Impact of NTN UE Deployment on Downlink Interference in TN/NTN Coexistence Scenarios

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***Abstract*— This paper examines the validity of the 1.5 km isolation distance between the terrestrial network (TN) cluster edge and the non-terrestrial networks (NTN) user terminal (UE) assumed in the 3GPP coexistence scenario. Monte Carlo simulations under LEO conditions show that coexistence is feasible at this distance, but deployments at the cluster edge or inside cause notable throughput degradation, indicating that the assumed distance may be overly conservative for LEO environments.**

***Keywords* —3GPP, TN-NTN coexistence, interference analysis**

I. Introduction

With the growing demand for data in telecommunication systems, research on wide-area coverage technologies has drawn increasing attention. In response, the 3rd Generation Partnership Project (3GPP), a key standardization body for terrestrial network (TN)-based communication systems, has advanced standardization through studies on non-terrestrial networks (NTN), which employ aerial platforms such as satellites and high-altitude platform stations (HAPS) as base stations or relays. To ensure TN–NTN coexistence, 3GPP defined simulation assumptions and conducted coexistence studies. From these studies, RF requirements for NTNs were derived. One such study focused on a downlink interference scenario where a TN base station interferes with an NTN user terminal (UE). This scenario assumed a simplified condition in which a 1.5 km isolation distance was maintained between the TN cluster edge and the NTN UE, with no other UEs present in the area. Although this assumption was intended to reduce simulation complexity by preventing the NTN UE from connecting to TN signals, the RF requirements derived from it may not fully reflect practical deployment environments.

Accordingly, this paper investigates the basis for the isolation distance and analyzes interference effects as a function of the distance between the TN cluster and the NTN UE using simulation.

II. 3GPP Coexistence Assumptions and Evaluation

A. Introduction of Isolation Distance for Coexistence Study

Following the completion of the *Study Item on NR to support non-terrestrial networks* at the 3GPP TSG RAN #86 meeting, a Work Item (WI) was approved to specify the requirements for applying 5G NR to NTN scenarios [1]. Subsequently, the RAN4 group initiated discussions on coexistence study scenarios and the associated simulation assumptions for TN/NTN coexistence, with the aim of specifying the RF requirements for NTN operation in the S-band. In the initial TN/NTN deployment scenarios, the NTN UE was assumed to be deployed either randomly within the NTN coverage area, randomly within the TN cluster, or specifically positioned at the center or edge of TN cells [2]-[3]. In subsequent meetings, it was suggested that the tendency of UEs to prioritize access to networks offering higher QoS should be considered, leading to an alternative scenario in which the NTN UE is deployed at the edge or outside the TN cluster [4]. As coexistence studies advanced and simulation assumptions were refined, it was ultimately agreed to place the NTN UE at the cluster edge. In the urban scenario, interference from TN base stations was taken into account, and an isolation distance of 1.5 km (2 × ISD) between the TN cluster edge and the NTN UE was assumed.

B. Throughput Loss Trends in GEO and LEO Scenarios

Based on the coexistence study assumptions proposed through prior discussions between TN and NTN, member companies conducted simulation based studies and subsequently proposed the required adjacent channel selectivity (ACS) and adjacent channel leakage ratio (ACLR) specifications for NTN [5]. In this process, throughput loss was derived as a function of the adjacent channel interference ratio (ACIR), using the ACS and ACLR values of the TN system as a reference. ACIR is defined by the following relationship:

$$ACIR = \frac{1}{\frac{1}{ACLR}+\frac{1}{ACS}} \tag{1}$$

Based on this analysis, the ACIR corresponding to a 5% throughput loss was derived and used as a reference to define the required ACS and ACLR specifications for NTN systems. The assumed 1.5 km isolation distance may be appropriate for GEO configurations, where the higher satellite altitude leads to weaker received signal power. However, in LEO scenarios this distance appears overly conservative, since the much lower altitude results in stronger received signals at the NTN UE and thus a higher SINR. Consequently, the UE can withstand greater interference levels without exceeding the 5% throughput loss threshold. Figures 1 and 2 present the 5%-tile throughput loss of the NTN UE as a function of ACIR at different satellite altitudes, based on simulation results reported by multiple 3GPP companies.

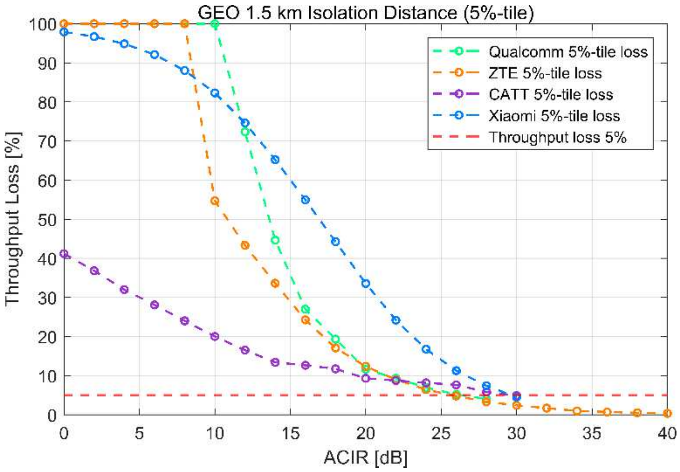

Fig. 1. 5%-tile Throughput Loss vs. ACIR in GEO Scenario

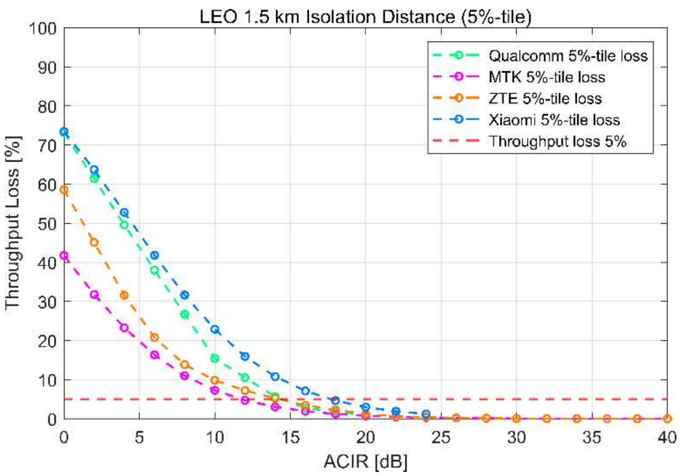

Fig. 2. 5%-tile Throughput Loss vs. ACIR in LEO Scenario

For companies that reported five or more consecutive values, the average ACIR was 14.55 dB in the LEO case and 25.48 dB in the GEO case [6]. By applying the ACS of the NTN UE (33 dB) specified by 3GPP and the ACLR of the TN base station (45 dB), the resulting ACIR indicates that no interference occurs at an isolation distance of 1.5 km in either scenario. However, considering the relatively high SINR characteristics of LEO satellites, this distance may be regarded as a conservative criterion for the LEO case.

III. Simulation Results and Evaluation of Isolation Distance

Based on the assumptions and parameters defined by 3GPP, interference analysis was conducted using a Monte Carlo approach [5].

TABLE I. Throughput Loss of NTN UE in LEO Scenario for Different Deployment Locations

UE deployment location	Throughput loss
2 ISD(1.5 km)	0.216%
TN cluster edge	5.56%
Inside TN cluster	16.49%

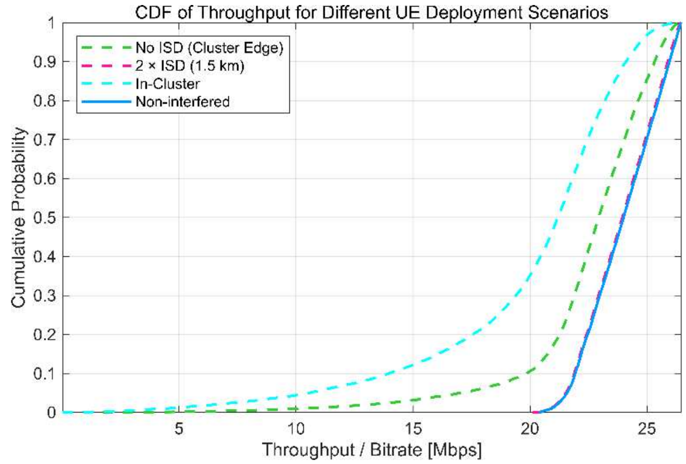

Fig. 3. CDF of Throughput for Different NTN UE Deployment Locations

In the LEO satellite scenario, the NTN UE is assumed to be deployed at three different locations isolation distance, TN cluster edge, and within the TN cluster and the resulting interference levels are compared. Table 1 and Fig. 3 present the throughput loss of the NTN UE for each deployment scenario.

IV. Conclusion

This study investigates the validity of the isolation distance proposed in the 3GPP scenario and analyzes the interference between TN and NTN based on the NTN UE's deployment location under a LEO environment. The simulation results show that there is virtually no interference at an isolation distance of 1.5 km, while throughput losses of 5.96% and 16.49% occur when the NTN UE is deployed at the edge or inside the TN cluster, respectively. These findings indicate that the currently assumed 1.5 km isolation distance is based on conservative assumptions, particularly in the context of LEO deployment.

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