3GPP TSG RAN WG1 Meeting #104e R1-210XXXX

April 12th – April 20th, 2021

Agenda Item: 8.15.1

Source: Moderator (MediaTek)

Title: Summary #1 of AI 8.15.1 Scenarios applicable to NB-IoT/eMTC

Document for: Discussion and Decision

# Introduction

At the RAN#86 meeting, a new Study Item was approved for IoT Non Terrestrial Network (NTN) and revised in RAN#91 [1]. There was an email discussion on [91E][42][NTN\_IoT\_Roadmap] In RAN#91 with moderator summary and final proposal for GTW input in [2].

In RAN#91-e GTW session, the Chairman endorsed a Way Forward Proposal in [3] on email discussion on [50][New\_proposals\_approval]. This included guidance from RAN Chairman for NTN NR and NTN IoT as follows

* *RAN#92E (June) to finalize the scope and project plan to deliver the essential minimum functionality of both NTN NR and NTN IoT (both NB-IoT and eMTC) within the existing TU allocations*
* *Detailed scoping exercise (NTN NR WID revision, NTN IoT WID approval) to be undertaken at RAN#92E (June)*

In this meeting, company views on scenarios applicable to NB-IoT/eMTC are summarized and observations/proposals on identified issues are made. Observations and proposals in Company’s TDoc contributions are listed in the Appendix.

# Link Budget Calibration

The following agreements were made in RAN1#104e.

Agreement:

The following assumptions are agreed for a common set of link budget parameters:

* UE power class (PC5=20 dBm)
* UE Noise Figure (NF=9 dB)
* Channel Bandwidth for NB-IoT and eMTC as was included in IoT NTN reference scenario parameters agreed in RAN1#103e
  + NB-IoT 180 kHz (DL), Up to 180 kHz with all permissible smaller resource allocations 12\*15 kHz, 6\*15 kHz, 3\*15 kHz, 1\*15 kHz, 1\*3.75 kHz
  + eMTC: 1080 kHz (DL), Up to 1080 kHz with all permissible smaller resource allocations, including 2\*180 kHz, 180 kHz, 2\*15 kHz or 3\*15 kHz or 6\*15 kHz (UL)
* Other losses

|  |  |  |  |
| --- | --- | --- | --- |
| Other Losses | GEO (35786 km) | LEO (1200 km) | LEO (600 km) |
| Scintillation losses | 2.2 | 2.2 | 2.2 |
| Atmospheric losses | 0.2 | 0.1 | 0.1 |
| Polarization loss | 3 | 3 | 3 |
| Shadow margin | 3 | 3 | 3 |

NOTE 1: With PC3 (23 dBm) there is a 3dB gain compared to the PC5 (20 dBm) assumption on UL.

NOTE 2: With NF=7 dB, there is a 2 dB improvement compare to NF=9 dB on DL.

NOTE 3: Link budgets with other link budget parameters are not excluded from being captured in the TR.

NOTE 4: These parameters are only for the purpose of link budget calculations.

NOTE 5: Atmospheric losses are a function of elevation angle.

Agreement:

Link budget analysis assumes 3 dB polarization loss for DL and 3 dB polarization loss on UL for satellite parameters Set 1, Set 2, Set 3, and Set 4

Agreement:

Include in TR 36.763, the 3 dB beam width (HPBW), central beam center elevation and central beam edge elevation in the satellite parameter set(s) to be used in link budget calculations – (Corresponding satellite parameter Set 3 and Set 4 are given in Section 9.4)

|  |  |  |  |
| --- | --- | --- | --- |
| SET 3 | GEO 35786 km | LEO-600 km | LEO-1200 km |
| 3 dB Beam width (HPBW) | 0.735 degree | 22.0631 degree | 22.0631 degree |
| Central beam center elevation | 20.88 degree | 43.78 degree | 46.05 degree |
| Central beam edge elevation | 12.5 degree | 30 degree | 30 degree |
| Central beam edge satellite-UE distance | 40316 km | 1074 km | 1998 km |

|  |  |
| --- | --- |
| SET 4 | LEO-600 km |
| 3 dB Beam width (HPBW) | 104.7 degree |
| Central beam center  elevation | 90 degree |
| Central beam edge elevation | 30 degree |
| Central beam edge satellite-UE distance | 1076 km |

NOTE 1: The 3 dB beam width (HPBW)  is already included in satellite parameter set 1 and Set 2 in TR 38.821 Table 6.1.1.1-1 and Table 6.1.1.1-2  respectively. The central beam center elevation  for Set-1 and Set-2 is defined as the target elevation angle that is included in in TR 38.821 Table 6.1.3.2-1.   The central beam edge satellite-UE distance can be derived from the central beam edge elevation and does not need to be included.

NOTE 2: Central beam center elevation is the beam center elevation of the central beam in the beam layout.

NOTE 3: Central beam edge elevation is the minimum beam edge elevation of the central beam in the beam layout.

NOTE 4 In SLS evaluation with a multiple beam layout, the central beam is the serving beam for UEs. The outer beams have beam center elevation that is different from the central beam center elevation.  For the interference modelling, the interference due to the outer beams is determined by using their respective beam center elevations.

NOTE 5: For the multiple-beam satellite cell, the longest beam edge distance will correspond to the minimum beam edge elevation of the most outer beam as illustrated in figure below.



Agreement:

Include the following tables in TR 36.763:

* Set 1 satellite parameters (based on TR 38.821, Table 6.1.1.1-1)
* Set 2 satellite parameters (based on TR 38.821, Table 6.1.1.1-2)
* Set 3 satellite parameters (Eutelsat R1-2101146 with central beam edge elevation 12.5 degree for GEO, and 30 degree for LEO-600 km and 1200 km)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Satellite orbit | | GEO | LEO-1200 | LEO-600 |
| Satellite altitude | | 35786 km | 1200 km | 600 km |
| Central beam edge elevation | | 12.5 degree | 30 degree | 30 degree |
| Central beam center elevation | | 20.9 degree | 46.05 degree | 43.8 degree |
| Payload characteristics for DL transmissions | | | | |
| Equivalent satellite antenna aperture (NOTE 1) | S-band  (i.e. 2 GHz) | 12 m | 0.4m | 0.4 m |
| Satellite EIRP density | 59.8 dBW/MHz | 33.7 dBW/MHz | 28.3 dBW/MHz |
| Satellite Tx max Gain | 45.7 dBi | 16.2 dBi | 16.2 dBi |
| 3dB beam width (HPBW) | 0.7353 degree | 22.1 degree | 22.1 degree |
| Satellite beam diameter (NOTE 2) | 459km | 470 km | 234 km |
| Payload characteristics for UL transmissions | | | | |
| Equivalent satellite antenna aperture (NOTE 1) | S-band  (i.e. 2 GHz) | 12 m | 0.4 m | 0.4 m |
| G/T | 16.7dB K-1 | -12.8 dB K-1 | -12.8 dB K-1 |
| Satellite Rx max Gain | 45.7 dBi | 16.2 dBi | 16.2 dBi |

NOTE 1: This value is equivalent to the antenna diameter in Sec. 6.4.1 of TR 38.811

NOTE 2: Satellite beam diameter is at Nadir point

NOTE 3: Central beam center elevation is referred to as central beam elevation in TR 38.821

NOTE 4: Central beam edge elevation is the minimum beam edge elevation of the central beam in the beam layout.

* Set 4 satellite parameters (Thales, Sateliot, Gatehouse R1-2101019)

|  |  |  |
| --- | --- | --- |
| Satellite orbit | | LEO-600 |
| Satellite altitude | | 600 km |
| Central beam edge elevation | | 30 degree |
| Central beam center elevation | | 90 degree |
| Payload characteristics for DL transmissions | | |
| Equivalent satellite antenna aperture (NOTE 1) | S-band  (i.e. 2 GHz) | 0.097 m |
| Satellite EIRP density | 21.45 dBW/MHz |
| Satellite Tx max Gain | 11 dBi |
| 3dB beam width (HPBW) | 104.7 degree |
| Satellite beam diameter (Note 2) | 1700 km |
| Payload characteristics for UL transmissions | | |
| Equivalent satellite antenna aperture (Note1) | S-band  (i.e. 2 GHz) | 0.097 m |
| G/T | - 18.6 dB·K-1 |
| Satellite Rx max Gain | 11 dBi |

NOTE 1: This value is equivalent to the antenna diameter in Sec. 6.4.1 of TR 38.811

NOTE 2: Satellite beam diameter is at Nadir point

NOTE 3: Central beam center elevation is referred to as central beam elevation in TR 38.821

NOTE 4: Central beam edge elevation is the minimum beam edge elevation of the central beam in the beam layout.

Agreement:

Include in TR 36.763, the 3 dB beam width (HPBW), central beam center elevation and central beam edge elevation in the satellite parameter set(s) to be used in link budget calculations – (Corresponding satellite parameter Set 3 and Set 4 are given in Section 9.4)

|  |  |  |  |
| --- | --- | --- | --- |
| SET 3 | GEO 35786 km | LEO-600 km | LEO-1200 km |
| 3 dB Beam width (HPBW) | 0.735 degree | 22.0631 degree | 22.0631 degree |
| Central beam center elevation | 20.88 degree | 43.78 degree | 46.05 degree |
| Central beam edge elevation | 12.5 degree | 30 degree | 30 degree |
| Central beam edge satellite-UE distance | 40316 km | 1074 km | 1998 km |

|  |  |
| --- | --- |
| SET 4 | LEO-600 km |
| 3 dB Beam width (HPBW) | 104.7 degree |
| Central beam center  elevation | 90 degree |
| Central beam edge elevation | 30 degree |
| Central beam edge satellite-UE distance | 1076 km |

NOTE 1: The 3 dB beam width (HPBW)  is already included in satellite parameter set 1 and Set 2 in TR 38.821 Table 6.1.1.1-1 and Table 6.1.1.1-2  respectively. The central beam center elevation  for Set-1 and Set-2 is defined as the target elevation angle that is included in in TR 38.821 Table 6.1.3.2-1.   The central beam edge satellite-UE distance can be derived from the central beam edge elevation and does not need to be included.

NOTE 2: Central beam center elevation is the beam center elevation of the central beam in the beam layout.

NOTE 3: Central beam edge elevation is the minimum beam edge elevation of the central beam in the beam layout.

NOTE 4 In SLS evaluation with a multiple beam layout, the central beam is the serving beam for UEs. The outer beams have beam center elevation that is different from the central beam center elevation.  For the interference modelling, the interference due to the outer beams is determined by using their respective beam center elevations.

NOTE 5: For the multiple-beam satellite cell, the longest beam edge distance will correspond to the minimum beam edge elevation of the most outer beam as illustrated in figure below.



## Link budget results summary

Link budget results were provided by Huawei, OPPO, Vivo, CATT, MediaTek, Nokia, CMCC, ZTE, Xiaomi, Ericsson, Qualcomm, Apple, Samsung, Sony, Sateliot

Huawei observed the worst CNR for the four sets of satellites are around -12 dB, -16 dB, -13dB and -17dB, respectively.

OPPO showed cdf of CIR for Set 1, Set 2, set 3. The set 3 has lowest CIR, with 5% percentile at -5 dB.

**Table 4. CIR results for both DL and UL in Satellite set 3**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | Ave. | 5% | 50% | 95% |
| DL | Scenario A  (GEO) | 2.0 | -2.1 | 1.9 | 6.1 |
| Scenario B&C-600km  (LEO-600) | -0.8 | -3.7 | -0.9 | 2.2 |
| Scenario B&C-1200km  (LEO-1200) | -1.0 | -3.9 | -1.0 | 1.7 |
| UL | Scenario A  (GEO) | 2.4 | -1.9 | 1.9 | 8.1 |
| Scenario B&C-600km  (LEO-600) | -2.7 | -4.8 | -2.8 | -0.5 |
| Scenario B&C-1200km  (LEO-1200) | -2.7 | -5.0 | -2.7 | -0.2 |

|  |  |
| --- | --- |
|  |  |
| 1. **GEO** | 1. **LEO-600** |
|  | |
| 1. **LEO-1200** | |

**Figure 3. CIR results for both DL and UL in Satellite set 3**

Vivo observed device antenna with 0 dBi gain assumption is optimistic for link budget calculations, lower antenna gain can be considered for the worst case, e.g. -5dBi.

CATT recommended smaller uplink transmission bandwidth for larger UL CNR when channel condition is poor. CNR in some cases reached below -20dB. Further consider whether we need to support the case with -20 dB CNR.

MediaTek commented that NB-IoT can support the observed SNR UL and DL with moderate level of repetitions consistent with MCL=154 dB. MediaTek, Samsung results show lowest SNR observed are for Set 4 with -12 dB on DL and -2.4 dB or -8.5 dB (ST with SCS=3.75 kHz or 15 kHz) on UL.

Nokia observed CNR is reduced as the channel bandwidth increases. CNR is reduced about 15.5 dB if the channel bandwidth increases from 30 kHz to 1080 kHz in uplink of eMTC. CNR of NB-IoT decreases about 16.8 dB when the channel bandwidth increases from 3.75 kHz to 180 kHz. Sets 1 and 2 results in positive maximum CNR (for NB-IoT), while set 3 and especially set 4 have challenging link budgets with low CNR.

CMCC observed that: For GEO with Set 2 satellite parameter, the UL CNR will reach -18.8dB level for NB-IoT with 180kHz BW, and reach -26.5dB level for eMTC with 1080kHz BW. For LEO at 1200km with Set 3 satellite parameter, the UL CNR will reach -17.4dB level for NB-IoT with 180kHz BW, and reach -25.2dB level for eMTC with 1080kHz BW. For LEO at 600km with Set 4 satellite parameter, the UL CNR will reach -14.9dB level for NB-IoT with 180kHz BW, and reach -22.7dB level for eMTC with 1080kHz BW. Additional path loss can be observed in some deployment scenarios – i.e Carriage and container penetration loss (9~20 dB) for logistics application; Vegetation loss (e.g., 9 dB) for outdoor application.

ZTE observed in all the cases, the coupling loss would be less than 164 dB, but in some cases of Set-3 LEO-1200 and Set-4 LEO-600, the coupling loss would be larger than 159 dB. CDFof CL DL and UL were provided. A large number of UEs would experience a worse coupling loss larger than 164 dB for urban and dense urban scenarios. For rural scenario, there are about 5% UEs which experience coupling loss larger than 164 dB. Further enhancement on the transmission may be needed to support cases with large coupling loss and/or low CNR.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | GEO | LEO-600 | LEO-1200 |
| Set-1 | Coupling loss (dB) | 151.04 | 140.99 | 146.39 |
| Set-2 | Coupling loss (dB) | 156.50 | 147.71 | 153.15 |
| Set-3 | Coupling loss (dB) | 156.24 | 154.16 | 159.55 |
| Set-4 | Coupling loss (dB) |  | 159.38 |  |

|  |  |
| --- | --- |
|  |  |
| Figure 1 Illustration of DL CL for GEO in rural | Figure 2 Illustration of DL CL for LEO-600 in rural |
|  |  |
| Figure 3 Illustration of DL CL for LEO-1200 in rural |  |
|  |  |
| Figure 4 Illustration of DL CL for GEO in ubran | Figure 5 Illustration of DL CL for LEO-600 in urban |
|  |  |
| Figure 6 Illustration of DL CL for LEO-1200 in urban |  |
|  |  |
| Figure 7 Illustration of DL CL for GEO in Dense urban | Figure 8 Illustration of DL CL for LEO-600 in Dense urban |
|  |  |
| Figure 9 Illustration of DL CL for LEO-1200 in Dense urban |  |

Xiaomi observed that low CNR is observed on the UL with maximum channel bandwidth is used, e.g, 180 kHz for NB-IoT and 1080 kHz for eMTC.

Ericsson observed that Set 1 typically has the most favourable link budget results whereas Set 4 has the most challenging link budgets

Qualcomm observed the uplink SNRs reduce significantly, which could make providing coverage at certain (especially low) elevation angles—e.g., those corresponding to the beam-edge, challenging. For Set 3, the uplink SNRs that are achievable will be lower than that in Set 2. At the edge of the beam approach -20 dB in Set 4, which could make providing coverage at these (low) elevation angles—e.g., those corresponding to the beam-edge—significantly challenging. A 15 kHz numerology and a full (one) PRB transmission (in the uplink) was used in the link budget results. Apple has similar obervations with full RB used on UL.

|  |  |  |
| --- | --- | --- |
| **Elevation Angle = 30 Degrees** | **Set 2** | **Set 3** |
| Uplink SNR (dB) @1200 km | -11.5 | **-19.4** |
| Uplink SNR (dB) @600 km | -6.2 | **-14** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Elevation Angle**  **= 30 Degrees** | **Set 2** | **Set 3** | **Set 4** |
| Uplink SNR (dB) @600 km | -6.2 | -14 | **-19.9** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Elevation Angle**  **= 30 Degrees** | **Set 2** | **Set 3** | **Set 4** |
| Downlink SNR (dB) @600 km | -4.3 | -4.3 | **-10.9** |

Sony proposed to prioritize link budget study for PC3 devices (23dBm) with 7dB noise figure. An AWGN channel model is assumed for IoT-NTN link level simulations.

Sateliot showed lowest SNR DL -13.98 dB and SNR UL -6.16 dB and best SNR DL 1.09 dB and SNR UL 6.19 dB for Set 4.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Configuration A**  (Based on common assumptions in TR 36.763 v0.1.0 section 6.2.1) | **Configuration B**  (common assumptions + some enhancements) |
| **Downlink SNR** | Elevation angle=90º | -5.91 dB | 1.09 dB |
| Elevation angle=30º | -13.98 dB | -6.98 dB |
| **Uplink SNR**  **(ST 3.75 kHz)** | Elevation angle=90º | 1.90 dB | 6.90 dB |
| Elevation angle=30º | -6.16 dB | -1.16 dB |

Moderator view is that there is reasonable consistency in link budget results and observations from contributing companies. The above summary of company contributions on link budget can be captured in a TP to TR 36.763.

***Initial proposal – Section 2.1-2***

* ***Capture in TR 36.763 the summary of link budget results from contributing companies in Section 2.1-2***

## Cases for link budget analysis

ZTE propose to capture cases for link budget analysis

***Initial proposal – Section 2.2***

* ***Capture in TR 36.763 the Table for cases for link budget analysis***

Table for Cases for link budget analysis

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Case*** | ***Satellite orbit*** | ***Satellite parameter set*** | ***Central beam center elevation (deg)*** | ***Central beam edge elevation (deg)*** | ***Frequency Reuse Factor*** |
| **1** | ***GEO*** | ***Set 1*** | ***12.5*** | ***10*** | ***1*** |
| **2** | ***GEO*** | ***Set 1*** | ***12.5*** | ***10*** | ***3*** |
| **3** | ***LEO-600*** | ***Set 1*** | ***30*** | ***26.98*** | ***1*** |
| **4** | ***LEO-600*** | ***Set 1*** | ***30*** | ***26.98*** | ***3*** |
| **5** | ***LEO-1200*** | ***Set 1*** | ***30*** | ***26.27*** | ***1*** |
| **6** | ***LEO-1200*** | ***Set 1*** | ***30*** | ***26.27*** | ***3*** |
| **7** | ***GEO*** | ***Set 2*** | ***20*** | ***10.95*** | ***1*** |
| **8** | ***GEO*** | ***Set 2*** | ***20*** | ***10.95*** | ***3*** |
| **9** | ***LEO-600*** | ***Set 2*** | ***30*** | ***23.80*** | ***1*** |
| **10** | ***LEO-600*** | ***Set 2*** | ***30*** | ***23.80*** | ***3*** |
| **11** | ***LEO-1200*** | ***Set 2*** | ***30*** | ***22.16*** | ***1*** |
| **12** | ***LEO-1200*** | ***Set 2*** | ***30*** | ***22.16*** | ***3*** |
| **13** | ***GEO*** | ***Set 3*** | ***20.88*** | ***12.5*** | ***1*** |
| **14** | ***GEO*** | ***Set 3*** | ***20.88*** | ***12.5*** | ***3*** |
| **15** | ***LEO-600*** | ***Set 3*** | ***43.78*** | ***30*** | ***1*** |
| **16** | ***LEO-600*** | ***Set 3*** | ***43.78*** | ***30*** | ***3*** |
| **17** | ***LEO-1200*** | ***Set 3*** | ***46.05*** | ***30*** | ***1*** |
| **18** | ***LEO-1200*** | ***Set 3*** | ***46.05*** | ***30*** | ***3*** |
| **19** | ***LEO-600*** | ***Set 4*** | ***90*** | ***30*** | ***1*** |

## Detailed link budget results

The detailed link budget results from contributing companies are included in Appendix 1

***Initial proposal – Section 2.3***

* ***Capture the detailed link budget results from contributing companies in Appendix 1 in TR 36.763***

# IoT NTN Scenarios

## Scenario C – LEO Set 4

Sateliot proposed to revise the “Max beam footprint size (edge to edge) regardless of the elevation angle” parameter for LEO scenarios indicated in 3GPP TR 36.763 V0.1.0 Table 6.1-1: “IoT NTN reference scenario parameters” to 1700 km (currently the parameter is set to 1000 km for LEO scenarios).

Moderator view is to revise the “Max beam footprint size (edge to edge) for LEO scenarios indicated in 3GPP TR 36.763 V0.1.0 Table 6.1-1: “IoT NTN reference scenario parameters” to 1700 km (currently the parameter is set to 1000 km for LEO scenarios). This is to align with Table 6.2-7: Set-4 satellite parameters for system level simulator calibration in TR 37.763 V0.1.0 which indicates Satellite beam diameter 1700 km.

***Initial proposal – Section 3.1***

* ***Revise the “Max beam footprint size (edge to edge) for LEO scenarios indicated in 3GPP TR 36.763 V0.1.0 Table 6.1-1: “IoT NTN reference scenario parameters” to 1700 km***

## Scenario D – MEO

Echostar / HUGUES made the following proposals and observation for a new scenario D for MEO

***Proposal 1****: To add MEO scenario D in Table 4.2-1 in TR 36.763.*

|  |  |
| --- | --- |
| NTN Configurations | Transparent satellite |
| GEO based non-terrestrial access network | Scenario A |
| LEO based non-terrestrial access network generating steerable beams (altitude 1200 km and 600km) | Scenario B |
| LEO based non-terrestrial access network generating fixed beams whose footprints move with the satellite (altitude 1200 km and 600km) | Scenario C |
| MEO based non-terrestrial access network generating fixed beams whose footprints move with the satellite (altitude 10000 km) | Scenario D |

*Table 4.2-1: IoT NTN reference scenarios*

***Proposal 2****: To add MEO IoT NTN reference scenario parameters in Table 6.1-1 in TR 36.763.*

|  |  |  |  |
| --- | --- | --- | --- |
| Scenarios | **GEO based non-terrestrial access network - scenario A** | **LEO based non-terrestrial access network -Scenario B & C** | **MEO based non-terrestrial access network -Scenario D** |
| Orbit type | station keeping a nominally fixed position in terms of elevation/azimuth with respect to a given earth point | circular orbiting at low altitude around the earth | circular orbiting at low altitude around the earth |
| Altitude | 35,786 km | 600 km  1,200 km | 10,000 km |
| Frequency Range | < 6 GHz (e.g. 2 GHz in S band) | | |
| Device channel Bandwidth (service link) (NOTE 7) | - NB-IoT 180 kHz (DL), Up to 180 kHz with all permissible smaller resource allocations 12\*15 kHz, 6\*15 kHz, 3\*15 kHz, 1\*15 kHz, 1\*3.75 kHz (UL)  - eMTC: 1080 kHz (DL), Up to 1080 kHz with all permissible smaller resource allocations, including 2\*180 kHz, 180 kHz, 2\*15 kHz or 3\*15 kHz or 6\*15 kHz (UL) | | |
| Payload | Transparent type | Transparent Type | Transparent type |
| Earth-fixed beams | Yes | Scenario B:  Yes (steerable beams), see NOTE 1  Scenario C: No (the beams move with the satellite) | Scenario D: The beams move with the satellite |
| Max beam footprint size (edge to edge) regardless of the elevation angle | 3500 km (NOTE 3) | 1000 km (NOTE 2) | 4018 km |
| Min Elevation angle for both sat-gateway and C-IoT device | 10° for service link and 10° for feeder link | 10° for service link and 10° for feeder link | 10° for service link and 5° for feeder link |
| Max distance between satellite and C-IoT device at min elevation angle | 40,581 km | 1,932 km (600 km altitude)   3,131 km (1,200 km altitude) | 14018 km |
| Max Round Trip Delay (propagation delay only) | 541.46ms (service and feeder links) | 25.77 ms (600km) (service and feeder links)  41.77 ms (1200km) (service and feeder links) | 95.19 ms (service and feeder links) |
| Max differential delay within a cell | 10.3 ms | 3.12 ms and 3.18 ms for respectively 600km and 1200km | 13.4 ms |
| Max Doppler shift (earth fixed user equipment) (NOTE 6) | 0.93 ppm | 24 ppm (600km)   21ppm(1200km) | 7.5 ppm |
| Max Doppler shift variation (earth fixed user equipment) (NOTE 6) | 0.000 045 ppm/s | 0.27 ppm/s (600km)    0.13 ppm/s (1200km) | 0.003 ppm/s |
| C-IoT device motion on the earth | Min 0 km/s (stationary device), max 120 km/h | Min 0 km/s (stationary device), max 120 km/h | Min 0 km/s (stationary device), max 120 km/h |
| C-IoT device antenna types | Omnidirectional antenna with 0 dBi TX antenna gain and 0 dBi RX antenna gain (NOTE 4) | | |
| C-IoT device max Tx power | UE power class 3 with up to 200 mW (23dBm), UE power class 5 with up to 100 mW (20 dBm) | | |
| C-IoT device Noise Figure | Omnidirectional antenna: 7 dB or 9 dB (NOTE 5) | | |
| Service link | 3GPP defined Narrow Band IoT and eMTC | | |
| NOTE 1: Each satellite has the capability to steer beams **towards fixed points on earth** using beamforming techniques. This is applicable for a period of time corresponding to the visibility time of the satellite.  NOTE 2: This beam size refers to the Nadir pointing of the satellite.  NOTE 3: The Maximum beam footprint size for GEO is based on current state of the art GEO High Throughput systems, assuming either spot beams at the edge of coverage (low elevation) or a single wide-beam.  NOTE 4: The use of a Circular polarized antenna is optional.  NOTE 5: Same Noise Figure of 7 dB as in Release 16 TR 38.821 or 9 dB as in Release 12 TR 36.888 for device can be assumed for link budget. The noise figure is device vendor implementation specific.  NOTE 6: Max Doppler shift and Max Doppler shift variation in the absence of any device pre-compensation of satellite Doppler shift on the service link.  NOTE 7: System bandwidth is FFS | | | |

***Table 6.1-1: IoT NTN reference scenario parameters***

***Proposal 3****: To include MEO Set-5 parameters for link budget analysis in a new Table 6.2-8 in TR 36.763, as a representative characterization of NTN-IoT scenarios with MEO altitude and characteristics.*

|  |  |
| --- | --- |
|  | **Proposed MEO Scenarios (Set 5)** |
| Satellite orbit | MEO |
| Satellite altitude | 10,000 km |
| Payload characteristics for DL transmission | |
| Frequency band | S-band (i.e. 2 GHz) |
| Equivalent satellite antenna aperture (NOTE1) | 1.5 m |
| Satellite EIRP density | 45.4 dBW/MHz |
| Satellite Tx max Gain | 28.1 dBi |
| 3dB beamwidth | 6.5 degrees |
| Satellite beam diameter (at nadir pointing) | 1140 km |
| Payload characteristics for UL reception | |
| Frequency band | S-band (i.e. 2 GHz) |
| Equivalent satellite antenna aperture (NOTE1) | 1.5 m |
| G/T | 3.8 dB/K |
| Satellite Rx max Gain | 28.1 dBi |
| NOTE 1: This value is equivalent to the antenna diameter for the parabolic reflector modelled in Sec. 6.4.1 of TR 38.811.  NOTE 2: Antenna models different from the parabolic reflector described in TR 38.811 should be used. | |

**Table 6.2-8: Sets of satellite parameters for link budget and system level evaluations**

***Proposal 4****: To add MEO Set-5 satellite parameters for system level simulator calibration in a new Table 6.2-9 in TR 36.763.*

|  |  |
| --- | --- |
| Set 5 | MEO |
| 3 dB Beam width (HPBW) | 6.5 degrees |
| Central beam center elevation | 90 degrees |
| Central beam edge elevation | 86.1 degrees |
| Central beam edge satellite-UE distance | 10042 km |

**Table 6.2-9: Set-5 parameters for link budget analysis**

***Observation****: The doppler shift/variation and the delay variation for MEO are smaller than for LEO. The maximum delay for MEO is smaller than for GEO. The IoT-NTN enhancements for LEO and GEO should be sufficient to support MEO.*

Link budget using “Set 5” NTN-IoT scenarios with MEO altitude and characteristics.



***Initial proposal - Section 3-2***

* ***Include the following in TR 36.763***
* ***Add MEO scenario D in Table 4.2-1 in TR 36.763.***
* ***Add MEO IoT NTN reference scenario parameters in Table 6.1-1 in TR 36.763.***
* ***Include MEO Set-5 parameters for link budget analysis in a new Table 6.2-8 in TR 36.763, as a representative characterization of NTN-IoT scenarios with MEO altitude and characteristics.***
* ***Add MEO Set-5 satellite parameters for system level simulator calibration in a new Table 6.2-9 in TR 36.763.***
* ***Add observation in TR 36.763: The doppler shift/variation and the delay variation for MEO are smaller than for LEO. The maximum delay for MEO is smaller than for GEO. The IoT-NTN enhancements for LEO and GEO should be sufficient to support MEO.***

# Conclusions

TBA

# References

1. RP-210868, “New Study WID on NB-IoT/eTMC support for NTN”, MediaTek, RAN#91-e, March 2021
2. RP-210915, “Moderator's summary for email discussion [91E][42][NTN\_IoT\_roadmap]”, Ericsson (RAN1 Vice-Chair), RAN#91-e, March 2021
3. RP-210906, Way forward on new proposals, Nokia (RAN Chair), RAN#91-e, March 2021
4. R1-2102750, Echostar/Hugues, Discussion on NTN-IoT scenarios with MEO, RAN1#104bis-e, April 2021
5. R1-2102343, Huawei, Application scenarios of IoT in NTN, RAN1#104bis-e, April 2021
6. R1-2102422, OPPO, Discussion on scenarios applicable to NB-IoT/eMTC, RAN1#104bis-e, April 2021
7. R1-2102550, OPPO, Discussion on scenarios applicable to NB-IoT/eMTC, RAN1#104bis-e, April 2021
8. R1-2102617, CATT, Applicable scenario and initial evaluation result to NB-IoT/eMTC, RAN1#104bis-e, April 2021
9. R1-2102754, MediaTek, Scenarios applicable to IoT NTN, RAN1#104bis-e, April 2021
10. R1-2102831, Nokia, Nokia Shanghai Bell, Link budget evaluations for NB-IoT/eMTC over NTN, RAN1#104bis-e, April 2021
11. R1-2102905, CMCC, Discussion on scenarios applicable to NB-IoT and eMTC, RAN1#104bis-e, April 2021
12. R1-2102916, ZTE, Discussion on the scenarios and assumption for IoT-NTN, RAN1#104bis-e, April 2021
13. R1-2102972, Xiaomi, Discussion on the link budget of NB-IoT/eMTC over NTN, RAN1#104bis-e, April 2021
14. R1-2103060, Ericsson, On scenarios and evaluations for eMTC and NB-IoT based NTN, RAN1#104bis-e, April 2021
15. R1-2103070, Qualcomm, Scenarios applicable to NB-IoT/eMTC, RAN1#104bis-e, April 2021
16. R1-2103132, Apple, Link Budget Analysis of IoT NTN, RAN1#104bis-e, April 2021
17. R1-2103266, Samsung, Initial link budget evaluation for NB-IoT/eMTC, RAN1#104bis-e, April 2021
18. R1-2103318, Sony, Scenarios for IoT- NTN, RAN1#104bis-e, April 2021
19. R1-2103716, Sateliot, Gatehouse, Thales, Link budget analysis for Set-4, RAN1#104bis-e, April 2021

# Appendix 1

## Huawei link budget results (R1-2102343)

Table 1 Link budget results

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter set** | **Satellite orbit** | **UL/DL** | **B(kHZ)** | **Elevation angle** | **UE Location** | **TX: EIRP/spot/BW [dBW]** | **RX: G/T [dB/T]** |  | **[dBi]** | **Sat. EIRP density [dBW/MHz]** | **Shadow fading margin [dB]** | **Scintillation Loss [dB]** | **Additional losses [dB]** | **Free space path loss [dB]** | **Atmospheric path loss [dB]** | **CNR [dB]** |
| Set1 | GEO | DL | 180 | 12.5 | centre | 51.55 | -36.62 | 51 | 0 | 59 | 3 | 2.2 | 0 | 190.58 | 0.00 | -4.804 |
| 180 | 2.3 | edge | 51.55 | -36.62 | 51 | 0 | 59 | 3 | 2.2 | 0 | 190.58 | 0.87 | -5.910 |
| UL | 180 | 12.5 | centre | -10.00 | 19.00 | 0 | 51 |  | 3 | 2.2 | 0 | 190.58 | 0.00 | -10.733 |
| 180 | 2.3 | edge | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.81 | 0.87 | -11.839 |
| 90 | 12.5 | centre | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.58 | 0.00 | -7.723 |
| 90 | 2.3 | edge | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.81 | 0.87 | -8.829 |
| 45 | 12.5 | centre | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.58 | 0.00 | -4.712 |
| 45 | 2.3 | edge | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.81 | 0.87 | -5.819 |
| 15 | 12.5 | centre | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.58 | 0.00 | 0.059 |
| 15 | 2.3 | edge | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.81 | 0.87 | -1.047 |
| 3.75 | 12.5 | centre | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.58 | 0.00 | 6.079 |
| 3.75 | 2.3 | edge | -10.00 | 19.00 | 0 | 51 | 3 | 2.2 | 0 | 190.81 | 0.87 | 4.973 |
| LEO600 | DL | 180 | 30 | centre | 26.55 | -36.62 | 30 | 0 | 34 | 3 | 2.2 | 0 | 159.10 | 0.00 | 1.677 |
| 180 | 27 | edge | 26.55 | -36.62 | 30 | 0 | 34 | 3 | 2.2 | 0 | 159.71 | 0.00 | 1.063 |
| UL | 180 | 30 | centre | -10.00 | 1.10 | 0 | 30 |  | 3 | 2.2 | 0 | 159.10 | 0.00 | 2.848 |
| 180 | 27 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.71 | 0.00 | 2.235 |
| 90 | 30 | centre | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.10 | 0.00 | 5.858 |
| 90 | 27 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.71 | 0.00 | 5.245 |
| 45 | 30 | centre | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.10 | 0.00 | 8.868 |
| 45 | 27 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.71 | 0.00 | 8.255 |
| 15 | 30 | centre | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.10 | 0.00 | 13.640 |
| 15 | 27 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.71 | 0.00 | 13.026 |
| 3.75 | 30 | centre | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.10 | 0.00 | 19.660 |
| 3.75 | 27 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 159.71 | 0.00 | 19.047 |
| LEO1200 | DL | 180 | 30 | centre | 32.55 | -36.62 | 30 | 0 | 40 | 3 | 2.2 | 0 | 164.49 | 0.00 | 2.290 |
| 180 | 26.3 | edge | 32.55 | -36.62 | 30 | 0 | 40 | 3 | 2.2 | 0 | 165.11 | 0.00 | 1.669 |
| UL | 180 | 30 | centre | -10.00 | 1.10 | 0 | 30 |  | 3 | 2.2 | 0 | 164.49 | 0.00 | -2.539 |
| 180 | 26.3 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 165.11 | 0.00 | -3.160 |
| 90 | 30 | centre | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 164.49 | 0.00 | 0.471 |
| 90 | 26.3 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 165.11 | 0.00 | -0.150 |
| 45 | 30 | centre | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 164.49 | 0.00 | 3.482 |
| 45 | 26.3 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 165.11 | 0.00 | 2.861 |
| 15 | 30 | centre | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 164.49 | 0.00 | 8.253 |
| 15 | 26.3 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 165.11 | 0.00 | 7.632 |
| 3.75 | 30 | centre | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 164.49 | 0.00 | 14.273 |
| 3.75 | 26.3 | edge | -10.00 | 1.10 | 0 | 30 | 3 | 2.2 | 0 | 165.11 | 0.00 | 13.653 |
|  | | | | | | | | | | | | | | | | |
| Set2 | GEO | DL | 180 | 20 | centre | 46.05 | -36.62 | 45.5 | 0 | 53.5 | 3 | 2.2 | 0 | 190.41 | 0.00 | -10.138 |
| 180 | 11 | edge | 46.05 | -36.62 | 45.5 | 0 | 53.5 | 3 | 2.2 | 0 | 190.61 | 0.00 | -10.338 |
| UL | 180 | 20 | centre | -10.00 | 14.00 | 0 | 45.5 |  | 3 | 2.2 | 0 | 190.41 | 0.00 | -15.566 |
| 180 | 11 | edge | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.61 | 0.00 | -15.767 |
| 90 | 20 | centre | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.41 | 0.00 | -12.556 |
| 90 | 11 | edge | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.61 | 0.00 | -12.757 |
| 45 | 20 | centre | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.41 | 0.00 | -9.546 |
| 45 | 11 | edge | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.61 | 0.00 | -9.746 |
| 15 | 20 | centre | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.41 | 0.00 | -4.775 |
| 15 | 11 | edge | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.61 | 0.00 | -4.975 |
| 3.75 | 20 | centre | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.41 | 0.00 | 1.246 |
| 3.75 | 11 | edge | -10.00 | 14.00 | 0 | 45.5 | 3 | 2.2 | 0 | 190.61 | 0.00 | 1.045 |
| LEO600 | DL | 180 | 30 | centre | 20.55 | -36.62 | 24 | 0 | 28 | 3 | 2.2 | 0 | 159.10 | 0.00 | -4.323 |
| 180 | 23.8 | edge | 20.55 | -36.62 | 24 | 0 | 28 | 3 | 2.2 | 0 | 160.42 | 0.00 | -5.647 |
| UL | 180 | 30 | centre | -10.00 | -4.90 | 0 | 24 |  | 3 | 2.2 | 0 | 159.10 | 0.00 | -3.152 |
| 180 | 23.8 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 160.42 | 0.00 | -4.475 |
| 90 | 30 | centre | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 159.10 | 0.00 | -0.142 |
| 90 | 23.8 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 160.42 | 0.00 | -1.465 |
| 45 | 30 | centre | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 159.10 | 0.00 | 2.868 |
| 45 | 23.8 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 160.42 | 0.00 | 1.545 |
| 15 | 30 | centre | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 159.10 | 0.00 | 7.640 |
| 15 | 23.8 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 160.42 | 0.00 | 6.316 |
| 3.75 | 30 | centre | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 159.10 | 0.00 | 13.660 |
| 3.75 | 23.8 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 160.42 | 0.00 | 12.337 |
| LEO1200 | DL | 180 | 30 | centre | 26.55 | -36.62 | 24 | 0 | 34 | 3 | 2.2 | 0 | 164.49 | 0.00 | -3.710 |
| 180 | 22.2 | edge | 26.55 | -36.62 | 24 | 0 | 34 | 3 | 2.2 | 0 | 165.85 | 0.00 | -5.075 |
| UL | 180 | 30 | centre | -10.00 | -4.90 | 0 | 24 |  | 3 | 2.2 | 0 | 164.49 | 0.00 | -8.539 |
| 180 | 22.2 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 165.85 | 0.00 | -9.903 |
| 90 | 30 | centre | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 164.49 | 0.00 | -5.529 |
| 90 | 22.2 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 165.85 | 0.00 | -6.893 |
| 45 | 30 | centre | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 164.49 | 0.00 | -2.518 |
| 45 | 22.2 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 165.85 | 0.00 | -3.883 |
| 15 | 30 | centre | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 164.49 | 0.00 | 2.253 |
| 15 | 22.2 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 165.85 | 0.00 | 0.888 |
| 3.75 | 30 | centre | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 164.49 | 0.00 | 8.273 |
| 3.75 | 22.2 | edge | -10.00 | -4.90 | 0 | 24 | 3 | 2.2 | 0 | 165.85 | 0.00 | 6.909 |
|  | | | | | | | | | | | | | | | | |
| Set3 | GEO | DL | 180 | 20.9 | centre | 52.35 | -36.62 | 45.7 | 0 | 59.8 | 3 | 2.2 | 0 | 190.39 | 0.00 | -3.818 |
| 180 | 12.5 | edge | 52.35 | -36.62 | 45.7 | 0 | 59.8 | 3 | 2.2 | 0 | 190.58 | 0.00 | -4.004 |
| UL | 180 | 20.9 | centre | -10.00 | 16.70 | 0 | 45.7 |  | 3 | 2.2 | 0 | 190.39 | 0.00 | -12.847 |
| 180 | 12.5 | edge | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.58 | 0.00 | -13.033 |
| 90 | 20.9 | centre | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.39 | 0.00 | -9.837 |
| 90 | 12.5 | edge | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.58 | 0.00 | -10.023 |
| 45 | 20.9 | centre | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.39 | 0.00 | -6.826 |
| 45 | 12.5 | edge | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.58 | 0.00 | -7.012 |
| 15 | 20.9 | centre | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.39 | 0.00 | -2.055 |
| 15 | 12.5 | edge | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.58 | 0.00 | -2.241 |
| 3.75 | 20.9 | centre | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.39 | 0.00 | 3.966 |
| 3.75 | 12.5 | edge | -10.00 | 16.70 | 0 | 45.7 | 3 | 2.2 | 0 | 190.58 | 0.00 | 3.779 |
| LEO600 | DL | 180 | 43.8 | centre | 20.85 | -36.62 | 16.2 | 0 | 28.3 | 3 | 2.2 | 0 | 156.85 | 0.00 | -1.772 |
| 180 | 30 | edge | 20.85 | -36.62 | 16.2 | 0 | 28.3 | 3 | 2.2 | 0 | 159.10 | 0.00 | -4.023 |
| UL | 180 | 43.8 | centre | -10.00 | -12.80 | 0 | 16.2 |  | 3 | 2.2 | 0 | 156.85 | 0.00 | -8.801 |
| 180 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 159.10 | 0.00 | -11.052 |
| 90 | 43.8 | centre | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 156.85 | 0.00 | -5.791 |
| 90 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 159.10 | 0.00 | -8.042 |
| 45 | 43.8 | centre | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 156.85 | 0.00 | -2.781 |
| 45 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 159.10 | 0.00 | -5.032 |
| 15 | 43.8 | centre | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 156.85 | 0.00 | 1.991 |
| 15 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 159.10 | 0.00 | -0.260 |
| 3.75 | 43.8 | centre | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 156.85 | 0.00 | 8.011 |
| 3.75 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 159.10 | 0.00 | 5.760 |
| LEO1200 | DL | 180 | 46.05 | centre | 26.25 | -36.62 | 16.2 | 0 | 33.7 | 3 | 2.2 | 0 | 162.33 | 0.00 | -1.851 |
| 180 | 30 | edge | 26.25 | -36.62 | 16.2 | 0 | 33.7 | 3 | 2.2 | 0 | 164.49 | 0.00 | -4.010 |
| UL | 180 | 46.05 | centre | -10.00 | -12.80 | 0 | 16.2 |  | 3 | 2.2 | 0 | 162.33 | 0.00 | -14.280 |
| 180 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 164.49 | 0.00 | -16.439 |
| 90 | 46.05 | centre | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 162.33 | 0.00 | -11.269 |
| 90 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 164.49 | 0.00 | -13.429 |
| 45 | 46.05 | centre | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 162.33 | 0.00 | -8.259 |
| 45 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 164.49 | 0.00 | -10.418 |
| 15 | 46.05 | centre | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 162.33 | 0.00 | -3.488 |
| 15 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 164.49 | 0.00 | -5.647 |
| 3.75 | 46.05 | centre | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 162.33 | 0.00 | 2.533 |
| 3.75 | 30 | edge | -10.00 | -12.80 | 0 | 16.2 | 3 | 2.2 | 0 | 164.49 | 0.00 | 0.373 |
|  | | | | | | | | | | | | | | | | |
| Set 4 | LEO600 | DL | 180 | 90 | centre | 14.00 | -36.62 | 11 | 0 | 21.45 | 3 | 2.2 | 0 | 154.03 | 0.00 | -5.808 |
| 180 | 30 | edge | 14.00 | -36.62 | 11 | 0 | 21.45 | 3 | 2.2 | 0 | 159.10 | 0.00 | -10.873 |
| UL | 180 | 90 | centre | -10.00 | -18.60 | 0 | 11 |  | 3 | 2.2 | 0 | 154.03 | 0.00 | -11.786 |
| 180 | 30 | edge | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 159.10 | 0.00 | -16.852 |
| 90 | 90 | centre | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 154.03 | 0.00 | -8.776 |
| 90 | 30 | edge | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 159.10 | 0.00 | -13.842 |
| 45 | 90 | centre | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 154.03 | 0.00 | -5.766 |
| 45 | 30 | edge | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 159.10 | 0.00 | -10.832 |
| 15 | 90 | centre | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 154.03 | 0.00 | -0.995 |
| 15 | 30 | edge | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 159.10 | 0.00 | -6.060 |
| 3.75 | 90 | centre | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 154.03 | 0.00 | 5.026 |
| 3.75 | 30 | edge | -10.00 | -18.60 | 0 | 11 | 3 | 2.2 | 0 | 159.10 | 0.00 | -0.040 |

## OPPO link budget results (R1-2102422)

Satellite set 1:

Table 1 and Table 2 provide the link budget results for NB-IoT and eMTC in scenario A, scenario B&C-600km, scenario B&C-1200km respectively, with satellite parameter set 1.

**Table 1. Link budget results for NB-IoT in Satellite set 1**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| NB-IoT | | DL | UL | | | | |
| Channel bandwidth (kHz) | | 180 | 180 | 90 | 45 | 15 | 3.75 |
| Scenario A | CNR (dB) | -5.03 | -13.95 | -10.94 | -7.93 | -3.16 | 2.86 |
| CIR (dB) | 1.10 | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 |
| CINR (dB) | -5.97 | -14.06 | -11.15 | -8.34 | -4.27 | -0.49 |
| Scenario B&C-600km | CNR (dB) | 1.58 | -0.25 | 2.76 | 5.77 | 10.54 | 16.56 |
| CIR (dB) | -0.20 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| CINR (dB) | -2.41 | -3.09 | -1.78 | -0.94 | -0.28 | 0.00 |
| Scenario B&C-1200km | CNR (dB) | 2.18 | -5.65 | -2.64 | 0.37 | 5.14 | 11.16 |
| CIR (dB) | -0.10 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| CINR (dB) | -2.12 | -6.66 | -4.46 | -2.73 | -1.01 | -0.13 |

**Table 2. Link budget results for eMTC in Satellite set 1**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| eMTC | | DL | UL | | | | |
| Channel bandwidth (kHz) | | 1080 | 360 | 180 | 90 | 45 | 30 |
| Scenario A | CNR (dB) | -5.03 | -16.96 | -13.95 | -10.94 | -7.93 | -6.17 |
| CIR (dB) | 1.10 | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 |
| CINR (dB) | -5.97 | -17.02 | -14.06 | -11.15 | -8.34 | -6.76 |
| Scenario B&C-600km | CNR (dB) | 1.58 | -3.26 | -0.25 | 2.76 | 5.77 | 7.53 |
| CIR (dB) | -0.20 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| CINR (dB) | -2.41 | -4.91 | -3.09 | -1.78 | -0.94 | -0.62 |
| Scenario B&C-1200km | CNR (dB) | 2.18 | -8.66 | -5.65 | -2.64 | 0.37 | 2.13 |
| CIR (dB) | -0.10 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| CINR (dB) | -2.12 | -9.19 | -6.66 | -4.46 | -2.73 | -1.95 |

|  |  |
| --- | --- |
|  |  |
| 1. **GEO** | 1. **LEO-600** |
|  | |
| 1. **LEO-1200** | |

**Figure 1. CIR results for both DL and UL in Satellite set 1**

Satellite set 2:

Table 3 and Table 4 provide the link budget results for NB-IoT and eMTC in scenario A, scenario B&C-600km, scenario B&C-1200km respectively, with satellite parameter set 2.

**Table 3. Link budget results for NB-IoT in Satellite set 2**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| NB-IoT | | DL | UL | | | | |
| Channel bandwidth (kHz) | | 180 | 180 | 90 | 45 | 15 | 3.75 |
| Scenario A | CNR (dB) | -10.53 | -18.95 | -15.94 | -12.93 | -8.16 | -2.14 |
| CIR (dB) | 1.90 | 2.30 | 2.30 | 2.30 | 2.30 | 2.30 |
| CINR (dB) | -10.77 | -18.99 | -16.01 | -13.06 | -8.54 | -3.48 |
| Scenario B&C-600km | CNR (dB) | -4.42 | -6.25 | -3.24 | -0.23 | 4.54 | 10.56 |
| CIR (dB) | 0.00 | -0.80 | -0.80 | -0.80 | -0.80 | -0.80 |
| CINR (dB) | -5.76 | -7.34 | -5.20 | -3.54 | -1.91 | -1.11 |
| Scenario B&C-1200km | CNR (dB) | -3.82 | -11.65 | -8.64 | -5.63 | -0.86 | 5.16 |
| CIR (dB) | 0.00 | -0.50 | -0.50 | -0.50 | -0.50 | -0.50 |
| CINR (dB) | -5.33 | -11.97 | -9.26 | -6.79 | -3.69 | -1.54 |

**Table 4. Link budget results for eMTC in Satellite set 2**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| eMTC | | DL | UL | | | | |
| Channel bandwidth (kHz) | | 1080 | 360 | 180 | 90 | 45 | 30 |
| Scenario A | CNR (dB) | -10.53 | -21.96 | -18.95 | -15.94 | -12.93 | -11.17 |
| CIR (dB) | 1.90 | 2.30 | 2.30 | 2.30 | 2.30 | 2.30 |
| CINR (dB) | -10.77 | -21.98 | -18.99 | -16.01 | -13.06 | -11.36 |
| Scenario B&C-600km | CNR (dB) | -4.42 | -9.26 | -6.25 | -3.24 | -0.23 | 1.53 |
| CIR (dB) | 0.00 | -0.80 | -0.80 | -0.80 | -0.80 | -0.80 |
| CINR (dB) | -5.76 | -9.84 | -7.34 | -5.20 | -3.54 | -2.80 |
| Scenario B&C-1200km | CNR (dB) | -3.82 | -14.66 | -11.65 | -8.64 | -5.63 | -3.87 |
| CIR (dB) | 0.00 | -0.50 | -0.50 | -0.50 | -0.50 | -0.50 |
| CINR (dB) | -5.33 | -14.83 | -11.97 | -9.26 | -6.79 | -5.52 |

|  |  |
| --- | --- |
|  |  |
| 1. **GEO** | 1. **LEO-600** |
|  | |
| 1. **LEO-1200** | |

**Figure 2. CIR results for both DL and UL in Satellite set 2**

Satellite set 3:

Table 5 and Table 6 provide the link budget results for NB-IoT and eMTC in scenario A, scenario B&C-600km, scenario B&C-1200km respectively, with satellite parameter set 3.

**Table 5. Link budget results for NB-IoT in Satellite set 3**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| NB-IoT | | DL | UL | | | | |
| Channel bandwidth (kHz) | | 180 | 180 | 90 | 45 | 15 | 3.75 |
| Scenario A | CNR (dB) | -4.23 | -16.25 | -13.24 | -10.23 | -5.46 | 0.56 |
| CIR (dB) | 2.00 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 |
| CINR (dB) | -5.15 | -16.31 | -13.36 | -10.46 | -6.12 | -1.63 |
| Scenario B&C-600km | CNR (dB) | -4.12 | -14.15 | -11.14 | -8.13 | -3.36 | 2.66 |
| CIR (dB) | -0.80 | -2.70 | -2.70 | -2.70 | -2.70 | -2.70 |
| CINR (dB) | -5.78 | -14.45 | -11.72 | -9.23 | -6.05 | -3.81 |
| Scenario B&C-1200km | CNR (dB) | -4.12 | -19.55 | -16.54 | -13.53 | -8.76 | -2.74 |
| CIR (dB) | -1.00 | -2.70 | -2.70 | -2.70 | -2.70 | -2.70 |
| CINR (dB) | -5.85 | -19.64 | -16.72 | -13.88 | -9.72 | -5.73 |

**Table 6. Link budget results for eMTC in Satellite set 3**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| eMTC | | DL | UL | | | | |
| Channel bandwidth (kHz) | | 1080 | 360 | 180 | 90 | 45 | 30 |
| Scenario A | CNR (dB) | -4.23 | -19.26 | -16.25 | -13.24 | -10.23 | -8.47 |
| CIR (dB) | 2.00 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 |
| CINR (dB) | -5.15 | -19.29 | -16.31 | -13.36 | -10.46 | -8.81 |
| Scenario B&C-600km | CNR (dB) | -4.12 | -17.16 | -14.15 | -11.14 | -8.13 | -6.37 |
| CIR (dB) | -0.80 | -2.70 | -2.70 | -2.70 | -2.70 | -2.70 |
| CINR (dB) | -5.78 | -17.32 | -14.45 | -11.72 | -9.23 | -7.92 |
| Scenario B&C-1200km | CNR (dB) | -4.12 | -22.56 | -19.55 | -16.54 | -13.53 | -11.77 |
| CIR (dB) | -1.00 | -2.70 | -2.70 | -2.70 | -2.70 | -2.70 |
| CINR (dB) | -5.85 | -22.61 | -19.64 | -16.72 | -13.88 | -12.28 |

|  |  |
| --- | --- |
|  |  |
| 1. **GEO** | 1. **LEO-600** |
|  | |
| 1. **LEO-1200** | |

**Figure 3. CIR results for both DL and UL in Satellite set 3**

Satellite set 4:

Table 7 and Table 8 provide the link budget results for NB-IoT and eMTC in scenario B&C-600km respectively, with satellite parameter set 4.

**Table 7. Link budget results for NB-IoT in Satellite set 4**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| NB-IoT | | DL | UL | | | | |
| Channel bandwidth (kHz) | | 180 | 180 | 90 | 45 | 15 | 3.75 |
| Scenario B&C-600km | CNR (dB) | -10.97 | -19.95 | -16.94 | -13.93 | -9.16 | -3.14 |
| CINR (dB) | -10.97 | -19.95 | -16.94 | -13.93 | -9.16 | -3.14 |

**Table 8. Link budget results for eMTC in Satellite set 4**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| eMTC | | DL | UL | | | | |
| Channel bandwidth (kHz) | | 1080 | 360 | 180 | 90 | 45 | 30 |
| Scenario B&C-600km | CNR (dB) | -10.97 | -22.96 | -19.95 | -16.94 | -13.93 | -12.17 |
| CINR (dB) | -10.97 | -22.96 | -19.95 | -16.94 | -13.93 | -12.17 |

## Vivo link budget results (R1-2102550)

**Table 1. Link budget results for Set-1 satellites and NB-IoT/eMTC devices**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Device type | UL/DL | Bandwidth | GEO | | LEO-1200 | | LEO-600 | |
| Free space path loss[dB] | CNR [dB] | Free space path loss[dB] | CNR [dB] | Free space path loss[dB] | CNR [dB] |
| NB-IoT | DL | 180kHz | 190.58 | -4.97 | 164.49 | 2.22 | 159.10 | 1.61 |
| UL | 12\*15kHz | 190.58 | -13.89 | 164.49 | -5.61 | 159.10 | -0.22 |
| 6\*15kHz | 190.58 | -10.88 | 164.49 | -2.60 | 159.10 | 2.79 |
| 3\*15kHz | 190.58 | -7.87 | 164.49 | 0.41 | 159.10 | 5.8 |
| 1\*15kHz | 190.58 | -3.10 | 164.49 | 5.18 | 159.10 | 10.57 |
| 1\*3.75kHz | 190.58 | 2.92 | 164.49 | 11.2 | 159.10 | 16.59 |
| eMTC | DL | 1080kHz | 190.58 | -4.97 | 164.49 | 2.22 | 159.10 | 1.61 |
| UL | 1080kHz | 190.58 | -21.68 | 164.49 | -13.39 | 159.10 | -8.00 |
| 2\*180kHz | 190.58 | -16.91 | 164.49 | -8.62 | 159.10 | -3.23 |
| 180kHz | 190.58 | -13.89 | 164.49 | -5.61 | 159.10 | -0.22 |
| 6\*15kHz | 190.58 | -10.88 | 164.49 | -2.60 | 159.10 | 2.79 |
| 3\*15kHz | 190.58 | -7.87 | 164.49 | 0.41 | 159.10 | 5.80 |
| 2\*15kHz | 190.58 | -3.10 | 164.49 | 5.18 | 159.10 | 10.57 |

**Table 2. Link budget results for Set-2 satellites and NB-IoT/eMTC devices**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Device type | UL/DL | Bandwidth | GEO | | LEO-1200 | | LEO-600 | |
| Free space path loss[dB] | CNR [dB] | Free space path loss[dB] | CNR [dB] | Free space path loss[dB] | CNR [dB] |
| NB-IoT | DL | 180kHz | 190.58 | -10.47 | 164.49 | -3.78 | 159.10 | -4.39 |
| UL | 12\*15kHz | 190.58 | -18.89 | 164.49 | -11.61 | 159.10 | -6.22 |
| 6\*15kHz | 190.58 | -15.88 | 164.49 | -8.60 | 159.10 | -3.21 |
| 3\*15kHz | 190.58 | -12.87 | 164.49 | -5.59 | 159.10 | -0.20 |
| 1\*15kHz | 190.58 | -8.10 | 164.49 | -0.82 | 159.10 | 4.57 |
| 1\*3.75kHz | 190.58 | -2.08 | 164.49 | 5.20 | 159.10 | 10.59 |
| eMTC | DL | 1080kHz | 190.58 | -10.47 | 164.49 | -3.78 | 159.10 | -4.39 |
| UL | 1080kHz | 190.58 | -26.68 | 164.49 | -19.39 | 159.10 | -14.00 |
| 2\*180kHz | 190.58 | -21.91 | 164.49 | -14.62 | 159.10 | -9.23 |
| 180kHz | 190.58 | -18.89 | 164.49 | -11.61 | 159.10 | -6.22 |
| 6\*15kHz | 190.58 | -15.88 | 164.49 | -8.60 | 159.10 | -3.21 |
| 3\*15kHz | 190.58 | -12.87 | 164.49 | -5.59 | 159.10 | -0.20 |
| 2\*15kHz | 190.58 | -8.10 | 164.49 | -0.82 | 159.10 | 4.57 |

**Table 3. Link budget results for Set-3 satellites and NB-IoT/eMTC devices**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Device type | UL/DL | Bandwidth | GEO | | LEO-1200 | | LEO-600 | |
| Free space path loss[dB] | CNR [dB] | Free space path loss[dB] | CNR [dB] | Free space path loss[dB] | CNR [dB] |
| NB-IoT | DL | 180kHz | 190.58 | -4.17 | 164.49 | -4.08 | 159.10 | -4.09 |
| UL | 12\*15kHz | 190.58 | -16.19 | 164.49 | -19.51 | 159.10 | -14.12 |
| 6\*15kHz | 190.58 | -13.18 | 164.49 | -16.50 | 159.10 | -11.11 |
| 3\*15kHz | 190.58 | -10.17 | 164.49 | -13.49 | 159.10 | -8.10 |
| 1\*15kHz | 190.58 | -5.40 | 164.49 | -8.72 | 159.10 | -3.33 |
| 1\*3.75kHz | 190.58 | 0.62 | 164.49 | -2.70 | 159.10 | 2.69 |
| eMTC | DL | 1080kHz | 190.58 | -4.17 | 164.49 | -4.08 | 159.10 | -4.09 |
| UL | 1080kHz | 190.58 | -23.98 | 164.49 | -27.29 | 159.10 | -21.90 |
| 2\*180kHz | 190.58 | -19.21 | 164.49 | -22.52 | 159.10 | -17.13 |
| 180kHz | 190.58 | -16.19 | 164.49 | -19.51 | 159.10 | -14.12 |
| 6\*15kHz | 190.58 | -13.18 | 164.49 | -16.50 | 159.10 | -11.11 |
| 3\*15kHz | 190.58 | -10.17 | 164.49 | -13.49 | 159.10 | -8.10 |
| 2\*15kHz | 190.58 | -5.40 | 164.49 | -11.73 | 159.10 | -6.34 |

**Table 4. Link budget results for Set-4 satellites and NB-IoT/eMTC devices**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Device type | UL/DL | Bandwidth | LEO-600 | |
| Free space path loss[dB] | CNR [dB] |
| NB-IoT | DL | 180kHz | 159.10 | -10.94 |
| UL | 12\*15kHz | 159.10 | -19.92 |
| 6\*15kHz | 159.10 | -16.91 |
| 3\*15kHz | 159.10 | -13.90 |
| 1\*15kHz | 159.10 | -9.13 |
| 1\*3.75kHz | 159.10 | -3.11 |
| eMTC | DL | 1080kHz | 159.10 | -10.94 |
| UL | 1080kHz | 159.10 | -27.70 |
| 2\*180kHz | 159.10 | -22.93 |
| 180kHz | 159.10 | -19.92 |
| 6\*15kHz | 159.10 | -16.91 |
| 3\*15kHz | 159.10 | -13.90 |
| 2\*15kHz | 159.10 | -12.14 |

## CATT link budget results (R1-2102617)

Link budget results for Set-1

**Table 1 Link budget result for eMTC NTN with Set-1**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Satellite orbit** | **GEO** | | | | | | | | **LEO1200** | | | | | | | | | **LEO600** | | | | | | | | |
| **B(KHZ)** | **DL** | | **UL** | | | | | | **DL** | | **UL** | | | | | | | **DL** | | **UL** | | | | | | |
| **1080** | | **360** | | **180** | **90** | **45** | **30** | **1080** | | **360** | | **180** | | **90** | **45** | **30** | **1080** | | **360** | | **180** | | **90** | **45** | **30** |
| **Frequency (GHz)** | **2** | | **2** | | | | | | **2** | | **2** | | | | | | | **2** | | **2** | | | | | | |
| **TX: EIRP [DL:dBW/MHz**  **UL;dBW]** | **59** | | **-10** | | | | | | **40** | | **-10** | | | | | | | **34** | | **-10** | | | | | | |
| **RX: G/T [dB/K]** | **-33.62** | | **19** | | | | | | **-33.62** | | **1.1** | | | | | | | **-33.62** | | **1.1** | | | | | | |
| **Additional losses [dB]** | **0** | | **0** | | | | | | **0** | | **0** | | | | | | | **0** | | **0** | | | | | | |
| **Central beam edge elevation [degrees] & Free space path loss [dB]** | **Central beam edge elevation: 2.3**  **FSPL: 190.81** | | | | | | | | **Central beam edge elevation: 26.3**  **FSPL: 165.11** | | | | | | | | | **Central beam edge elevation: 27.0**  **FSPL: 159.71** | | | | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-5.2** | **-17.1** | | **-14.1** | | **-11.1** | **-8.1** | **-6.3** | **1.5** | **-9.2** | | **-6.2** | | **-3.2** | | **-0.2** | **1.5** | **0.9** | **-3.8** | | **-0.8** | | **2.1** | | **5.1** | **6.9** |
| **Central beam centre elevation [degrees] & Free space path loss [dB]** | **Central beam centre elevation: 12.5**  **FSPL: 190.58** | | | | | | | | **Central beam centre elevation: 30**  **FSPL: 164.49** | | | | | | | | | **Central beam centre elevation: 30**  **FSPL: 159.10** | | | | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-5.0** | **-16.9** | | **-13.9** | | **-10.9** | **-7.9** | **-6.1** | **2.1** | **-8.6** | | **-5.6** | | **-2.6** | | **0.3** | **2.1** | **1.5** | **-3.2** | | **-0.2** | | **2.7** | | **5.7** | **7.5** |

**Table 2 Link budget result for NB-IoT NTN with Set-1**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Satellite orbit** | **GEO** | | | | | | | | | | **LEO1200** | | | | | | | **LEO600** | | | | | | |
| **B(KHZ)** | **DL** | | | **UL** | | | | | | | **DL** | | **UL** | | | | | **DL** | | **UL** | | | | |
| **180** | | | **180** | | **90** | | **45** | **15** | **3.75** | **180** | | **180** | **90** | **45** | **15** | **3.75** | **180** | | **180** | **90** | **45** | **15** | **3.75** |
| **Frequency (GHz)** | **2** | | | **2** | | | | | | | **2** | | **2** | | | | | **2** | | **2** | | | | |
| **TX: EIRP [DL:dBW/MHz**  **UL;dBW]** | **59** | | | **-10** | | | | | | | **40** | | **-10** | | | | | **34** | | **-10** | | | | |
| **RX: G/T [dB/K]** | **-33.62** | | | **19** | | | | | | | **-33.62** | | **1.1** | | | | | **-33.62** | | **1.1** | | | | |
| **Additional losses [dB]** | **0** | | | **0** | | | | | | | **0** | | **0** | | | | | **0** | | **0** | | | | |
| **Central beam edge elevation [degrees] & Free space path loss [dB]** | **Central beam edge elevation: 2.3**  **FSPL: 190.81** | | | | | | | | | | **Central beam edge elevation: 26.3**  **FSPL: 165.11** | | | | | | | **Central beam edge elevation: 27.0**  **FSPL: 159.71** | | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-5.2** | | **-14.1** | | **-11.1** | | **-8.1** | | **-3.3** | **2.6** | **1.5** | **-6.2** | | **-3.2** | **-0.2** | **4.5** | **10.5** | **0.9** | **-0.8** | | **2.1** | **5.1** | **9.9** | **15.9** |
| **Central beam centre elevation [degrees] & Free space path loss [dB]** | **Central beam centre elevation: 12.5**  **FSPL: 190.58** | | | | | | | | | | **Central beam centre elevation: 30**  **FSPL: 164.49** | | | | | | | **Central beam centre elevation: 30**  **FSPL: 159.10** | | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-5.0** | **-13.9** | | | **-10.9** | | **-7.9** | | **-3.1** | **2.8** | **2.1** | **-5.6** | | **-2.6** | **0.3** | **5.1** | **11.1** | **1.5** | **-0.2** | | **2.7** | **5.7** | **10.5** | **16.5** |

Link budget results for Set-2

**Table 3 Link budget result for eMTC NTN with Set-2**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Satellite orbit** | **GEO** | | | | | | | | | **LEO1200** | | | | | | | | **LEO600** | | | | | | | | |
| **B(KHZ)** | **DL** | | **UL** | | | | | | | **DL** | | **UL** | | | | | | **DL** | | **UL** | | | | | | |
| **1080** | | **360** | | **180** | | **90** | **45** | **30** | **1080** | | **360** | | **180** | **90** | **45** | **30** | **1080** | | **360** | | **180** | | **90** | **45** | **30** |
| **Frequency (GHz)** | **2** | | **2** | | | | | | | **2** | | **2** | | | | | | **2** | | **2** | | | | | | |
| **TX: EIRP [DL:dBW/MHz**  **UL;dBW]** | **53.5** | | **-10** | | | | | | | **34** | | **-10** | | | | | | **28** | | **-10** | | | | | | |
| **RX: G/T [dB/K]** | **-33.62** | | **14** | | | | | | | **-33.62** | | **-4.9** | | | | | | **-33.62** | | **-4.9** | | | | | | |
| **Additional losses [dB]** | **0** | | **0** | | | | | | | **0** | | **0** | | | | | | **0** | | **0** | | | | | | |
| **Central beam edge elevation [degrees] & Free space path loss [dB]** | **Central beam edge elevation: 11**  **FSPL: 190.61** | | | | | | | | | **Central beam edge elevation: 22.2**  **FSPL: 165.85** | | | | | | | | **Central beam edge elevation: 23.8**  **FSPL: 160.42** | | | | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-10.5** | **-21.9** | | **-18.9** | | **-15.9** | | **-12.9** | **-11.1** | **-5.1** | **-16.0** | | **-13.0** | | **-9.9** | **-6.9** | **-5.2** | **-5.7** | **-10.5** | | **-7.5** | | **-4.5** | | **-1.5** | **0.2** |
| **Central beam centre elevation [degrees] & Free space path loss [dB]** | **Central beam centre elevation: 20**  **FSPL: 190.41** | | | | | | | | | **Central beam centre elevation: 30**  **FSPL: 164.49** | | | | | | | | **Central beam centre elevation: 30**  **FSPL: 159.10** | | | | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-10.3** | **-21.7** | | **-18.7** | | **-15.7** | | **-12.7** | **-10.9** | **-3.8** | **-14.6** | | **-11.6** | | **-8.6** | **-5.6** | **-3.8** | **-4.4** | **-9.2** | | **-6.2** | | **-3.2** | | **-0.2** | **1.5** |

**Table 4 Link budget result for NB-IoT NTN with Set-2**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Satellite orbit** | **GEO** | | | | | | **LEO1200** | | | | | | **LEO600** | | | | | |
| **B(KHZ)** | **DL** | **UL** | | | | | **DL** | **UL** | | | | | **DL** | **UL** | | | | |
| **180** | **180** | **90** | **45** | **15** | **3.75** | **180** | **180** | **90** | **45** | **15** | **3.75** | **180** | **180** | **90** | **45** | **15** | **3.75** |
| **Frequency (GHz)** | **2** | **2** | | | | | **2** | **2** | | | | | **2** | **2** | | | | |
| **TX: EIRP [DL:dBW/MHz**  **UL;dBW]** | **53.5** | **-10** | | | | | **34** | **-10** | | | | | **28** | **-10** | | | | |
| **RX: G/T [dB/K]** | **-33.62** | **14** | | | | | **-33.62** | **-4.9** | | | | | **-33.62** | **-4.9** | | | | |
| **Additional losses [dB]** | **0** | **0** | | | | | **0** | **0** | | | | | **0** | **0** | | | | |
| **Central beam edge elevation [degrees] & Free space path loss [dB]** | **Central beam edge elevation: 11**  **FSPL: 190.61** | | | | | | **Central beam edge elevation: 22.2**  **FSPL: 165.85** | | | | | | **Central beam edge elevation: 23.8**  **FSPL: 160.42** | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-10.5** | **-18.9** | **-15.9** | **-12.9** | **-8.1** | **-2.1** | **-5.1** | **-13.0** | **-9.9** | **-6.9** | **-2.2** | **3.8** | **-5.7** | **-7.5** | **-4.5** | **-1.5** | **3.2** | **9.2** |
| **Central beam centre elevation [degrees] & Free space path loss [dB]** | **Central beam centre elevation: 20**  **FSPL: 190.41** | | | | | | **Central beam centre elevation: 30**  **FSPL: 164.49** | | | | | | **Central beam centre elevation: 30**  **FSPL: 159.10** | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-10.3** | **-18.7** | **-15.7** | **-12.7** | **-7.9** | **-1.9** | **-3.8** | **-11.6** | **-8.6** | **-5.6** | **-0.8** | **5.1** | **-4.4** | **-6.2** | **-3.2** | **-0.2** | **4.5** | **10.5** |

Link budget results for Set-3

**Table 5 Link budget result for eMTC NTN with Set-3**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Satellite orbit** | **GEO** | | | | | | | | **LEO1200** | | | | | | | **LEO600** | | | | | |
| **B(KHZ)** | **DL** | **UL** | | | | | | | **DL** | | **UL** | | | | | **DL** | **UL** | | | | |
| **1080** | **360** | **180** | | **90** | | **45** | **30** | **1080** | | **360** | **180** | **90** | **45** | **30** | **1080** | **360** | **180** | **90** | **45** | **30** |
| **Frequency (GHz)** | **2** | **2** | | | | | | | **2** | | **2** | | | | | **2** | **2** | | | | |
| **TX: EIRP [DL:dBW/MHz**  **UL;dBW]** | **59.8** | **-10** | | | | | | | **33.7** | | **-10** | | | | | **28.3** | **-10** | | | | |
| **RX: G/T [dB/K]** | **-33.62** | **16.7** | | | | | | | **-33.62** | | **-12.8** | | | | | **-33.62** | **-12.8** | | | | |
| **Additional losses [dB]** | **0** | **0** | | | | | | | **0** | | **0** | | | | | **0** | **0** | | | | |
| **Central beam edge elevation [degrees] & Free space path loss [dB]** | **Central beam edge elevation: 12.5**  **FSPL: 190.58** | | | | | | | | **Central beam edge elevation: 30**  **FSPL: 164.49** | | | | | | | **Central beam edge elevation: 30**  **FSPL: 159.10** | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-4.2** | **-19.2** | | **-16.2** | | **-13.2** | **-10.2** | **-8.4** | **-4.1** | | **-22.5** | **-19.5** | **-16.5** | **-13.5** | **-11.7** | **-4.1** | **-17.1** | **-14.1** | **-11.1** | **-8.1** | **-6.3** |
| **Central beam centre elevation [degrees] & Free space path loss [dB]** | **Central beam centre elevation: 20.9**  **FSPL: 190.39** | | | | | | | | **Central beam centre elevation: 46.05**  **FSPL: 162.33** | | | | | | | **Central beam centre elevation: 43.78**  **FSPL: 156.85** | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-4.0** | **-19.0** | **-16.0** | | **-13.0** | | **-10.0** | **-8.2** | **-1.9** | **-20.3** | | **-17.3** | **-14.3** | **-11.3** | **-9.6** | **-1.8** | **-14.9** | **-11.9** | **-8.8** | **-5.8** | **-4.1** |

**Table 6 Link budget result for NB-IoT NTN with Set-3**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Satellite orbit** | **GEO** | | | | | | | | | | **LEO1200** | | | | | | | | | | **LEO600** | | | | | | | |
| **B(KHZ)** | **DL** | | **UL** | | | | | | | | **DL** | | **UL** | | | | | | | | **DL** | **UL** | | | | | | |
| **180** | | **180** | | **90** | | **45** | **15** | **3.75** | | **180** | | **180** | | **90** | **45** | **15** | | **3.75** | | **180** | **180** | | **90** | **45** | **15** | **3.75** | |
| **Frequency (GHz)** | **2** | | **2** | | | | | | | | **2** | | **2** | | | | | | | | **2** | **2** | | | | | | |
| **TX: EIRP [DL:dBW/MHz**  **UL;dBW]** | **59.8** | | **-10** | | | | | | | | **33.7** | | **-10** | | | | | | | | **28.3** | **-10** | | | | | | |
| **RX: G/T [dB/K]** | **-33.62** | | **16.7** | | | | | | | | **-33.62** | | **-12.8** | | | | | | | | **-33.62** | **-12.8** | | | | | | |
| **Additional losses [dB]** | **0** | | **0** | | | | | | | | **0** | | **0** | | | | | | | | **0** | **0** | | | | | | |
| **Central beam edge elevation [degrees] & Free space path loss [dB]** | **Central beam edge elevation: 12.5**  **FSPL: 190.58** | | | | | | | | | | **Central beam edge elevation: 30**  **FSPL: 164.49** | | | | | | | | | | **Central beam edge elevation: 30**  **FSPL: 159.10** | | | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-4.2** | **-16.2** | | **-13.2** | | **-10.2** | | **-5.4** | | **0.5** | **-4.1** | **-19.5** | | **-16.5** | | **-13.5** | | **-8.7** | | **-2.7** | **-4.1** | | **-14.1** | **-11.1** | **-8.1** | **-3.3** | | **2.6** |
| **Central beam centre elevation [degrees] & Free space path loss [dB]** | **Central beam centre elevation: 20.9**  **FSPL: 190.39** | | | | | | | | | | **Central beam centre elevation: 46.05**  **FSPL: 162.33** | | | | | | | | | | **Central beam centre elevation: 43.78**  **FSPL: 156.85** | | | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-4.0** | **-16.0** | | | **-13.0** | | **-10.0** | **-5.2** | | **0.7** | **-1.9** | **-17.3** | | **-14.3** | | **-11.3** | | **-6.5** | | **-0.5** | **-1.8** | | **-11.9** | **-8.8** | **-5.8** | **-1.1** | | **4.9** |

Link budget results for Set-4

**Table 7 Link budget result with Set-4**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Satellite orbit** | **LEO600-eMTC** | | | | | | **LEO600-NB-IoT** | | | | | |
| **B(KHZ)** | **DL** | **UL** | | | | | **DL** | **UL** | | | | |
| **1080** | **360** | **180** | **90** | **45** | **30** | **180** | **180** | **90** | **45** | **15** | **3.75** |
| **Frequency (GHz)** | **2** | **2** | | | | | **2** | **2** | | | | |
| **TX: EIRP [DL:dBW/MHz**  **UL;dBW]** | **21.45** | **-10** | | | | | **21.45** | **-10** | | | | |
| **RX: G/T [dB/K]** | **-33.62** | **-18.6** | | | | | **-33.62** | **-18.6** | | | | |
| **Additional losses [dB]** | **0** | **0** | | | | | **0** | **0** | | | | |
| **Central beam edge elevation [degrees] & Free space path loss [dB]** | **Central beam edge elevation: 30**  **FSPL: 159.10** | | | | | | **Central beam edge elevation: 30**  **FSPL: 159.10** | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-10.9** | **-22.9** | **-19.9** | **-16.9** | **-13.9** | **-12.1** | **-10.9** | **-19.9** | **-16.9** | **-13.9** | **-9.1** | **-3.1** |
| **Central beam centre elevation [degrees] & Free space path loss [dB]** | **Central beam centre elevation: 90**  **FSPL: 154.03** | | | | | | **Central beam centre elevation: 90**  **FSPL: 154.03** | | | | | |
| **CNR [dB]**  **(with different bandwidth)** | **-5.9** | **-17.9** | **-14.8** | **-11.8** | **-8.8** | **-7.1** | **-5.9** | **-14.8** | **-11.8** | **-8.8** | **-4.0** | **1.9** |

## MediaTek link budget results (R1-2102754)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case | Satellite orbit | Parameter Set | Central beam edge elevation | Terminal | Frequency band |
| 1 | GEO | Set 1 | 2.3 deg | CIoT | S-band |
| 2 | LEO-1200 km | Set 1 | 26.3 deg | CIoT | S-band |
| 3 | LEO-600 km | Set 1 | 27 deg | CIoT | S-band |
| 4 | GEO | Set 2 | 11 deg | CIoT | S-band |
| 5 | LEO-1200 km | Set 2 | 22.2 deg | CIoT | S-band |
| 6 | LEO-600 km | Set 2 | 23.8 deg | CIoT | S-band |
| 7 | GEO | Set 3 | 12.5 deg | CIoT | S-band |
| 8 | LEO-1200 km | Set 3 | 30 deg | CIoT | S-band |
| 9 | LEO-600 km | Set 3 | 30 deg | CIoT | S-band |
| 10 | LEO-600 km | Set 4 | 30 deg | CIoT | S-band |

***Table 1****: List of Cases for Link Budget for NB-IoT / eMTC*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  3.75 kHz / 15 kHz / 3\*15 kHz / 6\*15 kHz / 180 kHz |
| 1 | 59 dBW/MHz | 81.6 dBm | -3.0 dB | 19 dB/K | 2.9 dB / -3.1 dB / -7.9 dB / -10.9 dB / -13.9 dB |
| 2 | 40 dBW/MHz | 62.6 dBm | 4.2 dB | 1.1 dB/K | 11.2 dB / 5.2 dB / 0.4 dB / -2.6 dB / -5.6 dB |
| 3 | 34 dBW/MHz | 56.6 dBm | 3.6 dB | 1.1 dB/K | 16.6 dB / 10.5 dB / 5.8 dB / 2.8 dB / -0.2 dB |
| 4 | 53.5 dBW/MHz | 76.1 dBm | -8.5 dB | 14 dB/K | -2.1 dB / -8.1 dB / -12.9 dB / -15.9 dB / -18.9 dB |
| 5 | 34 dBW/MHz | 56.6 dBm | -1.8 dB | -4.9 dB/K | 5.2 dB / -0.8 dB / -5.6 dB / -8.6 dB / -11.6 dB |
| 6 | 28 dBW/MHz | 50.6 dBm | -2.4 dB | -4.9 dB/K | 10.6 dB / 4.5 dB / -0.2 dB / -3.2 dB / -6.2 dB |
| 7 | 59.8 dBW/MHz | 84.4 dBm | -2.2 dB | 16.7 dB/K | 0.6 dB / -5.4 dB / -10.2 dB / -13.2 dB / -16.2 dB |
| 8 | 33.7 dBW/MHz | 56.3 dBm | -2.1 dB | -12.8 dB/K | -2.7 dB / -8.7 dB / -13.5 dB / -16.5 dB / -19.5 dB |
| 9 | 28.3 dBW/MHz | 50.9 dBm | -2.1 dB | -12.8 dB/K | 2.7 dB / -3.4 dB / -8.1 dB / -11.1 dB / -14.1 dB |
| 10 | 21.45 dBW/MHz | 44 dBm | -12.0 dB | -20.9 dB/K | -2.4 dB / -8.5 dB / -13.2 dB / -16.2 dB / -19.2 dB |

***Table 2****: Link Budget results*

## Nokia link budget results (R1-2102831)

Table 4 Downlink link budget for eMTC and NB-IoT with Set 1 parameters

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| eMTC, GEO | DL | 12.5 | 2 | 89.33 | -33.62 | 1.08 | 190.58 | 0.2 | 3 | 2.2 | 3 | 0 | -5.01 |
| eMTC, LEO1200 | DL | 30 | 2 | 70.33 | -33.62 | 1.08 | 164.49 | 0.1 | 3 | 2.2 | 3 | 0 | 2.19 |
| eMTC, LEO600 | DL | 30 | 2 | 64.33 | -33.62 | 1.08 | 159.10 | 0.1 | 3 | 2.2 | 3 | 0 | 1.58 |
| NB-IoT, GEO | DL | 12.5 | 2 | 81.55 | -33.62 | 0.18 | 190.58 | 0.2 | 3 | 2.2 | 3 | 0 | -5.01 |
| NB-IoT, LEO1200 | DL | 30 | 2 | 62.55 | -33.62 | 0.18 | 164.49 | 0.1 | 3 | 2.2 | 3 | 0 | 2.19 |
| NB-IoT, LEO600 | DL | 30 | 2 | 56.55 | -33.62 | 0.18 | 159.10 | 0.1 | 3 | 2.2 | 3 | 0 | 1.58 |

Table 5 Uplink link budget for eMTC with Set 1 parameters

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| eMTC, GEO | UL | 12.5 | 2 | 20 | 19.0 | 1.08 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -21.72 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.36 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -16.94 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.18 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -13.93 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.09 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -10.92 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.045 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -7.91 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.03 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -6.15 |
| eMTC, LEO1200 | UL | 30 | 2 | 20 | 1.1 | 1.08 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | -13.42 |
| UL | 30 | 2 | 20 | 1.1 | 0.36 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | -8.65 |
| UL | 30 | 2 | 20 | 1.1 | 0.18 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | -5.64 |
| UL | 30 | 2 | 20 | 1.1 | 0.09 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | -2.63 |
| UL | 30 | 2 | 20 | 1.1 | 0.045 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | 0.38 |
| UL | 30 | 2 | 20 | 1.1 | 0.03 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | 2.14 |
| eMTC, LEO600 | UL | 30 | 2 | 20 | 1.1 | 1.08 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | -8.03 |
| UL | 30 | 2 | 20 | 1.1 | 0.36 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | -3.26 |
| UL | 30 | 2 | 20 | 1.1 | 0.18 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | -0.25 |
| UL | 30 | 2 | 20 | 1.1 | 0.09 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | 2.76 |
| UL | 30 | 2 | 20 | 1.1 | 0.045 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | 5.77 |
| UL | 30 | 2 | 20 | 1.1 | 0.03 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | 7.53 |

Table 6 Uplink link budget for NB-IoT with Set 1 parameters

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| NB-IoT, GEO | UL | 12.5 | 2 | 20 | 19.0 | 0.18 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -13.93 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.09 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -10.92 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.045 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -7.91 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.015 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | -3.14 |
| UL | 12.5 | 2 | 20 | 19.0 | 0.00375 | 190.58 | 0.2 | 3.0 | 2.2 | 3 | 0 | 2.88 |
| NB-IoT, LEO1200 | UL | 30 | 2 | 20 | 1.1 | 0.18 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | -5.64 |
| UL | 30 | 2 | 20 | 1.1 | 0.09 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | -2.63 |
| UL | 30 | 2 | 20 | 1.1 | 0.045 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | 0.38 |
| UL | 30 | 2 | 20 | 1.1 | 0.015 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | 5.15 |
| UL | 30 | 2 | 20 | 1.1 | 0.00375 | 164.49 | 0.1 | 3.0 | 2.2 | 3 | 0 | 11.17 |
| NB-IoT, LEO600 | UL | 30 | 2 | 20 | 1.1 | 0.18 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | -0.25 |
| UL | 30 | 2 | 20 | 1.1 | 0.09 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | 2.76 |
| UL | 30 | 2 | 20 | 1.1 | 0.045 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | 5.77 |
| UL | 30 | 2 | 20 | 1.1 | 0.015 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | 10.54 |
| UL | 30 | 2 | 20 | 1.1 | 0.00375 | 159.10 | 0.1 | 3.0 | 2.2 | 3 | 0 | 16.56 |

Table 7 Downlink link budget for eMTC and NB-IoT with Set 2 parameters.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| eMTC, GEO | DL | 20 | 2 | 83.83 | -33.62 | 1.08 | 190.41 | 0.2 | 3 | 2.2 | 3 | 0 | -10.34 |
| eMTC, LEO1200 | DL | 30 | 2 | 64.33 | -33.62 | 1.08 | 164.49 | 0.1 | 3 | 2.2 | 3 | 0 | -3.81 |
| eMTC, LEO600 | DL | 30 | 2 | 58.33 | -33.62 | 1.08 | 159.10 | 0.1 | 3 | 2.2 | 3 | 0 | -4.42 |
| NB-IoT, GEO | DL | 20 | 2 | 76.05 | -33.62 | 0.18 | 190.41 | 0.2 | 3 | 2.2 | 3 | 0 | -10.34 |
| NB-IoT, LEO1200 | DL | 30 | 2 | 56.55 | -33.62 | 0.18 | 164.49 | 0.1 | 3 | 2.2 | 3 | 0 | -3.81 |
| NB-IoT, LEO600 | DL | 30 | 2 | 50.55 | -33.62 | 0.18 | 159.10 | 0.1 | 3 | 2.2 | 3 | 0 | -4.42 |

Table 8 Uplink link budget for eMTC with Set 2 parameters

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| eMTC, GEO | UL | 20 | 2 | 20 | 14.0 | 1.08 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -26.55 |
| UL | 20 | 2 | 20 | 14.0 | 0.36 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -21.78 |
| UL | 20 | 2 | 20 | 14.0 | 0.18 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -18.77 |
| UL | 20 | 2 | 20 | 14.0 | 0.09 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -15.76 |
| UL | 20 | 2 | 20 | 14.0 | 0.045 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -12.75 |
| UL | 20 | 2 | 20 | 14.0 | 0.03 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -10.99 |
| eMTC, LEO1200 | UL | 30 | 2 | 20 | -4.9 | 1.08 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -19.42 |
| UL | 30 | 2 | 20 | -4.9 | 0.36 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -14.65 |
| UL | 30 | 2 | 20 | -4.9 | 0.18 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -11.64 |
| UL | 30 | 2 | 20 | -4.9 | 0.09 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -8.63 |
| UL | 30 | 2 | 20 | -4.9 | 0.045 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -5.62 |
| UL | 30 | 2 | 20 | -4.9 | 0.03 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -3.86 |
| eMTC, LEO600 | UL | 30 | 2 | 20 | -4.9 | 1.08 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | -14.03 |
| UL | 30 | 2 | 20 | -4.9 | 0.36 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | -9.26 |
| UL | 30 | 2 | 20 | -4.9 | 0.18 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | -6.25 |
| UL | 30 | 2 | 20 | -4.9 | 0.09 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | -3.24 |
| UL | 30 | 2 | 20 | -4.9 | 0.045 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | -0.23 |
| UL | 30 | 2 | 20 | -4.9 | 0.03 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | 1.53 |

Table 9 Uplink link budget for NB-IoT with Set 2 parameters

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| NB-IoT, GEO | UL | 20 | 2 | 20 | 14.0 | 0.18 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -18.77 |
| UL | 20 | 2 | 20 | 14.0 | 0.09 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -15.76 |
| UL | 20 | 2 | 20 | 14.0 | 0.045 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -12.75 |
| UL | 20 | 2 | 20 | 14.0 | 0.015 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -7.98 |
| UL | 20 | 2 | 20 | 14.0 | 0.00375 | 190.41 | 0.2 | 3.00 | 2.2 | 3 | 0 | -1.95 |
| NB-IoT, LEO1200 | UL | 30 | 2 | 20 | -4.9 | 0.18 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -11.64 |
| UL | 30 | 2 | 20 | -4.9 | 0.09 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -8.63 |
| UL | 30 | 2 | 20 | -4.9 | 0.045 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -5.62 |
| UL | 30 | 2 | 20 | -4.9 | 0.015 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | -0.85 |
| UL | 30 | 2 | 20 | -4.9 | 0.00375 | 164.49 | 0.1 | 3.00 | 2.2 | 3 | 0 | 5.17 |
| NB-IoT, LEO600 | UL | 30 | 2 | 20 | -4.9 | 0.18 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | -6.25 |
| UL | 30 | 2 | 20 | -4.9 | 0.09 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | -3.24 |
| UL | 30 | 2 | 20 | -4.9 | 0.045 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | -0.23 |
| UL | 30 | 2 | 20 | -4.9 | 0.015 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | 4.54 |
| UL | 30 | 2 | 20 | -4.9 | 0.00375 | 159.10 | 0.1 | 3.00 | 2.2 | 3 | 0 | 10.56 |

Table 10 Downlink link budget for eMTC and NB-IoT with Set 3 parameters.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| GEO | DL | 12.5 | 2 | 90.13 | -33.62 | 1.08 | 190.58 | 0.2 | 3 | 2.2 | 3 | 0 | -4.20 |
| LEO1200 | DL | 30 | 2 | 64.03 | -33.62 | 1.08 | 164.48 | 0.1 | 3 | 2.2 | 3 | 0 | -4.11 |
| LEO600 | DL | 30 | 2 | 58.63 | -33.62 | 1.08 | 159.09 | 0.1 | 3 | 2.2 | 3 | 0 | -4.11 |
| GEO | DL | 12.5 | 2 | 82.35 | -33.62 | 0.18 | 190.58 | 0.2 | 3 | 2.2 | 3 | 0 | -4.20 |
| LEO1200 | DL | 30 | 2 | 56.25 | -33.62 | 0.18 | 164.48 | 0.1 | 3 | 2.2 | 3 | 0 | -4.11 |
| LEO600 | DL | 30 | 2 | 50.85 | -33.62 | 0.18 | 159.09 | 0.1 | 3 | 2.2 | 3 | 0 | -4.11 |

Table 11 Uplink link budget for eMTC with Set 3 parameters.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| eMTC, GEO | UL | 12.5 | 2 | 20 | 16.7 | 1.08 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -24.01 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.36 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -19.24 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.18 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -16.23 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.09 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -13.22 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.045 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -10.21 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.03 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -8.45 |
| eMTC, LEO1200 | UL | 30 | 2 | 20 | -12.8 | 1.08 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -27.32 |
| UL | 30 | 2 | 20 | -12.8 | 0.36 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -22.55 |
| UL | 30 | 2 | 20 | -12.8 | 0.18 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -19.54 |
| UL | 30 | 2 | 20 | -12.8 | 0.09 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -16.52 |
| UL | 30 | 2 | 20 | -12.8 | 0.045 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -13.51 |
| UL | 30 | 2 | 20 | -12.8 | 0.03 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -11.75 |
| eMTC, LEO600 | UL | 30 | 2 | 20 | -12.8 | 1.08 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -21.92 |
| UL | 30 | 2 | 20 | -12.8 | 0.36 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -17.15 |
| UL | 30 | 2 | 20 | -12.8 | 0.18 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -14.14 |
| UL | 30 | 2 | 20 | -12.8 | 0.09 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -11.13 |
| UL | 30 | 2 | 20 | -12.8 | 0.045 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -8.12 |
| UL | 30 | 2 | 20 | -12.8 | 0.03 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -6.36 |

Table 12 Uplink link budget for NB-IoT with Set 3 parameters.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| NB-IoT, GEO | UL | 12.5 | 2 | 20 | 16.7 | 0.18 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -16.23 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.09 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -13.22 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.045 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -10.21 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.015 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | -5.44 |
| UL | 12.5 | 2 | 20 | 16.7 | 0.00375 | 190.58 | 0.2 | 3.00 | 2.2 | 3 | 0 | 0.58 |
| NB-IoT, LEO1200 | UL | 30 | 2 | 20 | -12.8 | 0.18 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -19.54 |
| UL | 30 | 2 | 20 | -12.8 | 0.09 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -16.52 |
| UL | 30 | 2 | 20 | -12.8 | 0.045 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -13.51 |
| UL | 30 | 2 | 20 | -12.8 | 0.015 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -8.74 |
| UL | 30 | 2 | 20 | -12.8 | 0.00375 | 164.48 | 0.1 | 3.00 | 2.2 | 3 | 0 | -2.72 |
| NB-IoT, LEO600 | UL | 30 | 2 | 20 | -12.8 | 0.18 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -14.14 |
| UL | 30 | 2 | 20 | -12.8 | 0.09 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -11.13 |
| UL | 30 | 2 | 20 | -12.8 | 0.045 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -8.12 |
| UL | 30 | 2 | 20 | -12.8 | 0.015 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | -3.35 |
| UL | 30 | 2 | 20 | -12.8 | 0.00375 | 159.09 | 0.1 | 3.00 | 2.2 | 3 | 0 | 2.67 |

Table 13 Downlink link budget for eMTC and NB-IoT with Set 4 parameters.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| LEO600 | DL | 30 | 2 | 51.78 | -33.62 | 1.08 | 159.11 | 0.1 | 3 | 2.2 | 3 | 0 | -10.98 |
| LEO600 | DL | 30 | 2 | 44.00 | -33.62 | 0.18 | 159.11 | 0.1 | 3 | 2.2 | 3 | 0 | -10.98 |

Table 14 Uplink link budget for eMTC with Set 4 parameters.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| eMTC, LEO600 | UL | 30 | 2 | 20 | -18.6 | 1.08 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -27.74 |
| UL | 30 | 2 | 20 | -18.6 | 0.36 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -22.97 |
| UL | 30 | 2 | 20 | -18.6 | 0.18 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -19.96 |
| UL | 30 | 2 | 20 | -18.6 | 0.09 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -16.95 |
| UL | 30 | 2 | 20 | -18.6 | 0.045 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -13.94 |
| UL | 30 | 2 | 20 | -18.6 | 0.03 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -12.18 |

Table 15 Uplink link budget for NB-IoT with Set 4 parameters.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | Transmission mode | Elevation angle | Frequency [GHz] | TX: EIRP [dBm] | RX: G/T [dB/T] | Bandwidth [MHz] | Free space path loss [dB] | Atmospheric loss [dB] | Shadow fading margin [dB] | Scintillation Loss [dB] | Polarization loss [dB] | Additional losses [dB] | CNR [dB] |
| NB-IoT, LEO600 | UL | 30 | 2 | 20 | -18.6 | 0.18 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -19.96 |
| UL | 30 | 2 | 20 | -18.6 | 0.09 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -16.95 |
| UL | 30 | 2 | 20 | -18.6 | 0.045 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -13.94 |
| UL | 30 | 2 | 20 | -18.6 | 0.015 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -9.17 |
| UL | 30 | 2 | 20 | -18.6 | 0.00375 | 159.11 | 0.1 | 3.00 | 2.2 | 3 | 0 | -3.15 |

## CMCC link budget results (R1-2102905)

**Table 5: Summary of preliminary link budget for calibration.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | |  | **Set-1** | | | **Set 2** | | | **Set 3** | | | **Set 4** |
| **Satellite orbit** | GEO | LEO-1200 | LEO-600 | GEO | LEO-1200 | LEO-600 | GEO | LEO-1200 | LEO-600 | LEO-600 |
| **Satellite altitude (km)** | 35786 | 1200 | 600 | 35786 | 1200 | 600 | 35786 | 1200 | 600 | 600 |
| **Central beam center elevation (deg)** | 12.5 | 30 | 30 | 20 | 30 | 30 | 20.88 | 46.05 | 43.78 | 90 |
| **FSPL (dB)** | 190.6 | 164.5 | 159.1 | 190.4 | 164.5 | 159.1 | 190.4 | 162.3 | 156.9 | 154.0 |
|  | **UL/DL** | **BW (kHz)** |  |  | | | | | | | | | |
| **NB-IoT** | DL | 180 | CNR (dB) | -5.0 | 2.2 | 1.6 | -10.3 | -3.8 | -4.4 | -4.0 | -2.0 | -1.9 | -5.9 |
| UL | 180 | -13.9 | -5.6 | -0.3 | -18.8 | -11.6 | -6.3 | -16.0 | -17.4 | -11.9 | -14.9 |
| UL | 3.75 | 2.9 | 11.2 | 16.6 | -2.0 | 5.2 | 10.6 | 0.8 | -0.6 | 4.9 | 1.9 |
| **eMTC** | DL | 1080 | -5.0 | 2.2 | 1.6 | -10.3 | -3.8 | -4.4 | -4.0 | -2.0 | -1.9 | -5.9 |
| UL | 1080 | -21.7 | -13.4 | -8.0 | -26.5 | -19.4 | -14.0 | -23.8 | -25.2 | -19.7 | -22.7 |
| UL | 30 | -6.2 | 2.1 | 7.5 | -11.0 | -3.9 | 1.5 | -8.3 | -9.6 | -4.1 | -7.1 |

**Table 6: Summary of FSPL for some other elevation angles.**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Set-1** | | | **Set 2** | | | **Set 3** | | | **Set 4** |
| **Satellite orbit** | GEO | LEO-1200 | LEO-600 | GEO | LEO-1200 | LEO-600 | GEO | LEO-1200 | LEO-600 | LEO-600 |
| **Satellite altitude (km)** | 35786 | 1200 | 600 | 35786 | 1200 | 600 | 35786 | 1200 | 600 | 600 |
| **Elevation angle (deg)** | **Center of a central beam** | 12.5 | 30 | 30 | 20 | 30 | 30 | 20.88 | 46.05 | 43.78 | 90 |
| **Edge of a central beam** | 2.3 | 26.3 | 27 | 11 | 22.2 | 23.8 | 12.5 | 30 | 30 | 30 |
| **Minimum elevation** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **FSPL (dB)** | **Center of a central beam** | 190.6 | 164.5 | 159.1 | 190.4 | 164.5 | 159.1 | 190.4 | 162.3 | 156.9 | 154.0 |
| **Edge of a central beam** | 190.8 | 165.1 | 159.7 | 190.6 | 165.9 | 160.4 | 190.6 | 164.5 | 159.1 | 159.1 |
| **Maximum FSPL** | 190.6 | 168.4 | 164.2 | 190.6 | 168.4 | 164.2 | 190.6 | 168.4 | 164.2 | 164.2 |

## ZTE link budget results (R1-2102916)

Table 3 DL CNR for NB-IoT/eMTC

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | GEO | LEO-600 | LEO-1200 |
| Set-1 | Minimum DL CNR (dB) | -8.06 | -2.02 | -1.41 |
| Set-2 | Minimum DL CNR (dB) | -13.52 | -8.73 | -8.17 |
| Set-3 | Minimum DL CNR (dB) | -7.17 | -7.08 | -7.08 |
| Set-4 | Minimum DL CNR (dB) |  | -13.95 |  |

Table 4 UL CNR for NB-IoT/eMTC

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Bandwidth | GEO | LEO-600 | LEO-1200 |
| Set-1 | 3.75 kHz  15 kHz  30 kHz  45 kHz  90 kHz  180 kHz  360 kHz  1080 kHz | -0.18  -6.20  -9.21  -10.97  -13.98  -16.99  -20.00  -24.77 | 12.97  6.95  3.94  2.17  -0.84  -3.85  -6.86  -11.63 | 7.57  1.55  -1.46  -3.22  -6.23  -9.24  -12.25  -17.03 |
| Set-2 | 3.75 kHz  15 kHz  30 kHz  45 kHz  90 kHz  180 kHz  360 kHz  1080 kHz | -5.14  -11.16  -14.17  -15.93  -18.94  -21.95  -24.96  -29.73 | 6.25  0.23  -2.78  -4.54  -7.55  -10.56  -13.57  -18.34 | 0.81  -5.21  -8.22  -9.98  -12.99  -16.00  -19.01  -23.78 |
| Set-3 | 3.75 kHz  15 kHz  30 kHz  45 kHz  90 kHz  180 kHz  360 kHz  1080 kHz | -2.38  -8.40  -11.41  -13.17  -16.18  -19.20  -22.21  -26.98 | -0.30  -6.32  -9.33  -11.09  -14.10  -17.11  -20.12  -24.89 | -5.69  -11.71  -14.72  -16.48  -19.49  -22.50  -25.52  -30.29 |
| Set-4 | 3.75 kHz  15 kHz  30 kHz  45 kHz  90 kHz  180 kHz  360 kHz  1080 kHz |  | -6.12  -12.14  -15.15  -16.91  -19.92  -22.93  -25.94  -30.71 |  |

|  |  |
| --- | --- |
|  |  |
| Figure 1 Illustration of DL CL for GEO in rural | Figure 2 Illustration of DL CL for LEO-600 in rural |

|  |  |
| --- | --- |
|  |  |
| Figure 3 Illustration of DL CL for LEO-1200 in rural |  |
|  |  |
| Figure 4 Illustration of DL CL for GEO in ubran | Figure 5 Illustration of DL CL for LEO-600 in urban |
|  |  |
| Figure 6 Illustration of DL CL for LEO-1200 in urban |  |
|  |  |
| Figure 7 Illustration of DL CL for GEO in Dense urban | Figure 8 Illustration of DL CL for LEO-600 in Dense urban |
|  |  |
| Figure 9 Illustration of DL CL for LEO-1200 in Dense urban |  |

## Xiaomi link budget results (R1-2102972)

**Table 1. Link budgets for Set-1 satellites**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | | | GEO | | LEO-1200 | | LEO-600 | |
| Transmission mode | | | DL | UL | DL | UL | DL | UL |
| EIRP[dBW] | NB-IOT | | 51.55 | -10 | 32.55 | -10 | 26.55 | -10 |
| eMTC | | 59.33 | -10 | 40.33 | -10 | 34.33 | -10 |
| G/T[dB/K] | | | -33.62 | 19 | -33.62 | 1.1 | -33.62 | 1.1 |
| FSPL[dB] | | | 190.96 | 190.96 | 164.49 | 164.49 | 159.10 | 159.10 |
| Frequency [GHz] | | | 2 | 2 | 2 | 2 | 2 | 2 |
| Elevation angle[°] | | | 12.5 | 12.5 | 30 | 30 | 30 | 30 |
| CNY[dB] | | NB-IOT | -5.39 | -14.31 | 2.18 | -5.64 | 1.57 | -0.25 |
| eMTC | -5.39 | -22.10 | 2.18 | -13.42 | 1.57 | -8.03 |

**Table 2. Link budgets for Set-2 satellites**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | | | GEO | | LEO-1200 | | LEO-600 | |
| Transmission mode | | | DL | UL | DL | UL | DL | UL |
| EIRP[dBW] | NB-IOT | | 46.05 | -10 | 26.55 | -10 | 20.55 | -10 |
| eMTC | | 53.83 | -10 | 34.33 | -10 | 28.33 | -10 |
| G/T[dB/K] | | | -33.62 | 14 | -33.62 | -4.9 | -33.62 | -4.9 |
| FSPL[dB] | | | 189.66 | 189.66 | 164.49 | 164.49 | 159.10 | 159.10 |
| Frequency [GHz] | | | 2 | 2 | 2 | 2 | 2 | 2 |
| Elevation angle[°] | | | 20 | 20 | 30 | 30 | 30 | 30 |
| CNY[dB] | | NB-IOT | -9.59 | -18.01 | -3.82 | -11.64 | -4.43 | -6.25 |
| eMTC | -9.59 | -25.80 | -3.82 | -19.42 | -4.43 | -14.03 |

**Table 3. Link budgets for Set-3 satellites**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | | | GEO | | LEO-1200 | | LEO-600 | |
| Transmission mode | | | DL | UL | DL | UL | DL | UL |
| EIRP[dBW] | NB-IOT | | 52.35 | -10 | 26.25 | -10 | 20.85 | -10 |
| eMTC | | 60.13 | -10 | 34.03 | -10 | 28.63 | -10 |
| G/T[dB/K] | | | -33.62 | 16.7 | -33.62 | -12.8 | -33.62 | -12.8 |
| FSPL[dB] | | | 190.96 | 190.96 | 164.49 | 164.49 | 159.10 | 159.10 |
| Frequency [GHz] | | | 2 | 2 | 2 | 2 | 2 | 2 |
| Elevation angle[°] | | | 12.5 | 12.5 | 30 | 30 | 30 | 30 |
| CNY[dB] | | NB-IOT | -4.59 | -16.61 | -4.12 | -19.54 | -4.13 | -14.15 |
| eMTC | -4.59 | -24.40 | -4.12 | -27.32 | -4.13 | -21.93 |

**Table 4. Link budgets for Set-4 satellites**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Satellite orbit | | | LEO-600 | |
| Transmission mode | | | DL | UL |
| EIRP[dBW] | NB-IOT | | 14 | -10 |
| eMTC | | 21.78 | -10 |
| G/T[dB/K] | | | -33.62 | -18.6 |
| Frequency [GHz] | | | 2 | 2 |
| FSPL[dB] | | | 159.10 | 159.10 |
| Elevation angle[°] | | | 30 | 30 |
| CNY[dB] | | NB-IOT | -10.98 | -19.95 |
| eMTC | -10.98 | -27.73 |

## Ericsson link budget results (R1-2103060)

Table 1 Ranking of simulation scenarios starting with most favourable to least favourable in terms of expected SNR for LEO and GEO.

|  |  |  |
| --- | --- | --- |
|  | **UL** | **DL** |
| **LEO (600 km)** | Set 1, Set 2, Set 3, Set 4 | Set 1, Set 3, Set 2, Set 4 |
| **LEO (1200 km)** | Set 1, Set 2, Set 3 | Set 1, Set 2, Set 3 |
| **GEO** | Set 1, Set 3, Set 2 | Set 3, Set 1, Set 2 |

Table 2 Connection density for eMTC in TN and NTN.

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **LTE-M, TN, Conf A** | **LTE-M, TN, Conf B** | **NTN** |
| **Inter-site (or inter-spotbeam) distance (ISD)** | 500 m | 1732 m | 40 km |
| **No. of devices supported per sq. km with 6 PRBs** | 5,680,683 | 393,600 | 467 |

600 km LEO

Table 4 Link budget for 600 km LEO satellite for Set 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 56.6 | 20.0 | 64.3 | 20.0 |
| RX: G/T [dB/T] | -33.6 | 1.1 | -33.6 | 1.1 |
| Bandwidth [Hz] | 1.80E+05 | 1.80E+05 | 1.08E+06 | 1.80E+05 |
| Free space path loss (PL) [dB] | 159.1 | 159.1 | 159.1 | 159.1 |
| Atmospheric loss (LA) | 0.1 | 0.1 | 0.1 | 0.1 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-1.4** | **-3.2** | **-1.4** | **-3.2** |

Table 5 Link budget for 600 km LEO satellite for Set 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 50.6 | 20.0 | 58.3 | 20.0 |
| RX: G/T [dB/T] | -33.6 | -4.9 | -33.6 | -4.9 |
| Bandwidth [Hz] | 1.80E+05 | 1.80E+05 | 1.08E+06 | 1.80E+05 |
| Free space path loss (PL) [dB] | 159.1 | 159.1 | 159.1 | 159.1 |
| Atmospheric loss (LA) | 0.1 | 0.1 | 0.1 | 0.1 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-7.4** | **-9.2** | **-7.4** | **-9.2** |

Table 6 Link budget for 600 km LEO satellite for Set 3.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 50.9 | 20.0 | 58.6 | 20.0 |
| RX: G/T [dB/T] | -33.6 | -12.8 | -33.6 | -12.8 |
| Bandwidth [Hz] | 1.80E+05 | 1.80E+05 | 1.08E+06 | 1.80E+05 |
| Free space path loss (PL) [dB] | 159.1 | 159.1 | 159.1 | 159.1 |
| Atmospheric loss (LA) | 0.1 | 0.1 | 0.1 | 0.1 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-7.1** | **-17.1** | **-7.1** | **-17.1** |

Table 7 Link budget for 600 km LEO satellite for Set 4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 44.0 | 20.0 | 51.8 | 20.0 |
| RX: G/T [dB/T] | -33.6 | -18.6 | -33.6 | -18.6 |
| Bandwidth [Hz] | 1.80E+05 | 1.80E+05 | 1.08E+06 | 1.80E+05 |
| Free space path loss (PL) [dB] | 159.1 | 159.1 | 159.1 | 159.1 |
| Atmospheric loss (LA) | 0.1 | 0.1 | 0.1 | 0.1 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-13.9** | **-22.9** | **-13.9** | **-22.9** |

1200 km LEO

Table 8 Link budget for 1200 km LEO satellite for Set 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 62.6 | 20.0 | 70.3 | 20.0 |
| RX: G/T [dB/T] | -33.6 | 1.1 | -33.6 | 1.1 |
| Bandwidth [Hz] | 1.80E+05 | 1.80E+05 | 1.08E+06 | 1.80E+05 |
| Free space path loss (PL) [dB] | 164.5 | 164.5 | 164.5 | 164.5 |
| Atmospheric loss (LA) | 0.1 | 0.1 | 0.1 | 0.1 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-0.8** | **-8.6** | **-0.8** | **-8.6** |

Table 9 Link budget for 1200 km LEO satellite for Set 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 56.6 | 20.0 | 64.3 | 20.0 |
| RX: G/T [dB/T] | -33.6 | -4.9 | -33.6 | -4.9 |
| Bandwidth [Hz] | 1.80E+05 | 1.80E+05 | 1.08E+06 | 1.80E+05 |
| Free space path loss (PL) [dB] | 164.5 | 164.5 | 164.5 | 164.5 |
| Atmospheric loss (LA) | 0.1 | 0.1 | 0.1 | 0.1 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-6.8** | **-14.6** | **-6.8** | **-14.6** |

Table 10 Link budget for 1200 km LEO satellite for Set 3.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 56.3 | 20.0 | 64.0 | 20.0 |
| RX: G/T [dB/T] | -33.6 | -12.8 | -33.6 | -12.8 |
| Bandwidth [Hz] | 1.80E+05 | 1.80E+05 | 1.08E+06 | 1.80E+05 |
| Free space path loss (PL) [dB] | 164.5 | 164.5 | 164.5 | 164.5 |
| Atmospheric loss (LA) | 0.1 | 0.1 | 0.1 | 0.1 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-7.1** | **-22.5** | **-7.1** | **-22.5** |

GEO

Table 11 Link budget for GEO satellite for Set 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 81.6 | 20.0 | 89.3 | 20.0 |
| RX: G/T [dB/T] | -33.6 | 19.0 | -33.6 | 19.0 |
| Bandwidth [Hz] | 180000.0 | 180000.0 | 1080000.0 | 180000.0 |
| Free space path loss (PL) [dB] | 190.57 | 190.57 | 190.57 | 190.57 |
| Atmospheric loss (LA) | 0.2 | 0.2 | 0.2 | 0.2 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-8** | **-16.92** | **-8** | **-16.92** |

Table 12 Link budget for GEO satellite for Set 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 76.1 | 20.0 | 83.8 | 20.0 |
| RX: G/T [dB/T] | -33.6 | 14.0 | -33.6 | 14.0 |
| Bandwidth [Hz] | 180000.0 | 180000.0 | 1080000.0 | 180000.0 |
| Free space path loss (PL) [dB] | 190.41 | 190.41 | 190.41 | 190.41 |
| Atmospheric loss (LA) | 0.2 | 0.2 | 0.2 | 0.2 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-13.33** | **-21.76** | **-13.33** | **-21.76** |

Table 13 Link budget for GEO satellite for Set 3.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System | NB-IoT | | eMTC | |
|  | DL | UL | DL | UL |
| TX: EIRP/spotbeam [dBm] | 82.4 | 20.0 | 90.1 | 20.0 |
| RX: G/T [dB/T] | -33.6 | 16.7 | -33.6 | 16.7 |
| Bandwidth [Hz] | 180000.0 | 180000.0 | 1080000.0 | 180000.0 |
| Free space path loss (PL) [dB] | 190.57 | 190.57 | 190.57 | 190.57 |
| Atmospheric loss (LA) | 0.2 | 0.2 | 0.2 | 0.2 |
| Shadow fading margin (SF) [dB] | 3 | 3 | 3 | 3 |
| Scintillation loss (SL) [dB] | 2.2 | 2.2 | 2.2 | 2.2 |
| Polarization loss [dB] | 3 | 3 | 3 | 3 |
| Additional losses (AD) [dB] | 3 | 3 | 3 | 3 |
| Target SNR [dB] | **-7.20** | **-19.22** | **-7.20** | **-19.22** |

## Qualcomm link budget results (R1-2103070)

Link Budgets for Set 2 (LEO)

Table 1: Assumptions for calculating uplink link budgets in S-band LEO satellites (Set 2 in [2])

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Orbit Alt. (km)** | **Sat Antenna Gain (dBi)** | **G/T (dB/K)** | **UE Power (dBm)** | **UE antenna gain (dBi)** | **Shadowing Margin (dB)** | **Polarization loss (dB)** | **Signal BW**  **(kHz)** | **Channel Condition** |
| 1200/600 | 24 | -4.9 | 23  *(20)* | 0 | 3 | 3 (1 Tx ant) | 180 | Clear Sky and LOS |

Table 2: Uplink link budgets for beam center UEs with a full PRB UL transmission to S-band LEO satellites (Set 2 in [2]). The numbers in parentheses represent the achievable SNRs with 20 dBm power class UEs.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Elevation Angle (Deg)** | **10** | **20** | **30** | **40** | **50** | **60** | **70** | **80** | **90** |
| SNR (dB) @1200 km | -12.4  *(-15.4)* | -10.3  *(-13.3)* | -8.5  *(-11.5)* | -7.1  *(-10.1)* | -6.0  *(-9.0)* | -5.1  *(-8.1)* | -4.6  *(-7.6)* | -4.2  *(-7.2)* | -4.1  *(-7.1)* |
| SNR (dB) @600 km | -8.2  *(-11.2)* | -5.4  *(-8.4)* | -3.2  *(-6.2)* | -1.4  *(-4.4)* | 0.1  *(-3.1)* | 1.2  *(-2.2)* | 2.6  *(-1.6)* | 2.2  *(-1.2)* | 2.1  *(-1.1)* |

Table 3: Assumptions for calculating downlink link budgets in LEO satellites (Set 2 in [2])

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Orbit Alt. (km)** | **Baseline Sat EIRP** | **UE antenna gain (dBi)** | **UE NF (dB)** | **Shadowing Margin (dB)** | **No. of UE antennas** | **Channel Condition** |
| 1200 | 64dBm/MHz | 0 | 9 | 3 | 1 | Clear Sky and LOS |
| 600 | 58dBm/MHz | 0 | 9 | 3 | 1 | Clear Sky and LOS |

Table 4: Downlink link budgets for transmission from LEO satellites (Set 2 in [2]).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Elevation Angle (Deg)** | **10** | **20** | **30** | **40** | **50** | **60** | **70** | **80** | **90** |
| SNR (dB) @1200 km | -7.58 | -5.47 | -3.69 | -2.24 | -2.88 | -1.72 | 0.30 | 0.63 | 0.75 |
| SNR (dB) @600 km | -9.39 | -6.54 | -4.30 | -2.58 | -2.70 | -1.64 | 0.28 | 0.65 | 0.77 |

Link Budgets for Set 3 (LEO)

Table 5: Comparing Set 3 vs Set 2 UL link budgets for LEO satellites, at beam edge elevation for Set 3

|  |  |  |
| --- | --- | --- |
| **Elevation Angle = 30 Degrees** | **Set 2** | **Set 3** |
| Uplink SNR (dB) @1200 km | -11.5 | **-19.4** |
| Uplink SNR (dB) @600 km | -6.2 | **-14** |

Link Budgets for Set 4 (LEO 600 km orbit only)

Table 6: Comparing Set 4 vs Set 2 vs Set 3 UL link budgets for LEO satellites, at beam edge elevation for Set 4

|  |  |  |  |
| --- | --- | --- | --- |
| **Elevation Angle**  **= 30 Degrees** | **Set 2** | **Set 3** | **Set 4** |
| Uplink SNR (dB) @600 km | -6.2 | -14 | **-19.9** |

Table 7: Comparing Set 4 vs Set 2 vs Set 3 DL link budgets for LEO satellites, at beam edge elevation for Set 4

|  |  |  |  |
| --- | --- | --- | --- |
| **Elevation Angle**  **= 30 Degrees** | **Set 2** | **Set 3** | **Set 4** |
| Downlink SNR (dB) @600 km | -4.3 | -4.3 | **-10.9** |

## Apple link budget results (R1-2103132)

*Link budget for Set 1:*

Table 1: DL NB-IoT/eMTC link budget based on set 1 satellite parameters in [5]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | GEO | | LEO-1200 | | LEO-600 | |
|  | NB-IoT | eMTC | NB-IoT | eMTC | NB-IoT | eMTC |
| Satellite EIRP density (dBW/MHz) | 59 | | 40 | | 34 | |
| Channel bandwidth (MHz) | 0.18 | 1.08 | 0.18 | 1.08 | 0.18 | 1.08 |
| **Satellite EIRP (dBm)** | **81.55** | **89.33** | **62.55** | **70.33** | **56.55** | **64.33** |
|  |  | |  | |  | |
| Central beam edge elevation (degree) | 12.5 | | 30 | | 30 | |
| Max. distance between satellite and IoT device (km) | 40308 | | 1998 | | 1075 | |
| Carrier frequency (GHz) | 2 | | 2 | | 2 | |
| **Free space path loss (dB)** | **190.58** | | **164.48** | | **159.10** | |
| Shadowing (dB) | 3 | | 3 | | 3 | |
| Atmospheric path loss (dB) | 0.2 | | 0.1 | | 0.1 | |
| Scintillation loss (dB) | 2.2 | | 2.2 | | 2.2 | |
| Polarization loss (dB) | 3 | | 3 | | 3 | |
|  |  | |  | |  | |
| IoT antenna temperature (K) | 290 | | 290 | | 290 | |
| Thermal noise (dBW/Hz) | -174 | | -174 | | -174 | |
| **Noise floor (dBm)** | **-121.45** | **-113.67** | **-121.45** | **-113.67** | **-121.45** | **-113.67** |
| IoT noise figure (dB) | 9 | | 9 | | 9 | |
| IoT device antenna gain (dBi) | 0 | | 0 | | 0 | |
|  |  | |  | |  | |
| **CNR (dB)** | **-4.98** | **-4.98** | **2.22** | **2.22** | **1.60** | **1.60** |

Table 2: UL NB-IoT/eMTC link budget based on set 1 satellite parameters in [5]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | GEO | | LEO-1200 | | LEO-600 | |
|  | NB-IoT | eMTC | NB-IoT | eMTC | NB-IoT | eMTC |
| IoT device max Tx power (dBm) | 20 | | 20 | | 20 | |
| IoT device antenna gain (dBi) | 0 | | 0 | | 0 | |
| **IoT device EIRP (dBm)** | **20** | | **20** | | **20** | |
|  |  | |  | |  | |
| Central beam edge elevation (degree) | 12.5 | | 30 | | 30 | |
| Max. distance between satellite and IoT device (km) | 40308 | | 1998 | | 1075 | |
| Carrier frequency (GHz) | 2 | | 2 | | 2 | |
| **Free space path loss (dB)** | **190.58** | | **164.48** | | **159.10** | |
| Shadowing (dB) | 3 | | 3 | | 3 | |
| Atmospheric path loss (dB) | 0.2 | | 0.1 | | 0.1 | |
| Scintillation loss (dB) | 2.2 | | 2.2 | | 2.2 | |
| Polarization loss (dB) | 3 | | 3 | | 3 | |
|  |  | |  | |  | |
| Antenna temperature (K) | 290 | | 290 | | 290 | |
| G/T (dB/K) | 19 | | 1.1 | | 1.1 | |
| Satellite Rx gain (dBi) | 43.63 | | 25.72 | | 25.72 | |
| Channel bandwidth (MHz) | 0.015 | 0.18 | 0.015 | 0.18 | 0.015 | 0.18 |
|  |  | |  | |  | |
| **CNR (dB)** | **-3.12** | **-13.91** | **5.18** | **-5.61** | **10.56** | **-0.23** |

*Link budget for Set 2:*

Table 3: DL NB-IoT/eMTC link budget based on set 2 satellite parameters in [5]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | GEO | | LEO-1200 | | LEO-600 | |
|  | NB-IoT | eMTC | NB-IoT | eMTC | NB-IoT | eMTC |
| Satellite EIRP density (dBW/MHz) | 53.5 | | 34 | | 28 | |
| Channel bandwidth (MHz) | 0.18 | 1.08 | 0.18 | 1.08 | 0.18 | 1.08 |
| **Satellite EIRP (dBm)** | **76.05** | **83.83** | **56.55** | **64.33** | **50.55** | **58.33** |
|  |  | |  | |  | |
| Central beam edge elevation (degree) | 12.5 | | 30 | | 30 | |
| Max. distance between satellite and IoT device (km) | 40308 | | 1998 | | 1075 | |
| Carrier frequency (GHz) | 2 | | 2 | | 2 | |
| **Free space path loss (dB)** | **190.58** | | **164.48** | | **159.10** | |
| Shadowing (dB) | 3 | | 3 | | 3 | |
| Atmospheric path loss (dB) | 0.2 | | 0.1 | | 0.1 | |
| Scintillation loss (dB) | 2.2 | | 2.2 | | 2.2 | |
| Polarization loss (dB) | 3 | | 3 | | 3 | |
|  |  | |  | |  | |
| IoT antenna temperature (K) | 290 | | 290 | | 290 | |
| Thermal noise (dBW/Hz) | -174 | | -174 | | -174 | |
| **Noise floor (dBm)** | **-121.45** | **-113.67** | **-121.45** | **-113.67** | **-121.45** | **-113.67** |
| IoT noise figure (dB) | 9 | | 9 | | 9 | |
| IoT device antenna gain (dBi) | 0 | | 0 | | 0 | |
|  |  | |  | |  | |
| **CNR (dB)** | **-10.48** | **-10.48** | **-3.78** | **-3.78** | **-4.40** | **-4.40** |

Table 4: UL NB-IoT/eMTC link budget based on set 2 satellite parameters in [5]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | GEO | | LEO-1200 | | LEO-600 | |
|  | NB-IoT | eMTC | NB-IoT | eMTC | NB-IoT | eMTC |
| IoT device max Tx power (dBm) | 20 | | 20 | | 20 | |
| IoT device antenna gain (dBi) | 0 | | 0 | | 0 | |
| **IoT device EIRP (dBm)** | **20** | | **20** | | **20** | |
|  |  | |  | |  | |
| Central beam edge elevation (degree) | 12.5 | | 30 | | 30 | |
| Max. distance between satellite and IoT device (km) | 40308 | | 1998 | | 1075 | |
| Carrier frequency (GHz) | 2 | | 2 | | 2 | |
| **Free space path loss (dB)** | **190.58** | | **164.48** | | **159.10** | |
| Shadowing (dB) | 3 | | 3 | | 3 | |
| Atmospheric path loss (dB) | 0.2 | | 0.1 | | 0.1 | |
| Scintillation loss (dB) | 2.2 | | 2.2 | | 2.2 | |
| Polarization loss (dB) | 3 | | 3 | | 3 | |
|  |  | |  | |  | |
| Antenna temperature (K) | 290 | | 290 | | 290 | |
| G/T (dB/K) | 14 | | -4.9 | | -4.9 | |
| Satellite Rx gain (dBi) | 38.62 | | 19.72 | | 19.72 | |
| Channel bandwidth (MHz) | 0.015 | 0.18 | 0.015 | 0.18 | 0.015 | 0.18 |
|  |  | |  | |  | |
| **CNR (dB)** | **-8.12** | **-18.91** | **-0.82** | **-11.61** | **4.56** | **-6.23** |

*Link budget for Set 3:*

Table 5: DL NB-IoT/eMTC link budget based on set 3 satellite parameters in [2]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | GEO | | LEO-1200 | | LEO-600 | |
|  | NB-IoT | eMTC | NB-IoT | eMTC | NB-IoT | eMTC |
| Satellite EIRP density (dBW/MHz) | 59.8 | | 33.7 | | 28.3 | |
| Channel bandwidth (MHz) | 0.18 | 1.08 | 0.18 | 1.08 | 0.18 | 1.08 |
| **Satellite EIRP (dBm)** | **82.35** | **90.13** | **56.25** | **64.03** | **50.85** | **58.63** |
|  |  | |  | |  | |
| Central beam edge elevation (degree) | 12.5 | | 30 | | 30 | |
| Max. distance between satellite and IoT device (km) | 40308 | | 1998 | | 1075 | |
| Carrier frequency (GHz) | 2 | | 2 | | 2 | |
| **Free space path loss (dB)** | **190.20** | | **164.48** | | **159.10** | |
| Shadowing (dB) | 3 | | 3 | | 3 | |
| Atmospheric path loss (dB) | 0.2 | | 0.1 | | 0.1 | |
| Scintillation loss (dB) | 2.2 | | 2.2 | | 2.2 | |
| Polarization loss (dB) | 3 | | 3 | | 3 | |
|  |  | |  | |  | |
| IoT antenna temperature (K) | 290 | | 290 | | 290 | |
| Thermal noise (dBW/Hz) | -174 | | -174 | | -174 | |
| **Noise floor (dBm)** | **-121.45** | **-113.67** | **-121.45** | **-113.67** | **-121.45** | **-113.67** |
| IoT noise figure (dB) | 9 | | 9 | | 9 | |
| IoT device antenna gain (dBi) | 0 | | 0 | | 0 | |
|  |  | |  | |  | |
| **CNR (dB)** | **-4.18** | **-4.18** | **-4.08** | **-4.08** | **-4.10** | **-4.10** |

Table 6: UL NB-IoT/eMTC link budget based on set 3 satellite parameters in [2]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | GEO | | LEO-1200 | | LEO-600 | |
|  | NB-IoT | eMTC | NB-IoT | eMTC | NB-IoT | eMTC |
| IoT device max Tx power (dBm) | 20 | | 20 | | 20 | |
| IoT device antenna gain (dBi) | 0 | | 0 | | 0 | |
| **IoT device EIRP (dBm)** | **20** | | **20** | | **20** | |
|  |  | |  | |  | |
| Central beam edge elevation (degree) | 12.5 | | 30 | | 30 | |
| Max. distance between satellite and IoT device (km) | 40308 | | 1998 | | 1075 | |
| Carrier frequency (GHz) | 2 | | 2 | | 2 | |
| **Free space path loss (dB)** | **190.58** | | **164.48** | | **159.10** | |
| Shadowing (dB) | 3 | | 3 | | 3 | |
| Atmospheric path loss (dB) | 0.2 | | 0.1 | | 0.1 | |
| Scintillation loss (dB) | 2.2 | | 2.2 | | 2.2 | |
| Polarization loss (dB) | 3 | | 3 | | 3 | |
|  |  | |  | |  | |
| Antenna temperature (K) | 290 | | 290 | | 290 | |
| G/T (dB/K) | 16.7 | | -12.8 | | -12.8 | |
| Satellite Rx gain (dBi) | 41.32 | | 11.82 | | 11.82 | |
| Channel bandwidth (MHz) | 0.015 | 0.18 | 0.015 | 0.18 | 0.015 | 0.18 |
|  |  | |  | |  | |
| **CNR (dB)** | **-5.42** | **-16.21** | **-8.72** | **-19.51** | **-3.34** | **-14.13** |

*Link budget for Set 4:*

Table 7: DL NB-IoT/eMTC link budget based on set 4 satellite parameters in [2]

|  |  |  |
| --- | --- | --- |
| Satellite orbit | LEO-600 (DL) | |
|  | NB-IoT | eMTC |
| Satellite EIRP density (dBW/MHz) | 21.45 | |
| Channel bandwidth (MHz) | 0.18 | 1.08 |
| **Satellite EIRP (dBm)** | **44.00** | **51.78** |
|  |  | |
| Central beam edge elevation (degree) | 30 | |
| Max. distance between satellite and IoT device (km) | 1075 | |
| Carrier frequency (GHz) | 2 | |
| **Free space path loss (dB)** | **159.10** | |
| Shadowing (dB) | 3 | |
| Atmospheric path loss (dB) | 0.1 | |
| Scintillation loss (dB) | 2.2 | |
| Polarization loss (dB) | 3 | |
|  |  | |
| IoT antenna temperature (K) | 290 | |
| Thermal noise (dBW/Hz) | -174 | |
| **Noise floor (dBm)** | **-121.45** | **-113.67** |
| IoT noise figure (dB) | 9 | |
| IoT device antenna gain (dBi) | 0 | |
|  |  | |
| **CNR (dB)** | **-10.95** | **-10.95** |

Table 8: UL NB-IoT/eMTC link budget based on set 4 satellite parameters in [2]

|  |  |  |
| --- | --- | --- |
| Satellite orbit | LEO-600 | |
|  | NB-IoT | eMTC |
| IoT device max Tx power (dBm) | 20 | |
| IoT device antenna gain (dBi) | 0 | |
| **IoT device EIRP (dBm)** | **20** | |
|  |  | |
| Central beam edge elevation (degree) | 30 | |
| Max. distance between satellite and IoT device (km) | 1075 | |
| Carrier frequency (GHz) | 2 | |
| **Free space path loss (dB)** | **159.10** | |
| Shadowing (dB) | 3 | |
| Atmospheric path loss (dB) | 0.1 | |
| Scintillation loss (dB) | 2.2 | |
| Polarization loss (dB) | 3 | |
|  |  | |
| Antenna temperature (K) | 290 | |
| G/T (dB/K) | -18.6 | |
| Satellite Rx gain (dBi) | 6.02 | |
| Channel bandwidth (MHz) | 0.015 | 0.18 |
|  |  | |
| **CNR (dB)** | **-9.14** | **-19.93** |

## Samsung link budget results (R1-2103266)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SET 1 - Downlink link budget** | GEO  35786 km | LEO  1200 km | LEO  600 km | units |
| Elevation angle | 12.5 | 30 | 30 | degree |
| EIRP Density | 59 | 40 | 34 | dBW/MHz |
| EIRP per spot (1080 kHz) | 59.3 | 40.3 | 34.3 | dBW |
| EIRP per spot (180 kHz) | 51.6 | 32.6 | 26.6 | dBW |
| RX antenna gain | 0 | 0 | 0 | dBi |
| Path length UE-Satellite | 40316.7 | 1998.9 | 1075.1 | Km |
| FSPL | 190.6 | 164.5 | 159.1 | dB |
| FPSL + other losses | 199.0 | 172.8 | 167.4 | dB |
| Received power | -117.1 | -109.9 | -110.5 | dBW |
| **(C/N)\_DL (1080 kHz)** | **-3.0** | **4.2** | **3.6** | **dB** |
| **(C/N)\_DL (180 kHz)** | **-3.0** | **4.2** | **3.6** | **dB** |
| G/T = Ga – NF – 10\*LOG (To+(Ta-To)/(100.1\*NF)) | -31.6 | -31.6 | -31.6 | dB/K |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SET 1 - Uplink link budget** | GEO 35786 km | LEO 1200 km | LEO 600 km | units |
| Elevation angle | 12.5 | 30 | 30 | degree |
| Transmitted power | -7 | -7 | -7 | dBW |
| TX antenna gain | 0 | 0 | 0 | dBi |
| EIRP | -7 | -7 | -7 | dBW |
| RX antenna gain | 51 | 24.1 | 24.1 | dBi |
| Path length UE-Satellite | 40316.7 | 1998.9 | 1075.1 | Km |
| FSPL | 190.6 | 164.5 | 159.1 | dB |
| FPSL + other losses | 199.0 | 172.8 | 167.4 | dB |
| Received power | -155.0 | -155.7 | -150.3 | dBW |
| **(C/N)\_UL (45 kHz)** | **-7.9** | **0.4** | **5.8** | **dB** |
| **(C/N)\_UL (15 kHz)** | **-3.1** | **5.2** | **10.5** | **dB** |
| **(C/N)\_UL (3.75 kHz)** | **2.9** | **11.2** | **16.6** | **dB** |
| G/T  [TR 38.821 SET1, NR NTN] | 19 | 1.1 | 1.1 | dB/K |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SET 2 - Downlink link budget** | GEO 35786 km | LEO 1200 km | LEO 600 km | units |
| Elevation angle | 12.5 | 30 | 30 | degree |
| EIRP Density | 53.5 | 34 | 28 | dBW/MHz |
| EIRP per spot (1080 kHz) | 53.8 | 34.3 | 28.3 | dBW |
| EIRP per spot (180 kHz) | 46.1 | 26.6 | 20.6 | dBW |
| RX antenna gain | 0 | 0 | 0 | dBi |
| Carrier frequency | 2 | 2 | 2 | GHz |
| Path length UE-Satellite | 40316.7 | 1998.9 | 1075.1 | Km |
| FSPL | 190.6 | 164.5 | 159.1 | dB |
| FPSL + other losses | 199.0 | 172.8 | 167.4 | dB |
| Received power | -122.6 | -115.9 | -116.5 | dBW |
| **(C/N)\_DL (1080 kHz)** | **-8.5** | **-1.8** | **-2.4** | **dB** |
| **(C/N)\_DL (180 kHz)** | **-8.5** | **-1.8** | **-2.4** | **dB** |
| G/T = Ga – NF – 10\*LOG (To+(Ta-To)/(100.1\*NF)) | -31.6 | -31.6 | -31.6 | dB/K |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SET 2 - Uplink link budget** | GEO 35786 km | LEO 1200 km | LEO 600 km | units |
| Elevation angle | 12.5 | 30 | 30 | degree |
| Transmitted power | -7 | -7 | -7 | dBW |
| TX antenna gain | 0 | 0 | 0 | dBi |
| EIRP | -7 | -7 | -7 | dBW |
| RX antenna gain | 51 | 24.1 | 24.1 | dBi |
| Path length UE-Satellite | 40316.7 | 1998.9 | 1075.1 | Km |
| FSPL | 190.6 | 164.5 | 159.1 | dB |
| FPSL + other losses | 199.0 | 172.8 | 167.4 | dB |
| Received power | -155.0 | -155.7 | -150.3 | dBW |
| **(C/N)\_UL (45 kHz)** | **-12.9** | **-5.6** | **-0.2** | **dB** |
| **(C/N)\_UL (15 kHz)** | **-8.1** | **-0.8** | **4.5** | **dB** |
| **(C/N)\_UL (3.75 kHz)** | **-2.1** | **5.2** | **10.6** | **dB** |
| G/T [TR 38.821 SET1, NR NTN] | 14 | -4.9 | -4.9 | dB/K |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SET 3 - Downlink link budget** | GEO 35786 km | LEO 1200 km | LEO 600 km | units |
| Elevation angle | 12.5 | 30 | 30 | degree |
| EIRP Density | 59.8 | 33.7 | 28.3 | dBW/MHz |
| EIRP per spot (1080 kHz) | 60.1 | 34.0 | 28.6 | dBW |
| EIRP per spot (180 kHz) | 52.4 | 26.3 | 20.9 | dBW |
| RX antenna gain | 0 | 0 | 0 | dBi |
| Path length UE-Satellite | 40316.7 | 1998.9 | 1075.1 | Km |
| FSPL | 190.6 | 164.5 | 159.1 | dB |
| FPSL + other losses | 199.0 | 172.8 | 167.4 | dB |
| Received power | -116.3 | -116.2 | -116.2 | dBW |
| **(C/N)\_DL (1080 kHz)** | **-2.2** | **-2.1** | **-2.1** | **dB** |
| **(C/N)\_DL (180 kHz)** | **-2.2** | **-2.1** | **-2.1** | **dB** |
| G/T = Ga – NF – 10\*LOG (To+(Ta-To)/(100.1\*NF)) | -31.6 | -31.6 | -31.6 | dB/K |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SET 3 - Uplink link budget** | GEO 35786 km | LEO 1200 km | LEO 600 km | units |
| Elevation angle | 12.5 | 30 | 30 | degree |
| Transmitted power | -7 | -7 | -7 | dBW |
| TX antenna gain | 0 | 0 | 0 | dBi |
| EIRP | -7 | -7 | -7 | dBW |
| RX antenna gain | 51 | 24.1 | 24.1 | dBi |
| Path length UE-Satellite | 40316.7 | 1998.9 | 1075.1 | Km |
| FSPL | 190.6 | 164.5 | 159.1 | dB |
| FPSL + other losses | 199.0 | 172.8 | 167.4 | dB |
| Received power | -155.0 | -155.7 | -150.3 | dBW |
| **(C/N)\_UL (45 kHz)** | **-10.2** | **-13.5** | **-8.1** | **dB** |
| **(C/N)\_UL (15 kHz)** | **-5.4** | **-8.7** | **-3.4** | **dB** |
| **(C/N)\_UL (3.75 kHz)** | **0.6** | **-2.7** | **2.7** | **dB** |
| G/T [EUTELSAT (NB-IoT)] | 16.7 | -12.8 | -12.8 | dB/K |

|  |  |  |  |
| --- | --- | --- | --- |
| **SET 4 - Downlink link budget** | SINGLE BEAM  LEO 600 km | MULTIPLE BEAM  LEO 600 km | units |
| Elevation angle | 56.8 | 30 | degree |
| EIRP Density | 21.45 | 21.45 | dBW/MHz |
| EIRP per spot (1080 kHz) | 21.8 | 21.8 | dBW |
| EIRP per spot (180 kHz) | 14.0 | 14.0 | dBW |
| RX antenna gain | 0 | 0 | dBi |
| Path length UE-Satellite | 704.3 | 1075.1 | Km |
| FSPL | 155.4 | 159.1 | dB |
| FPSL + other losses | 163.7 | 167.4 | dB |
| Received power | -119.4 | -123.1 | dBW |
| **(C/N)\_DL (1080 kHz)** | **-8.3** | **-12.0** | **dB** |
| **(C/N)\_DL (180 kHz)** | **-8.3** | **-12.0** | **dB** |
| G/T = Ga – NF – 10\*LOG (To+(Ta-To)/(100.1\*NF)) | -31.6 | -31.6 | dB/K |

|  |  |  |  |
| --- | --- | --- | --- |
| **SET 4 - Uplink link budget** | SINGLE-BEAM LEO 600 km | MULTIPLE BEAM LEO 600 km | units |
| Elevation angle | 56.8 | 30 | degree |
| Transmitted power | -7 | -7 | dBW |
| TX antenna gain | 0 | 0 | dBi |
| EIRP | -7 | -7 | dBW |
| RX antenna gain | 24.1 | 24.1 | dBi |
| Path length UE-Satellite | 704.3 | 1075.1 | Km |
| FSPL | 155.4 | 159.1 | dB |
| FPSL + other losses | 163.7 | 167.4 | dB |
| Received power | -146.6 | -150.3 | dBW |
| **(C/N)\_UL (45 kHz)** | **-6.6** | **-13.2** | **dB** |
| **(C/N)\_UL (15 kHz)** | **-1.8** | **-8.5** | **dB** |
| **(C/N)\_UL (3.75 kHz)** | **4.2** | **-2.4** | **dB** |
| G/T [SATELIOT (NB-IoT)] | -17.9 | -20.9 | dB/K |

## Sony link budget results (R1-2103318)

Table 1 - Link budget evaluation for Rel-15 eMTC (sub-PRB PUSCH)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | GEO | | LEO-1200 | | LEO-600 | |
| Transmission mode | DL | UL | DL | UL | DL | UL |
| Frequency [GHz] | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| TX: EIRP [dBm] | 90.13 | 23.00 | 64.03 | 23.00 | 58.63 | 23.00 |
| RX: G/T [dB/T] | -31.62 | 16.70 | -31.62 | -12.80 | -31.62 | -12.80 |
| Bandwidth [MHz] | 1.08 | 0.015 | 1.08 | 0.015 | 1.08 | 0.015 |
| Free space path loss [dB] | 190.58 | 190.58 | 164.49 | 164.49 | 159.10 | 159.10 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Atmospheric loss [dB] | 0.12 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 |
| Shadow fading margin [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Scintillation Loss [dB] | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 |
| Polarization loss [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Additional losses [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| CNR [dB] | -5.124 | -5.361 | -5.120 | -8.757 | -5.123 | -3.360 |

**Table 2 - Link budget evaluation for Rel-13 eMTC (full-PRB PUSCH)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | GEO | | LEO-1200 | | LEO-600 | |
| Transmission mode | DL | UL | DL | UL | DL | UL |
| Frequency [GHz] | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| TX: EIRP [dBm] | 90.13 | 23.00 | 64.03 | 23.00 | 58.63 | 23.00 |
| RX: G/T [dB/T] | -31.62 | 16.70 | -31.62 | -12.80 | -31.62 | -12.80 |
| Bandwidth [MHz] | 1.08 | 0.180 | 1.08 | 0.180 | 1.08 | 0.180 |
| Free space path loss [dB] | 190.58 | 190.58 | 164.49 | 164.49 | 159.10 | 159.10 |
| Atmospheric loss [dB] | 0.12 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 |
| Shadow fading margin [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Scintillation Loss [dB] | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 |
| Polarization loss [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Additional losses [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| CNR [dB] | -5.124 | -16.153 | -5.120 | -19.549 | -5.123 | -14.152 |

**Table 3 - Link budget evaluation for NB-IoT**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | GEO | | LEO-1200 | | LEO-600 | |
| Transmission mode | DL | UL | DL | UL | DL | UL |
| Frequency [GHz] | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| TX: EIRP [dBm] | 82.35 | 23.00 | 56.25 | 23.00 | 50.85 | 23.00 |
| RX: G/T [dB/T] | -31.62 | 16.70 | -31.62 | -12.80 | -31.62 | -12.80 |
| Bandwidth [MHz] | 0.180 | 0.015 | 0.180 | 0.015 | 0.180 | 0.015 |
| Free space path loss [dB] | 190.58 | 190.58 | 164.49 | 164.49 | 159.10 | 159.10 |
| Atmospheric loss [dB] | 0.12 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 |
| Shadow fading margin [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Scintillation Loss [dB] | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 | 2.20 |
| Polarization loss [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Additional losses [dB] | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| CNR [dB] | -5.124 | -5.361 | -5.120 | -8.757 | -5.123 | -3.360 |

## Sateliot, Gatehouse, Thales link budget results (R1-2103716)

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Configuration A**  (Based on common assumptions in TR 36.763 v0.1.0 section 6.2.1) | **Configuration B**  (common assumptions + some enhancements - marked in bold) |
| Satellite platform | Altitude | 600 km, circular orbit | 600 km, circular orbit |
| Transmit power | 33 dBm | **36 dBm** |
| Tx/Rx Antenna Gain | 11 dBi | 11 dBi |
| H-HPBW | 104.7 degrees | 104.7 degrees |
| V-HPBW | 40 degrees | 40 degrees |
| Antenna polarization | Circular | Circular |
| Antenna temperature | 290 K | 290 K |
| Noise Figure (NF) | 5 dB | **3 dB** |
| G/T | -18.6 dB/K | **-16.6 dB/K** |
| IoT device | Transmit power | 20 dBm | **23 dBm** |
| Tx/Rx Antenna Gain | 0 dBi | 0 dBi |
| Antenna polarization | Linear | Linear |
| Antenna temperature | 290 K | 290 K |
| Noise Figure (NF) | 9 dB | **5 dB** |
| G/T | -33.6 dB/K | **-29.6 dB/K** |
| NB-IoT protocol | Downlink channel bandwidth | 180 kHz | 180 kHz |
| Uplink channel bandwidth | 3.75 kHz | 3.75 kHz |
| Other losses | Polarization | 3 dB | 3 dB |
| Scintillation | 2.2 dB | 2.2 dB |
| Atmospheric absorption | 0.1 dB | 0.1 dB |
| Shadow margin | 3 dB | 3 dB |

**Table 1 -** Assumptions for link budget computation

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Configuration A**  (Based on common assumptions in TR 36.763 v0.1.0 section 6.2.1) | **Configuration B**  (common assumptions + some enhancements) |
| **Downlink SNR** | Elevation angle=90º | -5.91 dB | 1.09 dB |
| Elevation angle=30º | -13.98 dB | -6.98 dB |
| **Uplink SNR**  **(ST 3.75 kHz)** | Elevation angle=90º | 1.90 dB | 6.90 dB |
| Elevation angle=30º | -6.16 dB | -1.16 dB |

**Table 2 -** Link budget results at worst and best beam footprint locations.

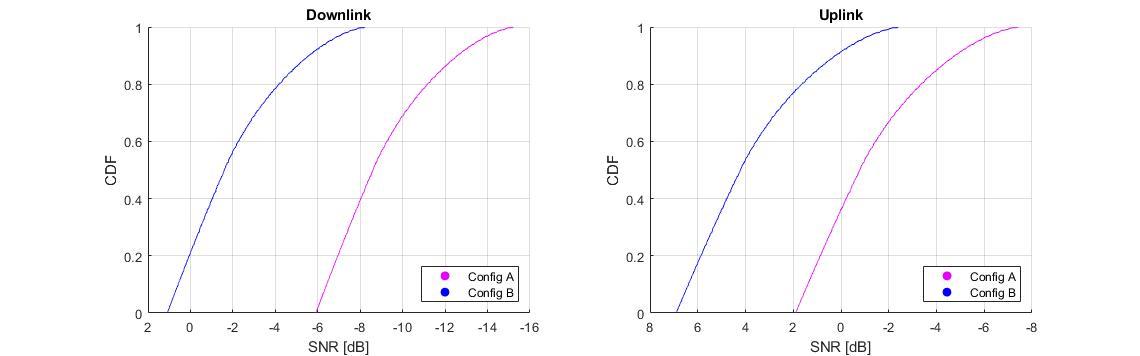


Figure 3 – CDF for SNR values within the beam coverage footprint

# Appendix 2

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Echostar (R1-2102750) | ***Proposal 1****: To add MEO scenario D in Table 4.2-1 in TR 36.763.*  ***Proposal 2****: To add MEO IoT NTN reference scenario parameters in Table 6.1-1 in TR 36.763.*  ***Proposal 3****: To include MEO Set-5 parameters for link budget analysis in a new Table 6.2-8 in TR 36.763, as a representative characterization of NTN-IoT scenarios with MEO altitude and characteristics.*  ***Proposal 4****: To add MEO Set-5 satellite parameters for system level simulator calibration in a new Table 6.2-9 in TR 36.763.*  ***Observation****: The doppler shift/variation and the delay variation for MEO are smaller than for LEO. The maximum delay for MEO is smaller than for GEO. The IoT-NTN enhancements for LEO and GEO should be sufficient to support MEO.* |
| Huawei (R1-2102344) | ***Proposal 1:*** *RAN1 agrees on the performance requirements of typical use cases in IoT over NTN**to ensure that the system design can fulfil such requirements.*  ***Proposal 2:*** *RAN1 agrees on the evaluation methodology and performance metrics, e.g. DL/UL peak data rate, latency, user density, power consumption, etc., for the candidate solutions targeting optimization of IoT over NTN.*  ***Proposal 3:*** *Capture the link budget results in the Appendix into TR 36.763.* |
| OPPO (R1-2102422) | ***Observation****: The evaluated link budget results for the scenarios of NB-IoT/eMTC over NTN are provided in Table 1~Table 8.*  ***Proposal 1****: Coverage enhancements should be studied and specified for IoT over NTN in Rel-17.*  ***Proposal 2****: Power consumption enhancements should be studied and specified for IoT over NTN in Rel-17.*  ***Proposal 3****: The features beneficial but not essential for IoT over NTN in Rel-17 should be studied and specified in later release.* |
| Vivo (R1-2102550) | ***Observation 1****: Free space path losses are 190.58 dB, 164.49 dB and 159.10 dB for GEO, LEO-1200, LEO-600, respectively.*  ***Observation 2****: Uplink channels with the largest bandwidth have the lowest CNRs.*  ***Observation 3****: Set-3 satellites and Set-4 satellites have quite lower achievable CNRs in UL.*  ***Observation 4****: FSPLs exceeds the MCL requirements in some scenarios.*  ***Proposal 1****: Lower devices antenna gain should be considered for NB-IoT/eMTC over NTN, e.g. -5 dBi.*  ***Proposal 2****: It is necessary to enhance UL coverage for NB-IoT/eMTC over NTN.*  ***Proposal 3****: MCL evaluation methodology in NR NTN can be reused for NB-IoT/eMTC over NTN.* |
| CATT (R1-2102617) | Regarding the scenario prioritization, observations and proposals are as follows:  ***Observation 1****: If LEO with earth moving cell is prioritized, we should further consider the solutions for idle/connected mode mobility, to adapt the frequent change of the cell coverage caused by the movement of the LEO satellites.*  ***Proposal 1****: Both GEO and LEO should be considered for IoT NTN in Rel-17.*  ***Proposal 2****: LEO-600km could be prioritized. However, the other orbits for LEO may also need to be considered for IoT NTN in Rel-17.*  ***Proposal 3****: Both earth moving cell and earth fixed cell should be considered for LEO in Rel-17 to allow the flexibility of network deployment.*  ***Proposal 4****: Both NB-IoT and eMTC should be supported in Rel-17 to support different commercial requirements.*  Regarding the evaluation result for link budget, observations and proposals are as follows:  ***Observation 2****: In eMTC system, the UL CNR’s difference in uplink bandwidth between 360khz and 30khz is about 10dB.*  ***Observation 3****: In NB-IoT system, the UL CNR’s difference in uplink bandwidth between 180khz and 3.75khz is about 15dB.*  ***Observation 4****: For Set-1, the worst UL CNR for the GEO system reaches -17dB, and the worst UL CNR for the LEO system is about -9dB.*  ***Observation 5****: For Set-2, the worst UL CNR for the GEO system reaches -22dB, and the worst UL CNR for the LEO system is about -16dB.*  ***Observation 6****: For Set-3, the worst UL CNR for the GEO system reaches -19dB, and the worst UL CNR for the LEO system is about -22dB.*  ***Observation 7****: For Set-4, the worst UL CNR for the LEO600-eMTC is close to -23dB, and the worst UL CNR for the LEO600-NB-IoT is close to -20dB.*  ***Observation 8****: For Set-4, the cell radius is 1700km, the UL CNR gap between the cell edge user and the center user is close to 5dB, and the UL CNR of the cell center user for the LEO600-eMTC is close to -7dB although the bandwidth decreases to 30khz.*  ***Proposal 5****: Capture Table 1-Table 7 results into TR 36.763.*  ***Proposal 6****: Based on evaluated results, the use case with below -10dB is not recommanded to support in IoT over NTN.* |
| MediaTek (R1-2102754) | ***Proposal 1****: Link Budget results for Set 1, Set 2, Set 3, and Set 4 in Table 1 and Table 2 are included in TR 36.763*  ***Observation 1****: A UE may only need a new GNSS position solely for UE pre-compensation for UL synchronization in corner case scenarios where (i) it is not fixed; (ii) reporting of the GNSS position is not needed by application layer.*  ***Observation 2****: The satellite system design should fix key parameters such as EIRP and G/T in the satellite to ensure the link budget can be closed on DL and UL.*  ***Observation 2****: NB-IoT can support minimum performance requirement for NB-IoT NTN Set 1, Set 2, Set 3 and Set 4 by using specified range of repetitions*  *- NPDSCH, NPDCCH, NPUSCH format 1 and 2*  *- NPRACH*  ***Observation 3****: NB-IoT can support minimum performance requirement for NPBCH.*  ***Observation 4****: It is up to the eNB UL scheduler to select the sub-carrier spacing and UL channel bandwidth with the required number of repetitions to transmit a TBS on NPUSCH or to transmit HARQ feedback on NPUSCH format 2.* |
| Nokia (R1-2102831) | ***Observation 1****: Including the proposed outdoor-to-indoor penetration loss requires link budget improvements.*  ***Observation 2****: Including the proposed vegetation loss requires link budget improvements.*  ***Observation 3****: Elevation angle smaller than agreed parameter set for outer tiers may cause more loss.*  ***Observation 4****: None-zero probability of NLOS shadow fading may impact much in link budget.*  ***Observation 5****: The uplink bottleneck channels are the channels with the largest bandwidth.*  ***Observation 6****: The UE power class(es), which support indoor scenarios shall be identified.*  ***Proposal 1****: RAN1 to agree indoor and/or vegetation-impacted UEs are in scope of the NTN IoT study.*  ***Proposal 2****: RAN1 to discuss how to handle poor GNSS performance in indoor and vegetation-impacted scenarios.*  ***Proposal 3****: RAN1 to define outdoor-to-indoor penetration loss of 25 dB for further link budget analysis.*  ***Proposal 4****: RAN1 to define vegetation loss of 10 dB for further link budget analysis.*  ***Proposal 5****: RAN1 to define the maximum number of repetitions and corresponding gain to apply in the link budget analysis, to provide worst coverage case.*  ***Proposal 6****: RAN1 to discuss impact of GNSS-based pre-compensation on combining gain of repetitions.*  ***Proposal 7****: Smaller elevation angle for outer tiers and NLOS shadow fading loss should also be considered in link budget for the worst coverage case.*  ***Proposal 8****: The link budget evaluations in Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14, and Table 15 shall be included in the study item report.* |
| CMCC (R1-2102905) | ***Observation 1****: Based on the latest parameters for link budget calibration, it can be observed that:*  *- For GEO with Set 2 satellite parameter, the UL CNR will reach -18.8dB level for NB-IoT with 180kHz BW, and reach -26.5dB level for eMTC with 1080kHz BW.*  *- For LEO at 1200km with Set 3 satellite parameter, the UL CNR will reach -17.4dB level for NB-IoT with 180kHz BW, and reach -25.2dB level for eMTC with 1080kHz BW.*  *- For LEO at 600km with Set 4 satellite parameter, the UL CNR will reach -14.9dB level for NB-IoT with 180kHz BW, and reach -22.7dB level for eMTC with 1080kHz BW.*  ***Observation 2****: Additional path loss can be observed in some deployment scenarios.*  *- Carriage and container penetration loss (9~20 dB) for logistics application.*  *- Vegetation loss (e.g., 9 dB) for outdoor application.*  ***Observation 3****: Additional 0~10 dB FSPL can be experienced by a UE in locations other than in the center of the central beam.*  ***Proposal 1****: Compare with link budget results for calibration, additional path loss should be considered for evaluating the basic coverage performance of IoT NTN in real deployment conditions.*  *- Carriage and container penetration loss for logistics application.*  *- Vegetation loss for outdoor application.*  *- Additional FSPL for lower elevation angle.* |
| ZTE (R1-2102916) | ***Observation 1****: For Set-3 and Set-4, coupling loss of LOS UE in some cases will be larger than 159 dB.*  ***Observation 2****: In some cases for Set-2, Set-3, and Set-4, even the coupling loss is smaller than 164 dB for NB-IoT and 159 dB for eMTC, the CNR is worse than the target SNR.*  ***Observation 3****: A large number of UEs would experience a worse coupling loss larger than 164 dB for urban and dense urban scenarios. And even for rural scenario, there are about 5% UEs which experience coupling loss larger than 164 dB.*  ***Proposal 1****: Cases listed in Table-1 within consideration on the different FR factor should be considered for link budget evaluation.*  ***Proposal 2****: Capturing the link budget results for cases listed in Table-1 into the TR.*  ***Proposal 3****: Further enhancement on the transmission may be needed to support cases with large coupling loss and/or low CNR.* |
| Xiaomi (R1-2102972) | ***Observation:*** *The CNR is quite low for some cases especially on the UL.*  ***Proposal 1:*** *Transmission enhancement may be needed for NB-IoT/eMTC over NTN based on the link budget results.* |
| Ericsson (R1-2103060) | ***Observation*** *1: eMTC and NB-IoT can address different types of IoT use cases based on their unique capabilities and thus complement each other.*  ***Observation 2****: NB-IoT supports ultra-low complexity devices with very narrow bandwidth, while eMTC can achieve higher data rates, more accurate device positioning, and supports voice calls and connected mode mobility.*  ***Observation 3****: The approved Rel-17 IoT NTN SID is dedicated to LEO and GEO satellite communication, while HAPS/HIBS and A2G are not in the scope.*  ***Observation 4****: Rel-17 IoT NTN study should equally treat eMTC and NB-IoT. The study item will be incomplete unless each of them is properly studied for its feasibility for NTN.*  ***Observation 5****: It was agreed at RAN2#112e that support for EPC is assumed for IoT NTN.*  ***Observation 6****: Identifying specific bands of interest in sub 6 GHz can be a topic for RAN4 to discuss when a potential normative phase begins.*  ***Observation 7****: The approved Rel-17 IoT NTN SID is dedicated to transparent payload.*  ***Observation 8****: To study the feasibility of NTN for eMTC and NB-IoT, it is important to properly evaluate the various design targets originally envisioned for eMTC and NB-IoT in the new context of NTN, taking into account factors such as the additional complexity, cost, and power consumption associated with GNSS operation.*  ***Observation 9****: The achievable connection density for IoT in NTN is much smaller than that in TN mainly due to a larger inter-spotbeam distance in NTN.*  *Based on the discussion in the previous sections we propose the following:*  ***Proposal 1****: IoT NTN study should focus on essential adaptations for NTN, while generic enhancements motivated by non-NTN are outside the scope.*  ***Proposal 2****: In Rel-17 IOT NTN SI, consider nominal S band (2 GHz) for evaluation purposes.*  ***Proposal 3****: In Rel-17 IOT NTN SI, limit the focus to FDD only.*  ***Proposal 4****: In Rel-17 IOT NTN SI, prioritize earth fixed beams.*  ***Proposal 5****: In Rel-17 IOT NTN SI, evaluate eMTC and NB-IoT in the context of NTN at least for the following targets: (1) coverage performance through link budget analysis; (2) supported device density; (3) complexity and cost of equipping eMTC/NB-IoT devices with NTN capability; (4) power consumption performance of eMTC/NB-IoT devices with NTN connectivity; and (5) latency performance of eMTC/NB-IoT devices in NTN systems.* |
| Qualcomm (R1-2103070) | ***Proposal 1****: RAN1 to define the downlink frequency accuracy of initial cell acquisition for eMTC and NB-IoT over NTN. This includes defining:*  *- Accuracy of crystal oscillator at the UE (in ppm)*  *- Maximum doppler frequency offset during initial acquisition*  ***Proposal 2****: RAN1 to discuss how accurately (e.g., in ppm) an eMTC/NB-IoT UE can be expected to maintain time and frequency synchronization for uplink transmissions, by tracking the location of the serving satellite and that of the UE itself.*  ***Proposal 3****: RAN1 to define solutions for maintaining uplink time and frequency synchronization, that are specific to the length of connections for eMTC/NB-IoT over NTN.*  ***Proposal 4****: For LEO satellites with fixed (non-steerable) satellite beams, define techniques to configure a cell (Ncell for NB-IoT) that spans resources across multiple satellite beams of a satellite.*  ***Proposal 5****: For NB-IoT over NTN, support only the following deployment modes*  *- Standalone*  *- In-band with / guard band of NR* |
| Apple (R1-2103132) | ***Observation 1****: For set 1 satellite parameters, the CNR for DL NB-IoT/eMTC is -4.98, 2.22 and 1.60 dB for GEO, LEO-1200 and LEO-600, respectively.*  ***Observation 2****: For set 1 satellite parameters, the CNR for UL NB-IoT/eMTC with bandwidth 15 kHz/180 kHz is -3.12/-13.91, 5.18/-5.61 and 10.56/-0.23 dB for GEO, LEO-1200 and LEO-600, respectively.*  ***Observation 3****: For set 2 satellite parameters, the CNR for DL NB-IoT/eMTC is -10.48, -3.78 and -4.40 dB for GEO, LEO-1200 and LEO-600, respectively.*  ***Observation 4****: For set 2 satellite parameters, the CNR for UL NB-IoT/eMTC with bandwidth 15 kHz/180 kHz is -8.12/-18.91, -0.82/-11.61 and 4.56/-6.23 dB for GEO, LEO-1200 and LEO-600, respectively.*  ***Observation 5****: For set 3 satellite parameters, the CNR for DL NB-IoT/eMTC is -4.18, -4.08 and -4.10 dB for GEO, LEO-1200 and LEO-600, respectively.*  ***Observation 6****: For set 3 satellite parameters, the CNR for UL NB-IoT/eMTC with bandwidth 15 kHz/180 kHz is -5.42/-16.21, -8.72/-19.51 and -3.34/-14.13 dB for GEO, LEO-1200 and LEO-600, respectively.*  ***Observation 7****: For set 4 satellite parameters, the CNR for DL NB-IoT/eMTC is -10.95 dB.*  ***Observation 8****: For set 4 satellite parameters, the CNR for UL NB-IoT/eMTC with bandwidth 15 kHz/180 kHz is -9.14/-19.93 dB.* |
| Sony (R1-2103318) | ***Proposal 1****: In the current stage of the study item, link budget study for PC3 devices (23dBm) with 7dB noise figure is prioritized.*  ***Proposal 2****: An AWGN channel model is assumed for IoT-NTN link level simulations.* |
| Sateliot, Gatehouse, Thales (R1-2103716) | ***Proposal 1****: Revise the “Max beam footprint size (edge to edge) regardless of the elevation angle” parameter for LEO scenarios indicated in 3GPP TR 36.763 V0.1.0 Table 6.1-1: “IoT NTN reference scenario parameters” to 1700 km (currently the parameter is set to 1000 km for LEO scenarios).* |
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