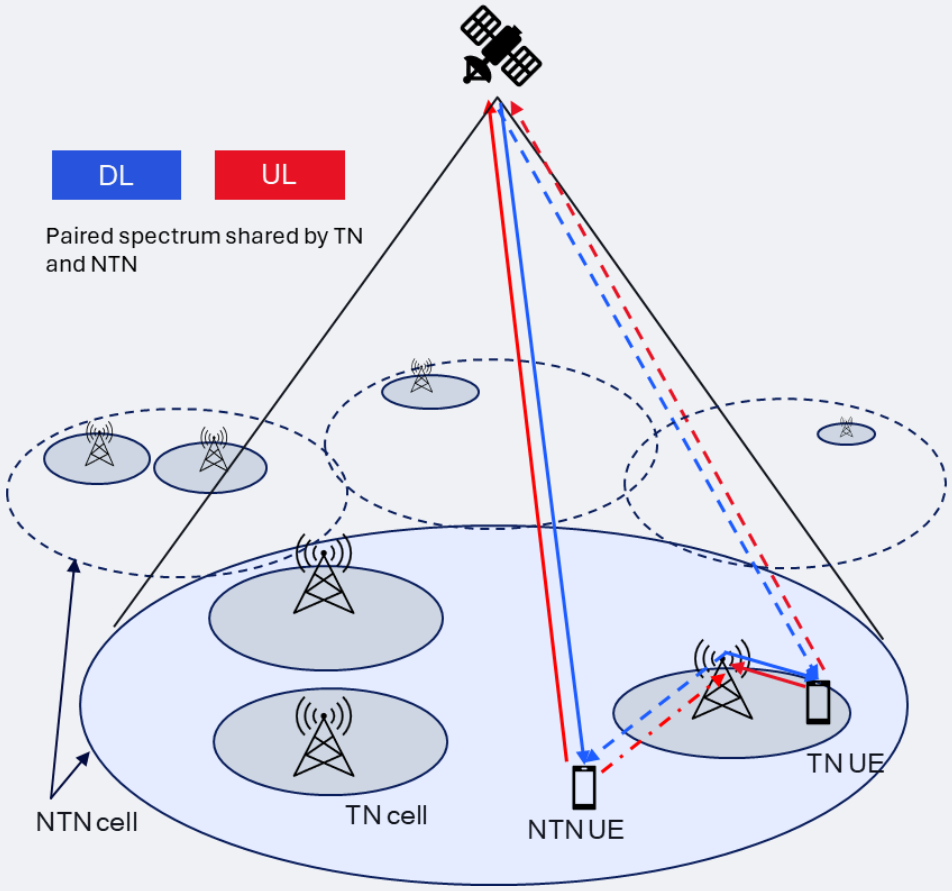
Qualcomm

# NTN-TN Spectrum Sharing Evaluation

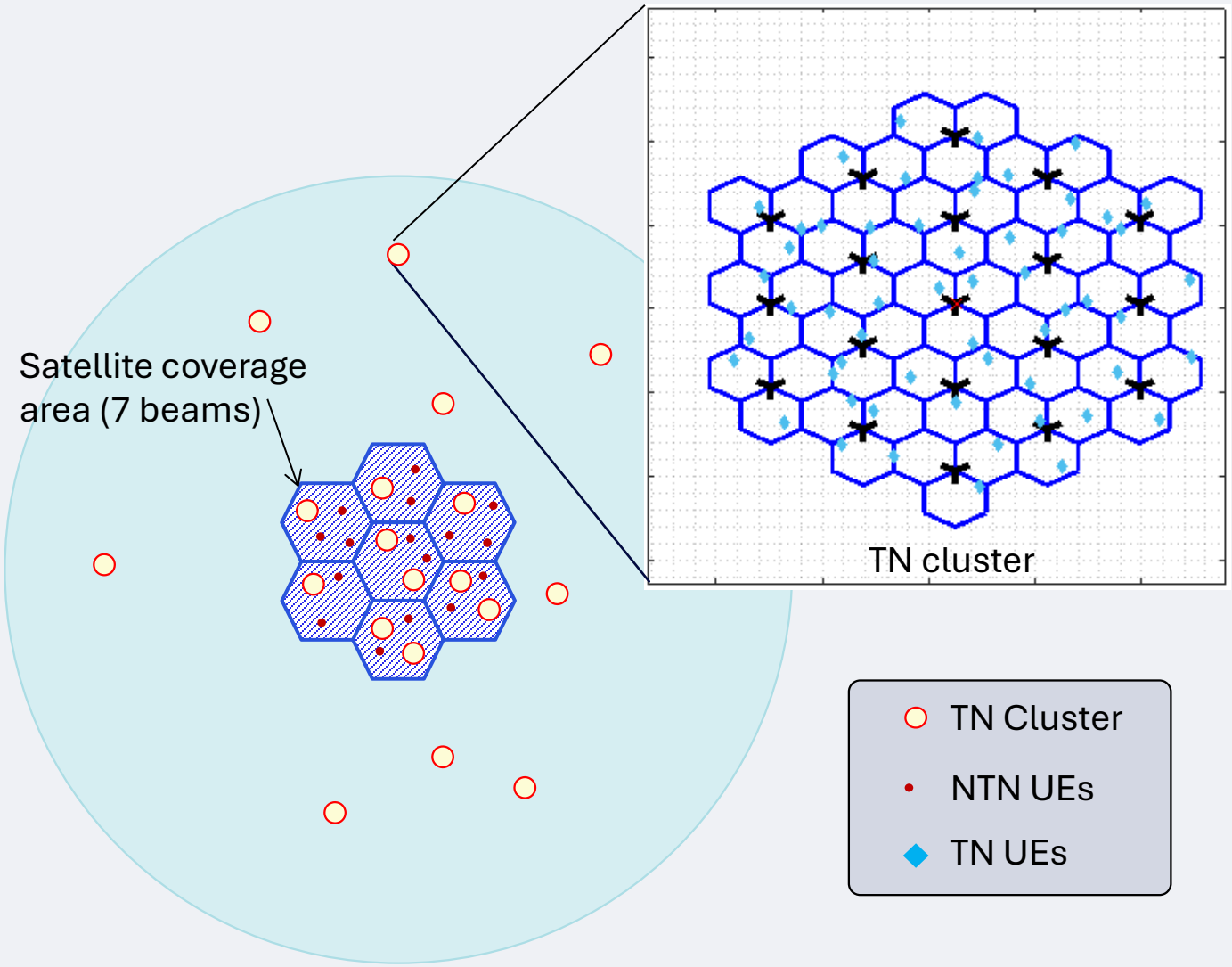
# Objective

- In this study, we evaluate the interference from a terrestrial network (TN) operated by a mobile network operator (MNO) to non-terrestrial network (NTN) operated by a satellite network operator (SNO).
- The NTN provides coverage using satellites in low earth orbits (LEOs).
- We assume that the TN and NTN are co-existing in the same frequency band.
- NTN and TN performance may degrade because of the co-channel interference.
- **In this study, we focus on the impact of TN interference on NTN UL.**




**NTN-TN spectrum sharing: Components of co-channel interference. Solid line indicates serving link, dotted line indicates interfering link.**

# Layout

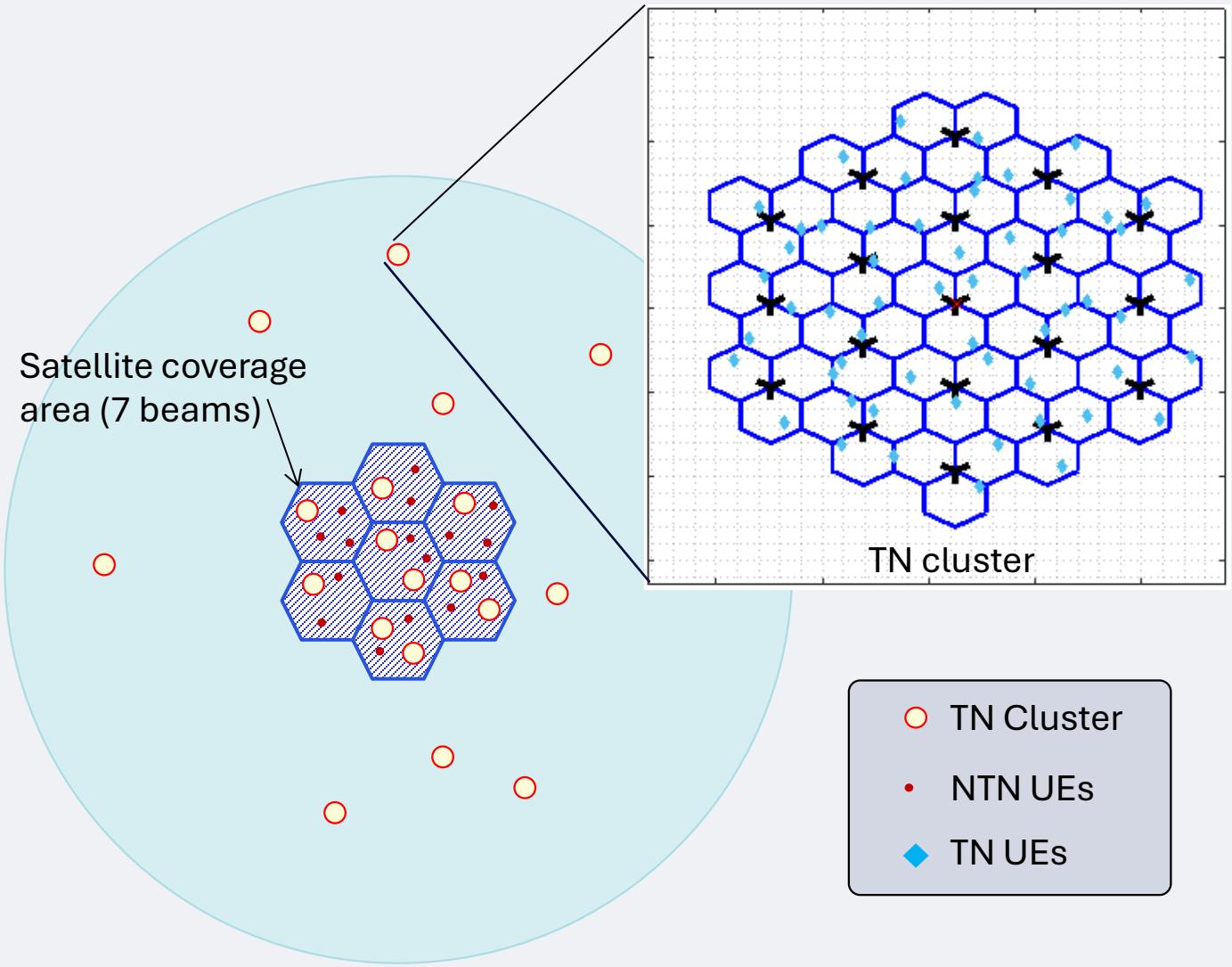



Simulation Region (Circle with 500 km radius)

- Total simulation region is a disk of 500 kms.
- 1 TN cluster = 19 sites (ISD = 500 m), 3 sectors/sites (57 gNBs). Each TN cell has at least 1 TN UE. FRF=1.
- TN clusters are dropped to cover 10% area of the simulation region.
- Satellite coverage area is the union of 7 beams (beam radius = 25 km). FRF =1.
- Each NTN cell (beam) has 10 NTN UEs.

Note: NTN UEs were dropped sufficiently far from TN clusters so that they camp on an NTN cell.

# Layout




Simulation Region (Circle with 500 km radius)

**Satellite Configuration**

| Parameter | Value |
|---|---|
| Satellite Altitude | 600 km |
| Satellite Scenario | NTN-Rural |
| Satellite elevation angle | 90° |
| Carrier Frequency | 2 GHz |
| Satellite Antenna Parameters | See next slide |

**UE Configuration**

| Parameter | Value |
|---|---|
| UE antenna configuration | (1,1,2) |
| UE UL Tx Power | 23 dBm (no power control) |
| UE UL Tx BW | 1 PRB |
| UE antenna element pattern | Omni |

UE drop and grouping: UEs were dropped within and outside TN clusters first, in geometric sense. Then each UE was associated with a cell (TN or NTN cell) based on max DL Rx power. We group the UEs into TN and NTN UEs based on the UE association to a cell which belongs to a TN and NTN, respectively.
**No UL power control was assumed.**

# Antenna Modeling for Satellites

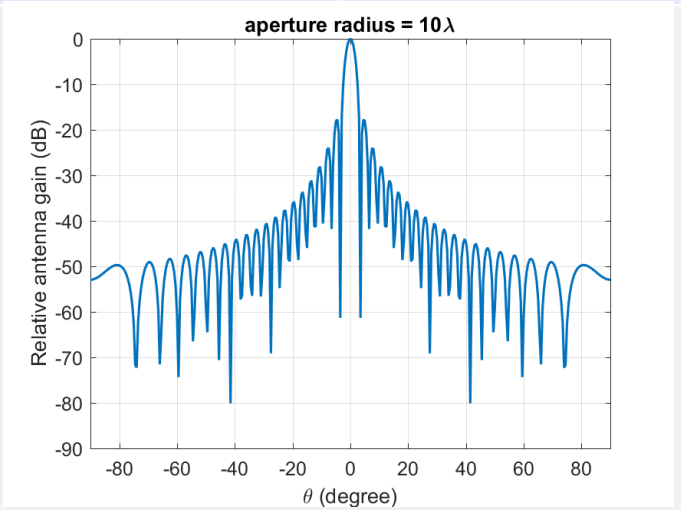
The following normalized antenna gain pattern, corresponding to a typical reflector antenna with a circular aperture, is considered:

$$1\ ;\ \theta = 0$$

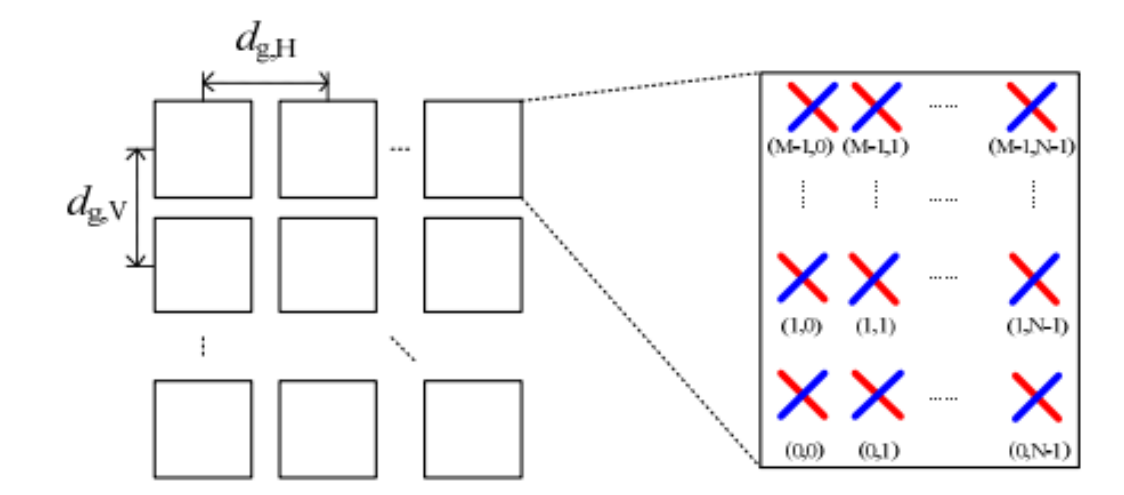
$$4\left|\frac{J_1(k\ a\ \sin\theta)}{k\ a\ \sin\theta}\right|^2\ ;0 < |\theta| \leq 90^o$$

Satellite beams were generated on the UV plane defined in the satellite reference frame by changing the beam boresight directions by beam spacing (See Table 6.1.1.1-4, TR 38.821 for details).

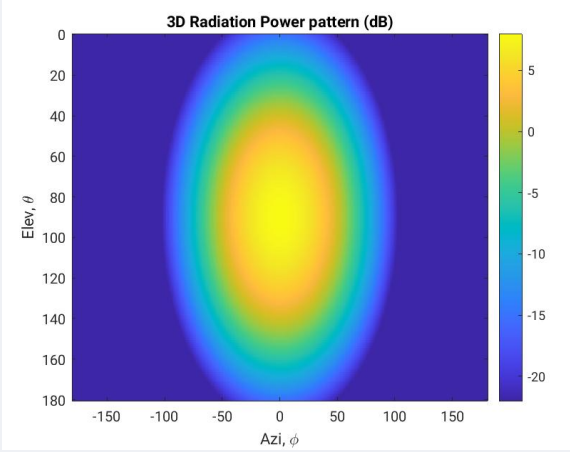
| Satellite Antenna Parameter | Value |
|---|---|
| Polarization | Circular |
| Antenna Pattern | Bessel Function |
| 3dB Beamwidth | 4.41° |
| Antenna Aperture | 2 m |
| G/T | 1.1 dB/K |
| DL EIRP | 34 dBW/MHz |



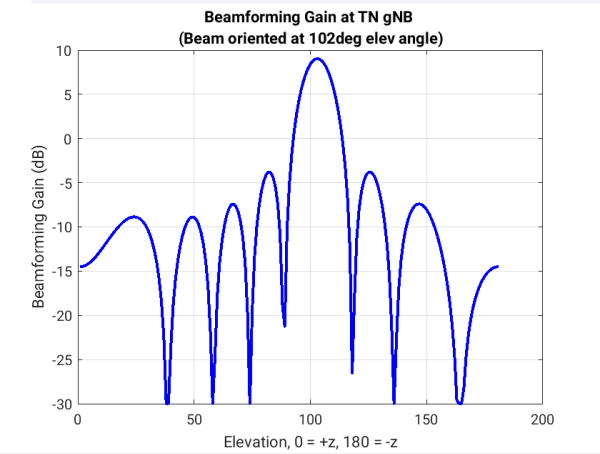
# Antenna Modeling for TN gNBs




**X-pol panel array antenna model**




**Radiation power pattern of a single antenna element**

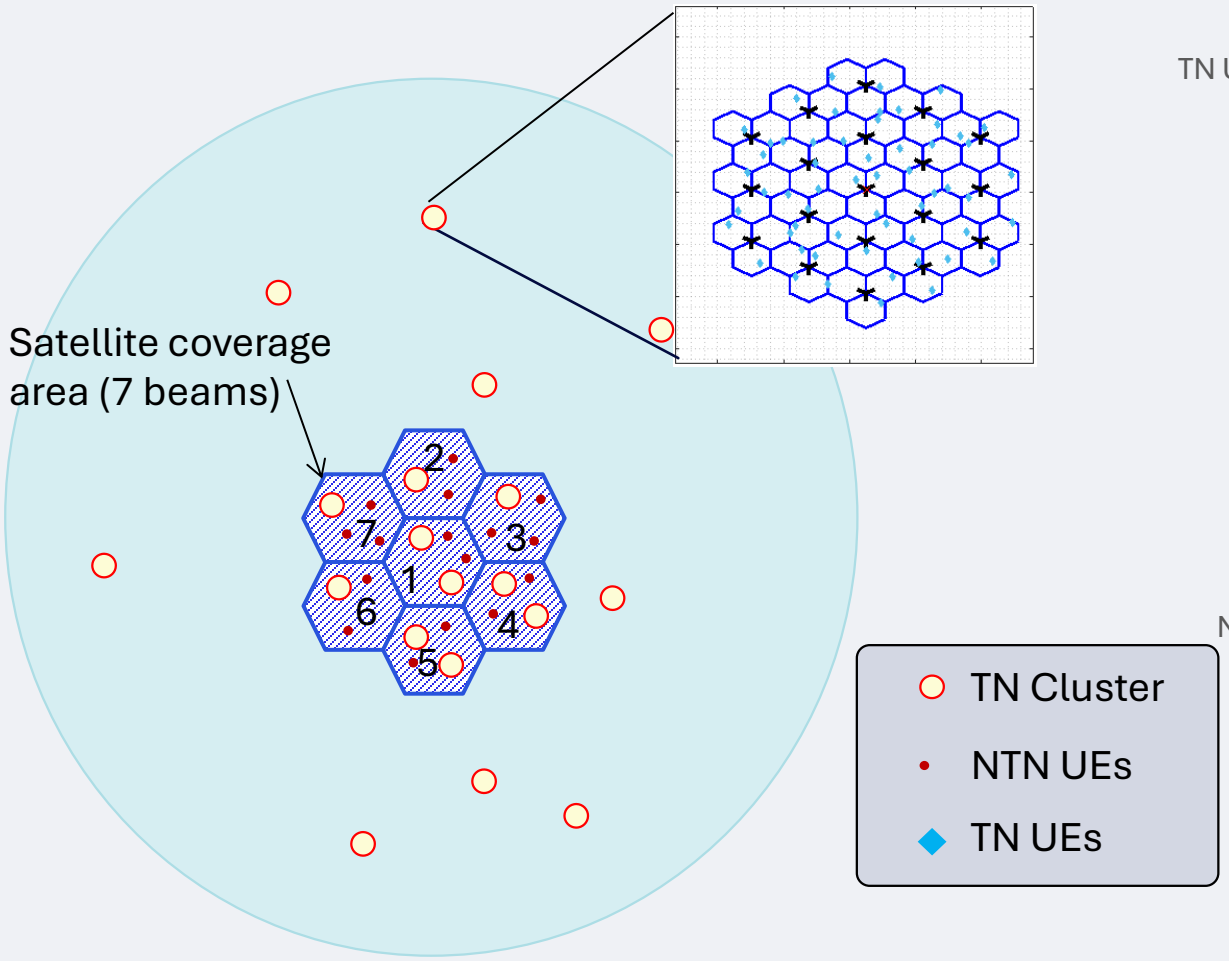



**Composite Beam Pattern of a gNB (downtilt = 102°)**

- The BS antenna is modelled by a uniform rectangular panel array, comprising $M_g N_g$ panels.
- Antenna panels are uniformly spaced in the horizontal direction with a spacing of $d_{g,H}$ and in the vertical direction with a spacing of $d_{g,V}$
- On each antenna panel, antenna elements are placed in the vertical and horizontal direction, where $N$ is the number of columns, $M$ is the number of antenna elements with the same polarization in each column.
- The antenna elements are uniformly spaced in the horizontal direction with a spacing of $d_H$ and in the vertical direction with a spacing of $d_V$.
- The antenna panel is either single polarized ($P = 1$) or dual polarized ($P = 2$). The rectangular panel array antenna can be described by the following tuple $(M_g, N_g, M, N, P)$.
- Each panel has a mechanical and electrical downtilt.

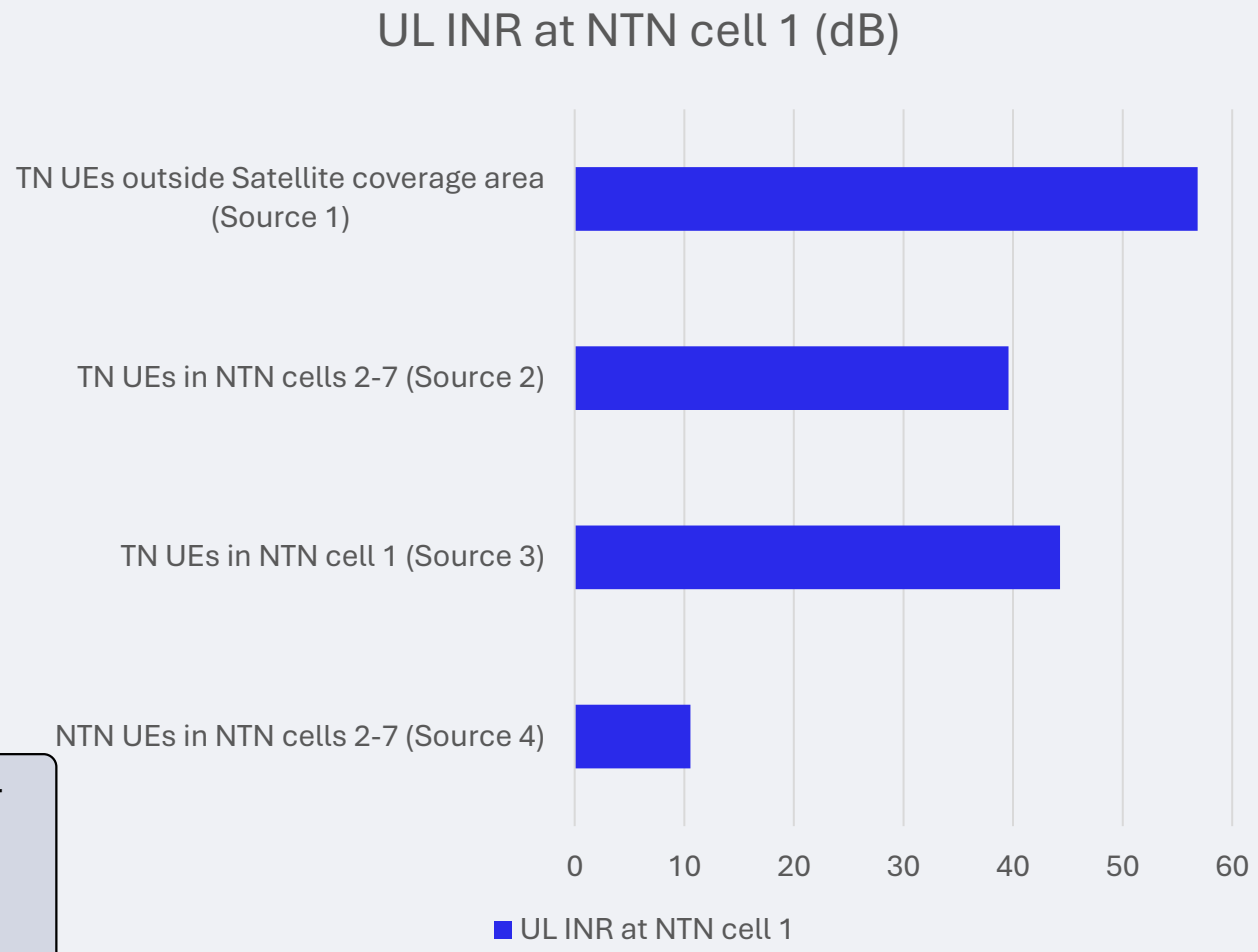
| TN gNB antenna Parameter | Value |
|---|---|
| $(M_g, N_g, M, N, P)$ | (1,1,1,8,2) |
| Downtilt Angle (mech, elec) | (0,102)° |
| Noise Figure | 5 dB |
| Tx Power | 46 dBm/10 MHz |

# Interference Analysis



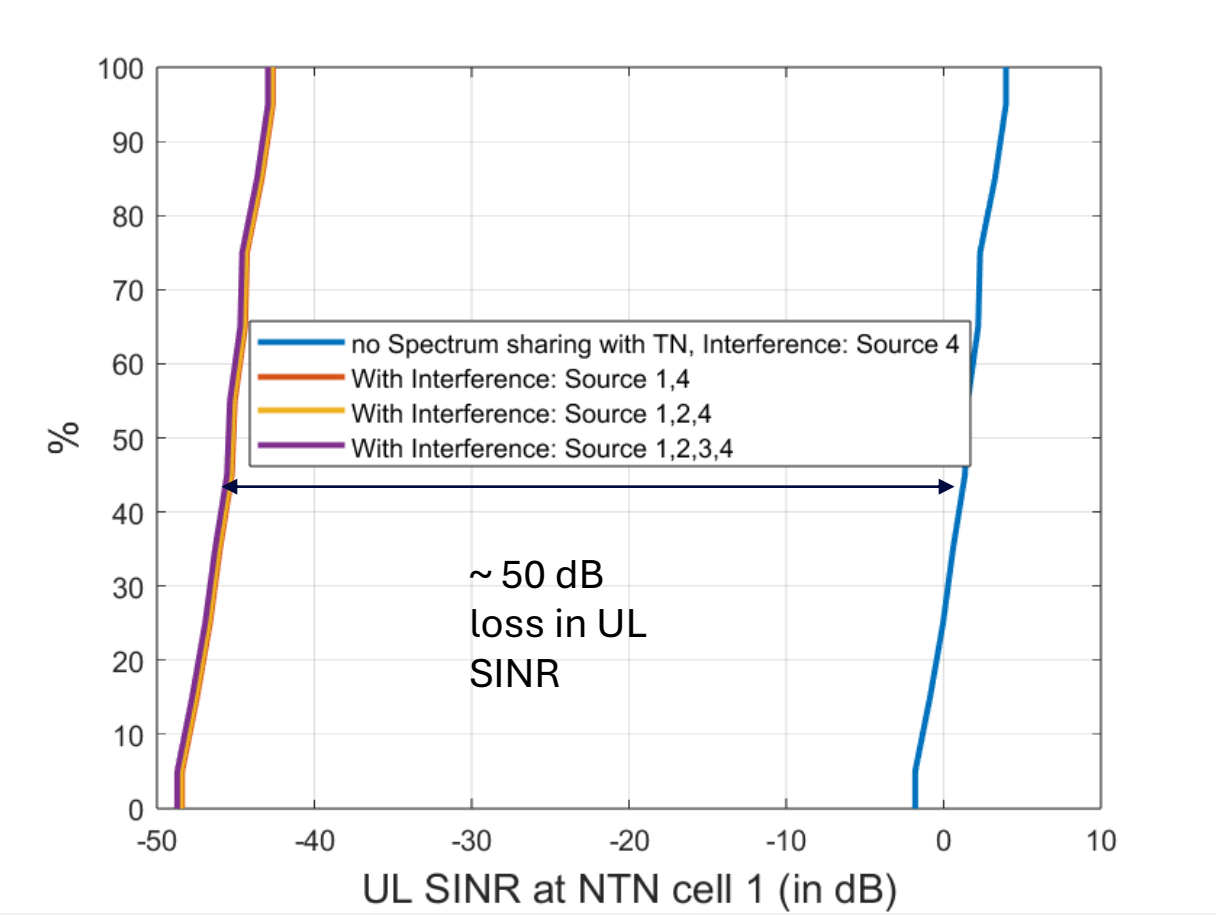

Simulation Region (Circle with 500 km radius)

**Note:** TN cluster location in this figure is for illustration purpose only. TN clusters were dropped in a way that they are non-overlapping and covers roughly 10% of the simulation region.




**Most Severe Interference source:** TN UEs outside satellite coverage area (union of 7 NTN cells). Note that between NTN cell 1 and the TN UE group (source 1), there is a 50 km buffer zone.

# SINR Analysis




We observe that the TN UEs lying outside the NTN coverage region (Source 1) causes roughly 50 dB loss in UL SINR observed at NTN cell 1.

**Conclusion 1: Based on the assumptions in this document, spectrum Sharing between NTN and TN may cause significant degradation of NTN UL performance.**

**Conclusion 2: The major contributor to the TN interference is the aggregate interference from TN UEs lying far away from the NTN cell.**

Actual amount of interference will depend on the TN cell size, TN cell density within satellite coverage, and load conditions in each cell. Furthermore, UL power control, satellite antenna pattern will affect TN UL interference statistics.