, and emergency response situations where installation speed and deployment flexibility are more important than maximum throughput.

The operational observations collected during the field trial are summarized in Table IV. The deployment confirmed that the Indoor Solution can be rapidly installed and successfully integrated with the OneWeb LEO satellite network using existing LTE and 5G infrastructure. The trial also identified several practical considerations, including the limited number of supported VRFs and elevated equipment temperature during prolonged operation.

Overall, these observations provide valuable guidance for future deployments. While additional thermal protection may be required for outdoor environments, the proposed solution demonstrates excellent deployment flexibility and is well suited for remote connectivity, disaster recovery, temporary events, government applications, and mission-critical communication scenarios.

VI. DISCUSSION

The field trial demonstrates that integrating a Indoor Solution with LEO satellite backhaul is a practical solution for extending LTE and 5G connectivity to locations where conventional terrestrial transmission is unavailable. The measured throughput, latency, and jitter confirm that the proposed architecture can provide stable broadband services while maintaining compatibility with the existing mobile network infrastructure. These findings validate the suitability of LEO satellite technology for rapidly deployable radio access networks.

Although the measured throughput and latency are lower than those achievable with GPON-based backhaul, the observed

performance is sufficient for most mobile broadband applications, including voice services, web browsing, video conferencing, and enterprise connectivity. The reduced latency of the LEO satellite system, compared with traditional GEO satellite networks, represents a significant improvement in user experience and expands the range of applications that can be effectively supported over satellite backhaul.

From an operational perspective, the trial also highlights the advantages of the Indoor Solution in terms of rapid deployment, simplified installation, and deployment flexibility. These characteristics make the solution well suited for disaster recovery, temporary events, remote industrial sites, isolated communities, and emergency communication scenarios where fast network restoration is essential. Overall, the proposed solution demonstrates that LEO satellite backhaul is a viable alternative to terrestrial transmission for LTE and 5G deployments.

VII. CONCLUSION

This paper presented the deployment and validation of a 5G Indoor Solution integrated with Low Earth Orbit (LEO) satellite backhaul in a live commercial network environment. The proposed solution demonstrated reliable LTE and 5G connectivity while eliminating the dependency on conventional terrestrial transmission infrastructure. Field measurements confirmed stable throughput, acceptable latency, and consistent network performance, validating the feasibility of LEO satellite technology as a practical backhaul solution for mobile networks.

The trial further demonstrated that the Indoor Solution enables rapid deployment with minimal infrastructure requirements, making it well suited for remote areas, disaster recovery, temporary events, and mission-critical communication scenarios. Although the measured performance remains below that of fiber-based backhaul, the flexibility and ease of deployment offered by the proposed architecture provide significant operational advantages. Future work will focus on evaluating multi-site deployments, optimizing satellite resource utilization, and investigating the integration of LEO satellite backhaul with 5G Standalone (SA) and NonTerrestrial Network (NTN) architectures.

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