3GPP TSG RAN WG1 Meeting #104bis-e R1-2103897

April 12th – April 20th, 2021

Agenda Item: 8.15

Source: Rapporteur (MediaTek Inc.)

Title: Text proposal for TR 36.763 for RAN1#104bis-e Agreements

Document for: 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)*

This document contains Text Proposals for TR 36.763 based on agreements in AI 8.15.1, 8.15.2, 8.15.3, 8.15.4 at RAN1#104bis-e for Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN) [4]. TR 36.673 V0.1.0 was endorsed in RAN1#104e in [5].

# TP for Section 4.2 “IoT Non-Terrestrial Networks reference scenarios” of TR 36.763

The Text Proposal on IoT NTN scenarios for TR 36.763 Chapter 4, Section 4.2 shown below is as agreed and captured in Chairman report for RAN1#104e:

**4.2 IoT Non-Terrestrial Networks reference scenarios**

--- Start of text proposal ---

Table 4.2-1: IoT NTN reference scenarios



|  |  |
| --- | --- |
| 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 |

--- End of text proposal ---

# TP for Section 6.1 “IoT NTN Reference Parameters” of TR 36.763

The Text Proposal on IoT NTN scenarios for TR 36.763 Chapter 6, Section 6.1 shown below is as agreed and captured in Chairman report for RAN1#104e:

**6.1 IoT NTN Reference Parameters**

--- Start of text proposal ---

Table 6.1-1: IoT NTN reference scenario parameters



|  |  |  |  |
| --- | --- | --- | --- |
| 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 medium 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 10° 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 | | | |

--- End of text proposal ---

# TP for Section 6.2 “Link Budget Analysis” of TR 36.763

**6.2 Link Budget Analysis**

6.2.1 Link Budget Parameters

--- Start of text proposal ---

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

(based on R1-2102750 – HUGUES / Echostar)

|  |  |
| --- | --- |
|  | **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. Other antenna models can be considered. | |

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

(based on R1-2102750 – HUGUES / Echostar)

|  |  |
| --- | --- |
| **Set 5** | **MEO** |
| 3 dB Beam width (HPBW) | 6.5 degrees |
| Central beam center elevation | 90 degrees |
| Central beam edge elevation | 81.6 degrees |
| Central beam edge satellite-UE distance | 10042 km |

Table 6.2-10: Set-5 satellite parameters for system level simulator calibration

(based on R1-2102750 – HUGUES / Echostar)

|  |  |  |  |
| --- | --- | --- | --- |
| 3GPP TR 36.763 V0.1.0 Table 6.1-1 parameters that could be impacted by the beam size revision: | Current values in TR 36.763 V0.1.0 for LEO 600 km | Assumed and computed values under the consideration of a beam of 1700 km in diameter pointed at Nadir: | Comment |
| Min Elevation angle for both sat-gateway and C-IoT device | 10° for service link and 10° for feeder link | 30° for service link and 10° for feeder link | Assumed value for service link is higher than value in Table 6.1-1 in TR 36.763. No revision needed. |
| Max distance between satellite and C-IoT device at min elevation angle | 1,932 km | 1075.8 km  (Computed for a terminal located at the beam edge, corresponding to an elevation angle of 30 degrees) | Computed value is lower than current value in Table 6.1-1 in TR 36.763. No revision needed. |
| Max Round Trip Delay (propagation delay only) | 25.77 ms (service and feeder links) | 20.05 ms  (Computed for a terminal located at the beam edge, corresponding to an elevation angle of 30 degrees. Feeder link elevation angle kept at 10º) | Computed value is lower than current value in Table 6.1-1 in TR 36.763. No revision needed. |
| Max differential delay within a cell | 3.12 ms | 1.58 ms  (Computed as the maximum differential delay between a device at beam edge and one at beam center) | Computed value is lower than current value in Table 6.1-1 in TR 36.763. No revision needed. |
| Max Doppler shift variation (earth fixed user equipment) (NOTE 6)” | 24 ppm | 19,95 ppm  (Computed for a terminal at beam edge, corresponding to an elevation angle of 30 degrees) | Computed value is lower than current value in Table 6.1-1 in TR 36.763. No revision needed. |

NOTE: There is no impact on Table 6.1-1 : IoT NTN reference scenario parameters 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.

NOTE: The parameter set for MEO is only for information/reference and evaluation/enhancements are mainly considered for GEO and LEO. These enhancements can be applicable for MEO.

--- End of text proposal ---

--- Start of text proposal ---

6.2.2 Summary of Link Budget Results

It was agreed in RAN1#104 that the summary of link budget results from contributing companies in Appendix 1, Section 6.1.1 is captured and further checked and revised as necessary in a Text Proposal to TR 36.763 [6]. The summary of link budget results will be captured with alignment between contributing companies. The detailed link budget results from contributing companies will be captured in a separate spreadsheet

The following observations from individual company contributions were made:

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | 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 |  |

* 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 |

6.2.2.1 Calibration of link budget results

Contributing companies:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Huawei | OPPO | Vivo | CATT | | MediaTek | | Nokia | | CMCC | | ZTE | |
| Xiaomi | Ericsson | Qualcomm | | Apple | | Samsung | | SONY | | Sateliot | |

OPPO, CATT, Huawei, Vivo, Nokia, CMCC, ZTE, Xiaomi, Ericsson, Apple, Sateliot (Configuration A) used agreed link budget assumptions for PC5 (20 dBm) and NF=9 dB in TR 36.763 for their simulations. MediaTek, Qualcomm, Samsung, Sony used link budget assumptions for PC3 (23 dBm) and NF=7 dB in the simulations.

A 3 dB difference between the two sets of results is due to different assumption of PC3 (23 dBm) and PC5 (20 dBm) for UL; there is also a difference of 2 dB due to a different assumption of Noise Figure (7 dB and 9 dB). To align assumptions for unified results, in the moderator summary we adjust figures of all companies with common assumptions for Noise Figure and PC5. When needed SNR DL figure is adjusted by 2 dB and SNR UL figure by 3 dB. With PC3 (23 dBm) there is a 3dB gain compared to the PC5 (20 dBm) assumption on UL. With NF=7 dB, there is a 2 dB gain compare to NF=9 dB. We used central beam edge elevations agreed in TR 36.763 for Set 1, Set 2, Set 3, and Set 4 for the determination of the FSPL. With these adjustments, we found reasonable consistency between the results from contributing companies

All contributing companies used agreed losses as shown in Table below

Table: Satellite losses

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

Table: Maximum Free Space Path Loss

|  |  |  |  |
| --- | --- | --- | --- |
| FSPL | GEO (35786 km) | LEO (1200 km) | LEO (600 km) |
| Set-1 | 190.8 dB | 164.5 dB | 159.1 dB |
| Set-2 | 190.3 dB | 164.5 dB | 159.1 dB |
| Set-3 | 190.6 dB | 164.5 dB | 159.1 dB |
| Set-4 | - | - | 159.1 dB |

Table: 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*** | ***2.3*** | ***1*** |
| **2** | ***LEO-1200*** | ***Set 1*** | ***30*** | ***26.27*** | ***1*** |
| **3** | ***LEO-600*** | ***Set 1*** | ***30*** | ***26.98*** | ***1*** |
| **4** | ***GEO*** | ***Set 2*** | ***20*** | ***10.95*** | ***1*** |
| **5** | ***LEO-1200*** | ***Set 2*** | ***30*** | ***22.16*** | ***1*** |
| **6** | ***LEO-600*** | ***Set 2*** | ***30*** | ***23.80*** | ***1*** |
| **7** | ***GEO*** | ***Set 3*** | ***20.88*** | ***12.5*** | ***1*** |
| **8** | ***LEO-1200*** | ***Set 3*** | ***46.05*** | ***30*** | ***1*** |
| **9** | ***LEO-600*** | ***Set 3*** | ***43.78*** | ***30*** | ***1*** |
| **10** | ***LEO-600*** | ***Set 4*** | ***90*** | ***30*** | ***1*** |

We’ll capture and summarize the individual company calibrated results based on calibration spreadsheet in the sub-sections below. The tables will be updated when calibration results are available in the spreadsheet.

6.2.2.1.1 Set 1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PC3 (23 dBm), NF=7 dB | | | | | |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  1080 kHz / 360 kHz /180 kHz / 90 kHz / 45 kHz / 30 kHz / 15 kHz / 3.75 kHz |
| 1 | 59 dBW/MHz | 81.6 dBm | -3.2 dB | 19 dB/K | -21.9 dB / -17.1 dB / -14.1 dB / -11.1 dB / -8.1 dB / -6.6 dB / -3.3 dB / 2.7 dB |
| 2 | 40 dBW/MHz | 62.6 dBm | 4.2 dB | 1.1 dB/K | -13.4 dB / -8.6 dB / -5.6 dB / -2.6 dB / 0.4 dB / 2.2 dB / 5.2 dB / 11.2 dB |
| 3 | 34 dBW/MHz | 56.6 dBm | 3.6 dB | 1.1 dB/K | -8.0 dB / -3.2 dB / -0.2 dB / 2.8 dB / 5.8 dB / 7.5 dB / 10.5 dB / 16.6 dB |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PC5 (20 dBm), NF=9 dB | | | | | |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  1080 kHz / 360 kHz /180 kHz / 90 kHz / 45 kHz / 30 kHz / 15 kHz / 3.75 kHz |
| 1 | 59 dBW/MHz | 81.6 dBm | -5.2 dB | 19 dB/K | -24.9 dB / -20.1 dB / -17.1 dB / -14.1 dB / -11.1 dB / -9.3 dB / -6.3 dB / -0.3 dB |
| 2 | 40 dBW/MHz | 62.6 dBm | 2.2 dB | 1.1 dB/K | -16.4 dB / -11.6 dB / -8.6 dB / -5.6 dB / -2.6 dB / -0.8 dB / 2.2 dB / 11.2 dB |
| 3 | 34 dBW/MHz | 56.6 dBm | 1.6 dB | 1.1 dB/K | -11.0 dB / -6.2 dB / -3.2 dB / -0.2 dB / 2.8 dB / 4.5 dB / 7.5 dB / 13.6 dB |

6.2.2.1.2 Set 2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PC3 (23 dBm), NF=7 dB | | | | | |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  1080 kHz / 360 kHz / 180 kHz / 90 kHz / 45 kHz / 30 kHz / 15 kHz / 3.75 kHz |
| 4 | 53.5 dBW/MHz | 76.1 dBm | -8.2 dB | 14 dB/K | -26.4 dB / -21.6 dB / -18.6 dB / -15.6 dB / -12.6 dB / -10.8 dB / -7.8 dB / -1.8 dB |
| 5 | 34 dBW/MHz | 56.6 dBm | -1.8 dB | -4.9 dB/K | -19.4 dB / -14.6 dB / -11.6 dB / -8.6 dB / -5.6 dB / -3.8 dB / -0.8 dB / 5.2 dB |
| 6 | 28 dBW/MHz | 50.6 dBm | -2.4 dB | -4.9 dB/K | -14.0 dB / -9.2 dB / -6.2 dB / -3.2dB / -0.2 dB / 1.5 dB / 4.5 dB / 10.6 dB |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PC5 (20 dBm), NF=9 dB | | | | | |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  1080 kHz / 360 kHz /180 kHz / 90 kHz / 45 kHz / 30 kHz / 15 kHz / 3.75 kHz |
| 4 | 53.5 dBW/MHz | 76.1 dBm | -10.2 dB | 14 dB/K | -29.4 dB / -24.6 dB / -21.6 dB / -18.6 dB / -15.6 dB / -13.8 dB / -10.8 dB / -4.8 dB |
| 5 | 34 dBW/MHz | 56.6 dBm | -3.8 dB | -4.9 dB/K | -22.4 dB / -17.6 dB / -14.6 dB / -11.6 dB / -8.6 dB / -6.8 dB / -3.8 dB / 2.2 dB |
| 6 | 28 dBW/MHz | 50.6 dBm | -4.4 dB | -4.9 dB/K | -17.0 dB / -12.2 dB / -9.2 dB / -6.2dB / -3.2 dB / -1.5 dB / 1.5 dB / 7.6 dB |

6.2.2.1.3 Set 3

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PC3 (23 dBm), NF=7 dB | | | | | |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  1080 kHz / 360 kHz / 180 kHz / 90 kHz / 45 kHz /30 kHz / 15 kHz / 3.75 kHz |
| 7 | 59.8 dBW/MHz | 84.4 dBm | -2.2 dB | 16.7 dB/K | -24.0 dB / -19.2 dB / -16.2 dB / -13.2 dB / -10.2 dB / -8.4 dB / -5.4 dB / 0.6 dB |
| 8 | 33.7 dBW/MHz | 56.3 dBm | -2.1 dB | -12.8 dB/K | -27.3 dB / -22.5 dB / -19.5 dB / -16.5 dB / -13.5 dB / -11.7 dB / -8.7 dB / -2.7 dB |
| 9 | 28.3 dBW/MHz | 50.9 dBm | -2.1 dB | -12.8 dB/K | -21.9 dB / -17.1 dB / -14.1 dB / -11.1 dB / -8.1 dB / -6.4 dB / -3.4 dB / 2.7 dB |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PC5 (20 dBm), NF=9 dB | | | | | |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  1080 kHz / 360 kHz /180 kHz / 90 kHz / 45 kHz / 30 kHz / / 15 kHz / 3.75 kHz |
| 7 | 59.8 dBW/MHz | 84.4 dBm | -4.2 dB | 16.7 dB/K | -27.0 dB / -22.2 dB / -19.2 dB / -16.2 dB / -13.2 dB / -11.4 dB / -8.4 dB / -2.4 dB |
| 8 | 33.7 dBW/MHz | 56.3 dBm | -4.1 dB | -12.8 dB/K | -30.3 dB / -25.5 dB / -22.5 dB / -19.5 dB / -16.5 dB / -14.7 dB / -11.7 dB / -5.7 dB |
| 9 | 28.3 dBW/MHz | 50.9 dBm | -4.1 dB | -12.8 dB/K | -24.9 dB / -20.1 dB / -17.1 dB / -14.1 dB / -11.1 dB / -9.4 dB / -6.4 dB / -0.3 dB |

6.2.2.1.4 Set 4

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PC3 (23 dBm), NF=7 dB | | | | | |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  1080 kHz / 360 kHz / 180 kHz / 90 kHz / 45 kHz / 30 kHz / 15 kHz / 3.75 kHz |
| 10 | 21.4 dBW/MHz | 44 dBm | -12.0 dB | -20.9 dB/K | -27.0 dB / -22.2 dB / -19.2 dB / -16.2 dB / -13.2 dB / -11.5 dB / -8.5 dB / -2.4 dB |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PC5 (25 dBm), NF=9 dB | | | | | |
| Cases | EIRP Density | EIRP per spot | DL C/N | G/T | UL C/N  1080 kHz / 360 kHz /180 kHz / 90 kHz / 45 kHz / 30 kHz / 15 kHz / 3.75 kHz |
| 10 | 21.4 dBW/MHz | 44 dBm | -12.0 dB | -20.9 dB/K | -30.0 dB / -25.2 dB / -121.2 dB / -19.2 dB / -16.2 dB / -14.5 dB / -11.5 dB / -5.4 dB |

6.2.2.2 Distribution of CIR simulation results

The cdf of CIR for Set 1, Set 2, set 3 with Frequency Reuse Factor FRF=1 provided in [OPPO, R1-2102422] are shown below. The set 3 has lowest CIR, with 5% percentile at -3.9 dB for DL and -5.0 dB for UL.

**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**

6.2.2.3 Distribution of Coupling Loss simulation results

6.2.2.3.1 Rural scenarios

The cdf of Coupling Loss (CL) for DL for set 1, set 2, set 3, and set 4 in rural scenarios was provided in [ZTE, R1-2102916]. In rural scenarios, the Coupling Loss of about

* 5%~10% GEO UEs are larger than 164 dB for Set-1, Set-2, and Set-3
* 5% LEO-600 are larger than 154 dB for Set-1, Set-2, Set-3, and Set-4
* 5% LEO-1200 UEs are larger than 160 dB for Set-1, Set-2, and Set-3

|  |  |
| --- | --- |
|  |  |
| 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 |  |

6.2.2.3.2 Urban scenarios

The cdf of Coupling Loss for DL for set 1, set 2, set 3, and set 4 in urban scenarios and dense urban scenarios was provided in [ZTE, R1-2102916].

* In urban scenario, the CLs of about 50% GEO UEs are larger than 164 dB, about 30% LEO-600 and LEO-1200 UEs are larger than 164 dB;

|  |  |
| --- | --- |
|  |  |
| 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 |  |

6.2.2.3.3 Dense urban scenarios

The cdf of Coupling Loss for DL for set 1, set 2, set 3, and set 4 in dense urban scenarios was provided in [ZTE, R1-2102916].

* In dense urban scenario, the CLs of about 50% GEO UEs are larger than 164 dB, the CLs of about 30%~40% LEO-600 and LEO-1200 UEs are larger than 164 dB.

|  |  |
| --- | --- |
|  |  |
| 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 |  |

6.2.2.4 Frequency Re-use Factor results

The link budget for Set 1, Set 2, Set 3 with Frequency re-use 1 and Frequency reuse 3 was provided in [ZTE, R1-2102916]. It can be observed that the CINR gains depend on the scenario GEO and LEO, parameter sets, and bandwidth assumption. We make the following observations that CINR gain with FRF=3 compare to FRF=1 improves significantly the CINR at the lowest orbit, with the highest gains observed on UL with the smallest bandwidth 3.75 kHz.

Table : Set 1 – DL and UL

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | GEO | | LEO-600 | | LEO-1200 | |
| Frequency reuse factor | 1 | 3 | 1 | 3 | 1 | 3 |
| Coupling Loss (dB) | 151.04 | 151.04 | 140.99 | 140.99 | 146.39 | 146.39 |
| DL | | | | | | |
| CNR (dB) | -8.06 | -8.06 | -2.02 | -2.02 | -1.42 | -1.42 |
| CIR (dB) | 4.99 | 13.87 | -0.64 | 10.64 | -0.64 | 10.64 |
| CINR (dB) | -8.27 | -8.09 | -4.39 | -2.25 | -4.06 | -1.68 |
| UL | | | | | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CNR (dB)  3.75 kHz (Tx 20 dBm)  15 kHz (Tx 20 dBm)  30 kHz (Tx 20 dBm)  45 kHz (Tx 20 dBm)  90 kHz (Tx 20 dBm)  180 kHz (Tx 20 dBm)  360 kHz (Tx 20 dBm)  1080 kHz (Tx 20 dBm) | -0.18  -6.20  -9.21  -10.97  -13.98  -16.99  -20.00  -24.77 | -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 | 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 | 7.57  1.55  -1.46  -3.22  -6.23  -9.24  -12.25  -17.03 |
| CIR (dB) | 4.62 | 14.00 | -0.26 | 11.72 | -0.24 | 11.81 |
| CINR (dB)  3.75 kHz (Tx 20 dBm)  15 kHz (Tx 20 dBm)  30 kHz (Tx 20 dBm)  45 kHz (Tx 20 dBm)  90 kHz (Tx 20 dBm)  180 kHz (Tx 20 dBm)  360 kHz (Tx 20 dBm)  1080 kHz (Tx 20 dBm) | -1.42  -6.55  -9.39  -11.09  -14.04  -17.02  -20.02  -24.78 | -0.34  -6.24  -9.23  -10.99  -13.99  -17.00  -20.00  -24.77 | -0.46  -1.02  -1.66  -2.22  -3.57  -5.42  -7.72  -11.93 | 9.29  5.70  3.27  1.72  -1.07  -3.96  -6.92  -11.65 | -0.91  -2.45  -3.90  -4.99  -7.21  -9.76  -12.52  -17.12 | 6.18  1.16  -1.66  -3.36  -6.30  -9.28  -12.27  -17.03 |

Table : Set 2 – DL and UL

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | GEO | | LEO-600 | | LEO-1200 | |
| Frequency reuse factor | 1 | 3 | 1 | 3 | 1 | 3 |
| Coupling loss (dB) | 156.50 | 156.50 | 147.71 | 147.71 | 153.15 | 153.15 |
| DL | | | | | | |
| CNR (dB) | -13.52 | -13.52 | -8.73 | -8.73 | -8.17 | -8.17 |
| CIR (dB) | 1.48 | 13.90 | -0.50 | 11.38 | 1.45 | 13.87 |
| CINR (dB) | -13.66 | -13.53 | -9.34 | -8.77 | -8.62 | -8.20 |
| UL | | | | | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CNR (dB)  3.75 kHz (Tx 20 dBm)  15 kHz (Tx 20 dBm)  30 kHz (Tx 20 dBm)  45 kHz (Tx 20 dBm)  90 kHz (Tx 20 dBm)  180 kHz (Tx 20 dBm)  360 kHz (Tx 20 dBm)  1080 kHz (Tx 20 dBm) | -5.14  -11.16  -14.17  -15.93  -18.94  -21.95  -24.96  -29.73 | -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 | 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 | 0.81  -5.21  -8.22  -9.98  -12.99  -16.00  -19.01  -23.78 |
| CIR (dB) | 2.36 | 14.10 | -0.14 | 11.75 | 1.75 | 12.68 |
| CINR (dB)  3.75 kHz (Tx 20 dBm)  15 kHz (Tx 20 dBm)  30 kHz (Tx 20 dBm)  45 kHz (Tx 20 dBm)  90 kHz (Tx 20 dBm)  180 kHz (Tx 20 dBm)  360 kHz (Tx 20 dBm)  1080 kHz (Tx 20 dBm) | -5.85  -11.35  -14.27  -16.00  -18.98  -21.97  -24.97  -29.74 | -5.19  -11.17  -14.18  -15.94  -18.95  -21.95  -24.96  -29.74 | -1.04  -2.97  -4.67  -5.89  -8.28  -10.94  -13.76  -18.41 | 5.17  -0.07  -2.93  -4.64  -7.60  -10.59  -13.58  -18.35 | -1.76  -6.01  -8.64  -10.26  -13.14  -16.08  -19.05  -23.80 | 0.54  -5.28  -8.26  -10.01  -13.00  -16.01  -19.02  -23.79 |

Table : Set 3 – DL and UL

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | GEO | | LEO-600 | | LEO-1200 | |
| Frequency reuse factor | 1 | 3 | 1 | 3 | 1 | 3 |
| Coupling loss (dB) | 156.24 | 156.24 | 154.16 | 154.16 | 159.55 | 159.55 |
| DL | | | | | | |
| CNR (dB) | -7.17 | -7.17 | -7.08 | -7.08 | -7.08 | -7.08 |
| CIR (dB) | 1.48 | 13.90 | 1.13 | 13.86 | 1.38 | 13.87 |
| CINR (dB) | -7.72 | -7.20 | -7.69 | -7.12 | -7.66 | -7.11 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| UL | | | | | | |
| CNR (dB)  3.75 kHz (Tx 20 dBm)  15 kHz (Tx 20 dBm)  30 kHz (Tx 20 dBm)  45 kHz (Tx 20 dBm)  90 kHz (Tx 20 dBm)  180 kHz (Tx 20 dBm)  360 kHz (Tx 20 dBm)  1080 kHz (Tx 20 dBm) | -2.38  -8.40  -11.41  -13.17  -16.18  -19.20  -22.21  -26.98 | -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 | -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 | -5.69  -11.71  -14.72  -16.48  -19.49  -22.50  -25.52  -30.29 |
| CIR (dB) | 2.34 | 14.44 | 2.39 | 12.44 | 1.33 | 12.62 |
| CINR (dB)  3.75 kHz (Tx 20 dBm)  15 kHz (Tx 20 dBm)  30 kHz (Tx 20 dBm)  45 kHz (Tx 20 dBm)  90 kHz (Tx 20 dBm)  180 kHz (Tx 20 dBm)  360 kHz (Tx 20 dBm)  1080 kHz (Tx 20 dBm) | -3.64  -8.75  -11.59  -13.29  -16.25  -19.23  -22.22  -26.98 | -2.47  -8.43  -11.42  -13.18  -16.19  -19.20  -22.21  -26.98 | -2.17  -6.87  -9.61  -11.28  -14.20  -17.16  -20.15  -24.90 | -0.53  -6.38  -9.36  -11.11  -14.11  -17.12  -20.13  -24.90 | -6.48  -11.92  -14.83  -16.56  -19.53  -22.52  -25.52  -30.29 | -5.76  -11.73  -14.73  -16.49  -19.50  -22.51  -25.52  -30.29 |

--- End of text proposal ---

# TP for Section 6.3 “Time and Frequency Synchronization” of TR 36.763

**6.3 Time and frequency synchronization**

--- Start of text proposal ---

**6.3.1 GNSS Position fix impact on UE power consumption**

It was agreed in RAN1#104-e that the summary of GNSS Position fix impact on UE power consumption based on Appendix A Section 5.1 in [7] is captured and further checked and revised as necessary in a Text Proposal to TR 36.763. The individual companies battery life analysis in Appendix A in [7] are captured in Annex C in TR 36.763.

**6.3.1.1 Assumptions for UE power consumption analysis**

TR 45.820 Section 7.2.4.5.2 provide power consumption assumptions for energy consumption model.

Table 5.4-1: Key input parameters for energy consumption analysis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (1) Battery capacity  (Wh) | (2) Battery power during Tx  (mW) | (3) Battery power for Rx (mW) | (4) Battery power when Idle but not in PSS (mW) | (5) Battery power in Power Save State (PSS) (mW) | (6) Time between end of IP packet carrying "report" and start of IP packet carrying "ack" on radio (ms) | (7) Number of reports per day |
| 5 |  |  |  | [0,015] | 1000 |  |
| For each report (refer to Figure 5.4-1): | | | | | | |
| (8) Rx time from PSS exit to re-entry into PSS  (ms) | (9) Idle time from PSS exit to re-entry into PSS  (ms) | (10) Tx time from PSS exit to re-entry into PSS  (ms) | (11) Time from last Rx or Tx activity to entry into PSS1  (ms) |  |  |  |
|  |  |  | 20000 |  |  |  |

Table 7.2.4.5-1: Power consumption assumptions

|  |  |  |
| --- | --- | --- |
| ***Activity*** | ***Power consumption***  ***(mW)*** | ***Comments*** |
| TX active | 545 | Transmitter active at +23 dBm, assuming 44% PA efficiency and 90 mW for other analog and baseband circuitry |
| RX active | 90 | Analog RF and digital baseband processing for active receiver |
| Idle  (light sleep) | 3 | Maintenance of precision oscillator reference for RF synthesizers |
| Deep Sleep | 0.015 | Low power crystal, sleep counters and state machine |



Huawei mention conditions for GNSS TTFF with cold start, warm start, hot start:

* The first is cold start with which no almanac information is stored in the receiver. The UE have to search signals from all the possible satellites and at least 4 satellites are needed for the positioning. Therefore, the duration will be affected by the rate of GNSS signal transmission and quality of reception. The time duration of cold start can range from tens of seconds to more than ten minutes. The typical values of cold start is 30 s if the GNSS signal is received with not much interruption.
* The second start is warm start which is based on the assumption that the some ephemeris information and clock correction data is already obtained. With some available information, the positioning time will be reduced to several seconds.
* The third start is hot start which is based on the assumption that GNSS receiver has valid ephemeris, clock correction and GNSS time reference with time for positioning can be as low as 1~2s.

Assumptions used by contributing companies in battery life analysis with NGSS position fix every UL transmissions:

* GNSS power consumption
  + Integrated GNSS and IoT module:
  + Separate GNSS module and IoT Module: Huawei, MediaTek (100 mW)
* GNSS Position Time To First Fix (TTFF)
  + Hot start: Huawei (1s or 2 s),
  + Warm start: Huawei (several seconds)
  + Cold start: Huawei (30 s)

In order to compare battery life analysis from contributing companies, we align their simulation results case by case based on assumption for reporting (2h and 6h), packet size (50 Bytes), GNSS position TTFF (2s and 5s), MCL = 154 dB assumption (this determines active time for Rx, Tx). This is to ensure there is convergence of methodology. The methodology included all transmissions and receptions in device in energy consumption models.

**6.3.1.2 Separate GNSS module and IoT Module**

Separate GNSS module and IoT Module assumptions for power consumption assumed in the analysis were as follows:

* Huawei, MediaTek (100 mW)
* CATT (216 mW)

For MediaTek and CATT simulation results we used scaling by 2 to provide figures from 1 day to 12 h to align with Huawei. Note that CATT used GNSS module power consumption of 216 mW; Huawei and MediaTek figures are shown with GNSS module power consumption of 100 mW. The results from companies show reasonable agreement and consistency in observations. At a medium MCL=154 dB, the battery life in NTN is in range 6 years to 16 years; the reduction in battery life is in range 10 % to 40 %.

|  |  |  |
| --- | --- | --- |
| GNSS TTFF (hot start 2s), 2h report | | |
| Source | Huawei  MCL=154 dB, 105 bytes UL, 320 ms report, GNSS 100 mW | MediaTek  MCL=154 dB, 50 bytes UL, 238 ms report, GNSS 100 mW |
| Total active IoT Rx time | 164 ms | 371 ms |
| Total active IoT Tx time | 534 ms | 335 ms |
| Battery life (TN) | 8.6 years | 10.5 years |
| Battery life (NTN) | 6.0 years | 6.9 years |
| Reduction in battery life | 30.2 % | 34.3 % |

|  |  |  |  |
| --- | --- | --- | --- |
| GNSS TTFF (warm start 5s), 12h report | | | |
| Source | Huawei  MCL=154 dB, 105 bytes UL, 320 ms report, GNSS 100 mW | MediaTek  MCL=154 dB, 50 bytes UL, 238 ms report, GNSS 100 mW | CATT  MCL=154 dB, 50 bytes UL, 320 ms report, **GNSS 216 mW** |
| Total active IoT Rx time | 164 ms | 371 ms | 641 ms |
| Total active IoT Tx time | 534 ms | 335 ms | 400 ms |
| Battery life (TN) | 24.3 years | 15.6 years | 15.6 years |
| Battery life (NTN) | 16.2 years | 11.9 years | 9.3 years |
| Reduction in battery life | 33.3% | 23.7 % | 40.4% |

**6.3.1.3 Integrated GNSS module and IoT Module**

Separate GNSS module and IoT Module assumptions for power consumption assumed in the analysis were as follows:

* Ericsson, MediaTek (37 mW)

Ericsson observed for eMTC/NB-IoT, the reduction in battery life can be up to around 6% at 164 dB MCL and up to around 17% at 144 dB MCL depending on the UL reporting interval, packet size, and RRC procedure. Similar observations can be made from ANNEX A in MediaTek contribution where the reduction in battery life can be around 2.6 % at 164 dB MCL and around 11.7% at 144 dB MCL with similar assumptions.

|  |  |  |
| --- | --- | --- |
| GNSS TTFF (hot start 1s), 2h report | | |
| Source | MediaTek  MCL=154 dB, 50 bytes UL, 238 ms report, GNSS 37 mW | Ericsson  MCL=154 dB, 50 bytes UL EDT, 238 ms report, GNSS 37 mW |
| Total active IoT Rx time | 371 ms | - |
| Total active IoT Tx time | 335 ms | - |
| Battery life (TN, years) | 10.5 years | 14.6 years |
| Battery life (NTN, years) | 9.5 years | 12.9 years |
| Reduction in battery life | 9.5 % | 11.6 % |

|  |  |  |
| --- | --- | --- |
| GNSS TTFF (warm start 5s), 24h report | | |
| Source | MediaTek  MCL=154 dB, 50 bytes UL, 238 ms report, GNSS 37 mW | Ericsson  MCL=154 dB, 50 bytes UL EDT, 238 ms report, GNSS 37 mW |
| Total active IoT Rx time | 371 ms | - |
| Total active IoT Tx time | 335 ms | - |
| Battery life (TN, years) | 31.2 years | 33.8 years |
| Battery life (NTN, years) | 27.9 years | 30.0 years |
| Reduction in battery life | 10.2 % | 11.2 % |

|  |  |  |
| --- | --- | --- |
| GNSS TTFF (hot start 1s), 2h report | | |
| Source | Nokia | MediaTek |
| MCL=164 dB, 50 bytes UL, GNSS 37 mW | MCL=164 dB, 50 bytes UL, GNSS 37 mW (integrated) |
| Total active IoT Rx time | 2171 ms | 2290 ms |
| Total active IoT Tx time | 2193 ms | 2110 ms |
| Battery life (TN) | 2.65 years | 2.68 years |
| Battery life (NTN) | 2.59 years | 2.61 years |
| Reduction in battery life | 2.33% | 2.61% |

|  |  |  |
| --- | --- | --- |
| GNSS TTFF (warm start 5s), 2h report | | |
| Source | Nokia | CATT |
| MCL=164 dB, 50 bytes UL, GNSS 37 mW | MCL=164 dB, 50 bytes UL, GNSS 20 mW |
| Total active IoT Rx time | 2171 ms | 3035 ms |
| Total active IoT Tx time | 2193 ms | 2560 ms |
| Battery life (TN) | 2.65 years | 2.3 years |
| Battery life (NTN) | 2.37 years | 2.2 years |
| Reduction in battery life | 10.66% | 4.35% |

|  |  |  |  |
| --- | --- | --- | --- |
| GNSS TTFF (warm start 5s), 24h report | | | |
| Source | Nokia | MediaTek | CATT |
| MCL=164 dB, 50 bytes UL, GNSS 37 mW | MCL=164 dB, 50 bytes UL, GNSS 37 mW (integrated) | MCL=164 dB, 50 bytes UL, GNSS 20 mW |
| Total active IoT Rx time | 2171 ms | 2290 ms | 3035 ms |
| Total active IoT Tx time | 2193 ms | 2110 ms | 2560 ms |
| Battery life (TN) | 18.01 years | 18.12 years | 16.6 years |
| Battery life (NTN) | 16.87 years | 16.95 years | 16.0 years |
| Reduction in battery life | 6.33% | 6.46% | 3.61% |

**6.3.1.4 Power consumption—short, sporadic connections**

Qualcomm considered case IoT UE transmit its payload once every hrs, once every hrs, etc; after transmitting the payload, the UE’s connection is released, and it goes back into deep sleep mode, until before the next transmission occasion. GNSS TTFF assumption is 2s. A typical NB-IoT over NTN scenario (e.g., a good coverage LEO satellite setting for Set 2) corresponding to a downlink SNR (for 15 kHz 1 PRB reception) of 0 dB and an uplink SNR (for 15 kHz 1 PRB transmission) of -5 dB (with a PC5 UE transmitting at the max. power of 20 dBm).



Figure 3: Short, sporadic transmissions for IoT over NTN.

**Under the studied scenario of short, sporadic connections, a GNSS fix before every connection consumes approximately of the UE’s total available energy.**

For UEs that are *mobile*, e.g., say tracking devices, etc., that are operating in this *short, sporadic connection* paradigm, this power penalty due to GNSS cannot be mitigated significantly, under the purview of Release 17 assumptions of GNSS-based uplink pre-compensation. However, for UEs that are *fixed*, e.g., smart meters, etc, these UEs may be able to save power by having a much more relaxed (e.g., once a week, or once a month, depending on the setting) GNSS fixing schedule.

**6.3.1.5 Power consumption—** **long connections (e.g., based on CDRX)**

Qualcomm considered case *long connection* according. The IoT UE may remain in connected mode for a significantly longer duration of time than the short, sporadic connections described above. These may be facilitated e.g., via connected mode DRX (CDRX), wherein much larger payloads are transmitted or received by the UE during the longer connection. 

Figure 4: Long connection with connected mode DRX for IoT over NTN.

A GNSS fix before every uplink transmission occasion (which, in the absence of other mechanisms, may end up being required to maintain uplink synchronization accuracy within specified limits) results in  **of the UE’s total power consumption resulting from GNSS fixes**. While we can mitigate this somewhat for fixed UEs, for mobile UEs (especially UEs moving at high speeds), without other enhancements to connected mode synchronization, we may not be able to avoid this hit to the UE’s power consumption on account of GNSS fixes.

**Under the studied scenario of a long connection employing connected mode DRX (with a DRX cycle of ), a GNSS fix before every uplink transmission consumes approximately of the UE’s total available energy without additional enhancements w.r.t uplink synchronization. This is especially true for mobile UEs that cannot depend on a prior acquired GNSS fix.**

**6.3.1.6 Other observations from power consumption evaluation**

MediaTek observed a general trend with smallest battery life reduction in the order of 1% to 3% when battery life is in the order of 1 year; and largest battery life reduction in the order of 30% to 68% when battery life is in the order of 10 years or longer. GNSS TTFF hot start 1s, 2s and warm start 5s, 30s were simulated.

Ericsson observed that the reduction in battery life can be up to around 6% at 164 dB MCL and up to around 17% at 144 dB MCL depending on the UL reporting interval, packet size, and RRC procedure.

MediaTek observed that in scenarios of fixed IoT Sensors, or GNSS position available in Application Layer for Asset tracking / Fleet management, the impact on battery life is 0 %. There is either no need for UE to get a GNSS position fix (because the UE is fixed position with GNSS position acquired only once during fitting) or the GNSS position is available in the application layer because the UE needs to include it in the report.

CATT observed over 1 year battery life with transmission every 2hr of 200B, and over 2 years battery life with transmission every 2hr of 50B (on 216 mW), and over 10 years with transmission every day of 50B or 200B on 20mw GNSS power consumption of integrated architecture.

Nokia observed GNSS measurement may cause for packet size 50byte case, battery life reduction as 2.33% if 1s hot-start GNSS measurement assumed and 10.66% if 5s warm-start GNSS measurement assumed. While for 200bytes case, reduction will be 1.1% and 5.29% separately for hot-start and warm-start case. More battery life reduction when GNSS start is larger than 5s.

Ericsson proposed RAN1 to discuss and agree on the assumptions for IoT NTN battery life evaluation such as MCL, transmit power, bandwidth and noise figure.

CMCC, APT proposed the study of potential impact of GNSS Position fix on UE power consumption to be de-prioritized.

The following observations are made based on contributing companies:

* Contributing companies have shown consistent observations when using similar assumptions for reporting interval, packet size, GNSS TTFF and power consumption and MCL
* Impact on battery life is 0 % for use case fixed IoT sensors with GNSS position acquired once during fitting, or use case GNSS position available in IoT application Layer for Asset tracking / Fleet management
* In use case where the IoT device is not fixed position and GNSS position in not available in IoT application Layer, the following were observed based on contributing companies:
  + Reduction in battery life is around 6% at 164 dB MCL and around 17% at 144 dB MCL depending on the UL reporting interval, packet size, and RRC procedure with GNSS TTFF hot start 1s and warm start 5s and GNSS power consumption of 37 mW (integrated IoT and GNSS modules).
  + Reduction in battery life is around 1% to 3% when battery life is around 1 year; and 30% to 68% when battery life is around 10 years or longer with GNSS TTFF hot start 1s and warm start 5s and GNSS power consumption of 37 mW (integrated IoT and GNSS modules) and 100 mW (separate IoT and GNSS modules).
  + GNSS measurement may cause for packet size 50byte case, battery life reduction as 2.33% if 1s hot-start GNSS measurement assumed and 10.66% if 5s warm-start GNSS measurement assumed. While for 200bytes case, reduction will be 1.1% and 5.29% separately for hot-start and warm-start case. More battery life reduction when GNSS start is larger than 5s.
  + For short, sporadic connections, a GNSS fix before every connection consumes 34% of the UE’s total available energy; and in long connection employing connected mode DRX (with a DRX cycle of ~10s), a GNSS fix before every uplink transmission consumes 45% of the UE’s total available energy.
  + For long connection employing connected mode DRX (with a DRX cycle of ~10s), a GNSS fix before every uplink transmission consumes approximately 45% of the UE’s total available energy without additional enhancements w.r.t uplink synchronization.
  + Over 1 year battery life with transmission every 2hr of 200B, and over 2 years battery life with transmission every 2hr of 50B (on 216 mW), and over 10 years with transmission every day of 50B or 200B on 20mw GNSS power consumption of integrated architecture.

The battery life evaluation using in Rel-13 TR 45.820 (Section 5.4) has shown that overall the impact of GNSS can be moderate to significant, while allowing battery life of several years in case of significant reduction. The results would suggest that mitigation of power consumption due to GNSS could be a promising area of research that would be beneficial in case of high battery life comparable with cellular IoT of 10 years or beyond would be target for NTN IoT. The evaluation based on contributing companies would suggest the battery life in NTN IoT is sufficient for a working solution in worst case for power consumption where GNSS position fix is assumed to be needed before each UL transmission. In typical IoT applications, the impact on battery life would be 0 % for fixed IoT sensors or GNSS position available in Application Layer.

**6.3.2 NTN SIB reading impact on UE power consumption**

The required power consumption to read SIB containing satellite ephemeris information for the short sporadic connections use case is not significant.

* Note: For this conclusion, it is assumed that the UE need not read broadcast SIB for the purpose of obtaining satellite ephemeris information in CONNECTED mode.

**6.3.3 Long UL transmission on PUSH**

UE pre-compensation done per N time units for long PUSCH is the baseline solution.

* The pre-compensation does not vary within a block of N time units
* FFS: the definition and value of N

**6.3.4 Long UL transmission on PRACH**

UE pre-compensation done per N time units for long PRACH is the baseline solution.

* The pre-compensation does not vary within a block of N time units
* FFS: the definition and value of N

**6.3.4 DL Synchronization**

For DL synchronization in the Rel-17 timeframe, the following should be considered

* New Channel raster with a step size increased to be greater than 100 kHz
* (part of) ARFCN-indication-in-MIB

--- End of text proposal ---

# TP for Section 6.4 “Timing Relationship Enhancements” of TR 36.763

**6.4 Timing relationships enhancements**

--- Start of text proposal ---

The following NB-IoT timing relationships need enhancing for essential minimum functionality of IoT NTN:

* NPDCCH to NPUSCH format 1
* RAR grant to NPUSCH format 1
* NPDSCH to HARQ-ACK on NPUSCH format 2
* Timing advance command activation
* FFS: NPDCCH order to NPRACH
* FFS: Other NB-IoT timing relationships

The enhancement based on extending the timing relationship, by e.g. Koffset, adopted in NR NTN should be the starting point for enhancement of NB-IoT timing relationships in IoT NTN. Details can be further discussed considering IoT NTN.

The following eMTC timing relationships need enhancing for **essential minimum functionality of** IoT NTN:

* MPDCCH to PUSCH
* RAR grant to PUSCH
* MPDCCH to scheduled uplink SPS
* PUSCH to HARQ-ACK on PUCCH
* CSI reference resource timing
* MPDCCH to aperiodic SRS
* Timing advance command activation
* FFS: MPDCCH order to PRACH
* FFS: Other eMTC timing relationships

The UE-specific TA and/or K\_offset can be used by the eNB in its scheduling to avoid UL-DL collisions in FDD-HD.

--- End of text proposal ---

# TP for Section 6.5 “HARQ” of TR 36.763

**6.5 Enhancements on HARQ**

--- Start of text proposal ---

Increasing the number of HARQ processes for NB-IoT and for eMTC in NTN is recommended not to be supported in Rel-17.

--- End of text proposal ---

# TP for Annex C: Individual Company battery life analysis of TR 36.763

--- Start of text proposal ---

**Annex C: Individual Company battery life analysis**

**C.1 Huawei battery life analysis (R1-2102344)**

**Table 1. Power consumption with 2 hours report period**

|  |  |  |  |
| --- | --- | --- | --- |
| **Report, 2hours** | | | |
| **Flow assumptions** | **Duration(ms)/each report** | **Power(mW)** | **Power consumption(mWh)** |
| **GNSS(DL)** | 2000 | 100 | 0.055556 |
| **NPSS(DL)** | 20 | 80 | 0.000444 |
| **NSSS(DL)** | 20 | 80 | 0.000444 |
| **NTN SIB(DL, 256bits)** | 24 | 70 | 0.000467 |
| **MIB-NB(DL)** | 60 | 70 | 0.001167 |
| **Msg1(UL)** | 102.4 | 500 | 0.014222 |
| **NPDCCH(DL)** | 8 | 70 | 0.000156 |
| **Msg2(DL, 56bits)** | 12 | 70 | 0.000233 |
| **Msg3(UL)** | 96 | 500 | 0.013333 |
| **NPDCCH(DL)** | 8 | 70 | 0.000156 |
| **Msg4(DL, 256bits)** | 24 | 70 | 0.000467 |
| **ACK/NACK for Msg4(UL)** | 16 | 500 | 0.002222 |
| **PDCCH(DL)** | 8 | 70 | 0.000156 |
| **Msg5(105bytes)** | 320 | 500 | 0.044444 |
| **Idle** | 30000 | 3 | 0.025000 |
| **Sleep(NTN)** | 7167281.6 | 0.015 | 0.029864 |
| **Sleep(TN)** | 7169305.6 | 0.015 | 0.029872 |
| **Total (TN, mWh)** | 0.132317 | | |
| **Total (NTN,mWH)** | 0.188330 | | |
| **Battery(Wh)** | 5.000000 | | |
| **Battery lifte**  **(TN, year)** | 8.627436 | | |
| **Battery lifte**  **(NTN, year)** | 6.061437 | | |

**Table 2. Power consumption with 6 hours report period**

|  |  |  |  |
| --- | --- | --- | --- |
| **Report, 6hours** | | | |
| **Flow assumptions** | **Duration(ms)/each report** | **Power(mW)** | **Power consumption(mWh)** |
| **GNSS(DL)** | 5000 | 100 | 0.138889 |
| **NPSS(DL)** | 20 | 80 | 0.000444 |
| **NSSS(DL)** | 20 | 80 | 0.000444 |
| **NTN SIB(DL, 256bits)** | 24 | 70 | 0.000467 |
| **MIB-NB(DL)** | 60 | 70 | 0.001167 |
| **Msg1(UL)** | 102.4 | 500 | 0.014222 |
| **NPDCCH(DL)** | 8 | 70 | 0.000156 |
| **Msg2(DL, 56bits)** | 12 | 70 | 0.000233 |
| **Msg3(UL)** | 96 | 500 | 0.013333 |
| **NPDCCH(DL)** | 8 | 70 | 0.000156 |
| **Msg4(DL, 256bits)** | 24 | 70 | 0.000467 |
| **ACK/NACK for Msg4(UL)** | 16 | 500 | 0.002222 |
| **PDCCH(DL)** | 8 | 70 | 0.000156 |
| **Msg5(105bytes)** | 320 | 500 | 0.044444 |
| **Idle** | 30000 | 3 | 0.025000 |
| **Sleep(NTN)** | 21564281.6 | 0.015 | 0.089851 |
| **Sleep(TN)** | 21569305.6 | 0.015 | 0.089872 |
| **Total (TN, mWh)** | 0.192317 | | |
| **Total (NTN,mWH)** | 0.331651 | | |
| **Battery(Wh)** | 5.000000 | | |
| **Battery lifte**  **(TN, year)** | 17.807399 | | |
| **Battery lifte**  **(NTN, year)** | 10.326083 | | |

**Table 3. Power consumption with 6 hours report period**

|  |  |  |  |
| --- | --- | --- | --- |
| **Report, 12hours** | | | |
| **Flow assumptions** | **Duration(ms)/each report** | **Power(mW)** | **Power consumption(mWh)** |
| **GNSS(DL)** | 5000 | 100 | 0.13889 |
| **NPSS(DL)** | 20 | 80 | 0.00044 |
| **NSSS(DL)** | 20 | 80 | 0.00044 |
| **NTN SIB(DL, 256bits)** | 24 | 70 | 0.00047 |
| **MIB-NB(DL)** | 60 | 70 | 0.00117 |
| **Msg1(UL)** | 102.4 | 500 | 0.01422 |
| **NPDCCH(DL)** | 8 | 70 | 0.00016 |
| **Msg2(DL, 56bits)** | 12 | 70 | 0.00023 |
| **Msg3(UL)** | 96 | 500 | 0.01333 |
| **NPDCCH(DL)** | 8 | 70 | 0.00016 |
| **Msg4(DL, 256bits)** | 24 | 70 | 0.00047 |
| **ACK/NACK for Msg4(UL)** | 16 | 500 | 0.00222 |
| **PDCCH(DL)** | 8 | 70 | 0.00016 |
| **Msg5(105bytes)** | 320 | 500 | 0.04444 |
| **Idle** | 30000 | 3 | 0.02500 |
| **Sleep(NTN)** | 43164281.6 | 0.015 | 0.17985 |
| **Sleep(TN)** | 43169305.6 | 0.015 | 0.17987 |
| **Total (TN, mWh)** | 0.282317 | | |
| **Total (NTN,mWH)** | 0.421651 | | |
| **Battery(Wh)** | 5.000000 | | |
| **Battery lifte**  **(TN, year)** | 24.261118 | | |
| **Battery lifte**  **(NTN, year)** | 16.244032 | | |

**C.2 CATT battery life analysis (R1-2102618)**

Table 5 The operation assumptions of protocol flow and GNSS for IoT NTN

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Battery capacity(Wh)** | **5** | **MCL 154dBm** | | **MCL 164dBm** | |
| **Protocol flow assumptions** | **Power(mW)** | **Duration(ms)/each report** | **Power consumption(mWh)** | **Duration(ms)/each report** | **Power consumption(mWh)** |
| **GNSS signal reception** | X | Y | X\*Y/36e5 | Y | X\*Y/36e5 |
| **NPSCH(DL)** | 80 | 291 | 0.006467 | 445 | 0.009889 |
| **NPBCH(DL)** | 70 | 10 | 0.000194 | 30 | 0.000583 |
| **NPRACH(UL)** | 500 | 40 | 0.005556 | 320 | 0.044444 |
| **NPDCCH(DL)** | 70 | 30 | 0.000583 | 220 | 0.004278 |
| **NPUSCH(UL, 50bytes)** | 500 | 320 | 0.044444 | 1920 | 0.266667 |
| **NPUSCH(UL, 200bytes)** | 500 | 960 | 0.133333 | 3840 | 0.533333 |
| **NPDCCH(DL)** | 70 | 30 | 0.000583 | 220 | 0.004278 |
| **NPDCCH(DL)** | 70 | 30 | 0.000583 | 220 | 0.004278 |
| **NPDSCH(DL)** | 70 | 100 | 0.001944 | 800 | 0.015556 |
| **NPUSCH(UL)** | 500 | 40 | 0.005556 | 320 | 0.044444 |
| **NPDCCH(DL)** | 70 | 30 | 0.000583 | 220 | 0.004278 |
| **NPDCCH(DL, monitor)** | 70 | 120 | 0.002333 | 880 | 0.017111 |
| **idle** | 3 | 11040 | 0.009200 | 60595 | 0.050496 |
| **Standby(50bytes,2 hr)** | 0.015 | 7137919 | 0.029741 | 7083810 | 0.029516 |
| **Standby(200bytes,2 hr)** | 0.015 | 7137279 | 0.029739 | 7081890 | 0.029508 |
| **Standby(50bytes,24 hr)** | 0.015 | 86337919 | 0.359741 | 86283810 | 0.359516 |
| **Standby(200bytes,24 hr)** | 0.015 | 86337279 | 0.359739 | 86281890 | 0.359508 |

Table 6 The battery life with and without GNSS reception

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **power(mw)/duration(s)**  **Packet size, reporting interval,MCL** | **Battery life (years)** | | | | | | | | | | |
| **no GNSS** | **20mw/5s** | **20mw/10s** | **20mw/20s** | **20mw/40s** | **20mw/50s** | **216mw/5s** | **216mw/10s** | **216mw/20s** | **216mw/40s** | **216mw/50s** |
| **50bytes,2 hrs,MCL154** | 10.6 | 8.4 | 7.0 | 5.2 | 3.5 | 3.0 | 2.8 | 1.6 | 0.9 | 0.5 | 0.4 |
| **200bytes,2 hrs,MCL154** | 5.8 | 5.1 | 4.5 | 3.7 | 2.7 | 2.4 | 2.3 | 1.4 | 0.8 | 0.4 | 0.4 |
| **50bytes,24 hrs,MCL154** | 31.3 | 29.4 | 27.8 | 25.0 | 20.8 | 19.1 | 18.6 | 13.2 | 8.4 | 4.8 | 4.0 |
| **200bytes,24 hrs,MCL154** | 26.0 | 24.7 | 23.5 | 21.5 | 18.3 | 17.0 | 16.6 | 12.2 | 7.9 | 4.7 | 3.9 |
| **50bytes,2 hrs,MCL164** | 2.3 | 2.2 | 2.1 | 1.9 | 1.6 | 1.5 | 1.4 | 1.0 | 0.7 | 0.4 | 0.3 |
| **200bytes,2 hrs,MCL164** | 1.5 | 1.4 | 1.4 | 1.3 | 1.2 | 1.1 | 1.1 | 0.8 | 0.6 | 0.4 | 0.3 |
| **50bytes,24 hrs,MCL164** | 16.6 | 16.0 | 15.5 | 14.6 | 13.1 | 12.4 | 12.2 | 9.6 | 6.8 | 4.2 | 3.6 |
| **200bytes,24 hrs,MCL164** | 12.5 | 12.2 | 11.9 | 11.4 | 10.4 | 10.0 | 9.8 | 8.1 | 6.0 | 3.9 | 3.3 |

Battery life with and without GNSS

**C.3 Qualcomm battery life analysis (R1-2103071)**

Table 1: Parameters for evaluating power consumption in IoT over NTN.

|  |  |  |
| --- | --- | --- |
| Operation | Current  (Referenced to downlink current ) | Duration |
| GNSS reception |  | **ms** |
| Downlink Reception |  | 1. PDCCH:  **ms** 2. PDSCH (RAR):  **ms** 3. PDSCH (Msg4): **ms** 4. PDSCH (Conn. Release):  **ms** |
| Uplink Transmission |  | 1. PRACH:  **ms** 2. Msg3:  **ms** 3. PUSCH (data):  **ms per ~ bits**   (*simulated with 8000 bits per ON-duration*)   1. HARQ-ACK:  **ms** |
| Sleep |  | 1. PSM: **8 hrs** 2. CDRX: |



Figure 3: Short, sporadic transmissions for IoT over NTN.

**Under the studied scenario of short, sporadic connections, a GNSS fix before every connection consumes approximately of the UE’s total available energy.**



Figure 4: Long connection with connected mode DRX for IoT over NTN.

**Under the studied scenario of a long connection employing connected mode DRX (with a DRX cycle of ), a GNSS fix before every uplink transmission consumes approximately of the UE’s total available energy without additional enhancements w.r.t uplink synchronization.**

**C.4 MediaTek battery life analysis (R1-2102755)**







|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| EVERY 2 HOUR (GNSS TTFF HOT START + NTN SIB 16B Reading) | | | | | | | |
|  |  | **50 BYTES** | | | **200 BYTES** | | |
| **GNSS TTFF** | **MCL** | **CIoT** | **Integrated** | **Module** | **CioT** | **Integrated** | **Module** |
| 0 s | 144 dB | 18.73 | | | 17.35 | | |
| 154 dB | 10.51 | | | 5.43 | | |
| 164 dB | 2.68 | | | 1.27 | | |
| 1 s | 144 dB | 18.73 | 15.8 | 12.72 | 17.35 | 14.81 | 12.07 |
| 154 dB | 10.51 | 9.52 | 8.31 | 5.43 | 5.16 | 4.78 |
| 164 dB | 2.68 | 2.61 | 2.51 | 1.27 | 1.26 | 1.23 |
| 2 s | 144 dB | 18.73 | 13.84 | 9.71 | 17.35 | 13.07 | 9.33 |
| 154 dB | 10.51 | 8.77 | 6.91 | 5.43 | 4.93 | 4.28 |
| 164 dB | 2.68 | 2.55 | 2.37 | 1.27 | 1.24 | 1.2 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| EVERY DAY (GNSS TTFF WARM START + NTN SIB 16B Reading) | | | | | | | |
|  |  | **50 BYTES** | | | **200 BYTES** | | |
| **GNSS TTFF** | **MCL** | **CIoT** | **Integrated** | **Module** | **CioT** | 1. **Integrated** | 1. **Module** |
| 0 s | 144 dB | 35.04 | | | 34.61 | | |
| 154 dB | 31.23 | | | 25.36 | | |
| 164 dB | 18.12 | | | 11.16 | | |
| 5 s | 144 dB | 35.04 | 30.9 | 23.81 | 34.61 | 19.56 | 11.18 |
| 154 dB | 31.23 | 27.9 | 23.68 | 25.36 | 18.32 | 10.76 |
| 164 dB | 18.12 | 16.95 | 15.29 | 11.16 | 12.86 | 8.61 |
| 30 s | 144 dB | 35.04 | 30.56 | 25.57 | 34.61 | 19.43 | 11.14 |
| 154 dB | 31.23 | 23.12 | 20.14 | 25.36 | 16.13 | 9.57 |
| 164 dB | 18.12 | 10.7 | 10.02 | 11.16 | 8.91 | 6.64 |

**C.5 Ericsson battery life analysis (R1-2103061)**



Figure 1 NB-IoT RRC Resume procedure with UL and DL data transmissions.



Figure 2 NB-IoT EDT procedure with UL data transmission.

Table 1 GNSS parameters for battery life evaluation.

|  |  |  |
| --- | --- | --- |
|  | GNSS TTFF  (sec) | Power consumption  (mW) |
| Hot start | 1 | 37 |
| Warm start | 5 | 37 |

Table 2 eMTC and NB-IoT power consumption for battery life evaluation.

|  |  |
| --- | --- |
| Mode | Power consumption (mW) |
| TX | 545 |
| RX | 90 |
| RRC Connected | 3 |
| RRC Idle | 0.015 |

Table 3 eMTC battery life with 200 bytes UL data and 50 bytes DL data for various values of MCL and UL reporting interval.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| eMTC, 200 bytes UL, 50 bytes DL | | Battery life TN (year) | Battery life NTN (year) | Change (%) | Battery life TN (year) | Battery life NTN (year) | Change (%) | Battery life TN (year) | Battery life NTN (year) | Change (%) |
| MCL (dB) | | 164 | | | 154 | | | 144 | | |
| 2 hr | EDT | 1.0 | 1.0 | ~0 | 8.8 | 8.2 | 6.82 | 22 | 18.4 | 16.36 |
| 2 hr | RRC Resume | 0.9 | 0.9 | ~0 | 8.2 | 7.6 | 7.32 | 22 | 18.4 | 16.36 |
| 24 hr | EDT | 9.1 | 9.1 | ~0 | 30.0 | 27.0 | 10.0 | 37.0 | 32.5 | 12.16 |
| 24 hr | RRC Resume | 8.4 | 8.4 | ~0 | 29.4 | 26.5 | 9.86 | 37.0 | 32.5 | 12.16 |

Table 4 eMTC battery life with 50 bytes UL data and 50 bytes DL data for various values of MCL and UL reporting interval.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| eMTC, 50 bytes UL, 50 bytes DL | | Battery life TN (year) | Battery life NTN (year) | Change (%) | Battery life TN (year) | Battery life NTN (year) | Change (%) | Battery life TN (year) | Battery life NTN (year) | Change (%) |
| MCL (dB) | | 164 | | | 154 | | | 144 | | |
| 2 hr | EDT | 2.6 | 2.5 | 3.85 | 14.6 | 12.9 | 11.64 | 23.4 | 19.4 | 17.09 |
| 2 hr | RRC Resume | 2.0 | 2.0 | ~0 | 13.2 | 11.8 | 10.61 | 23.5 | 19.4 | 17.45 |
| 24 hr | EDT | 17.9 | 16.8 | 6.14 | 33.8 | 30.0 | 11.24 | 36.3 | 32.1 | 11.57 |
| 24 hr | RRC Resume | 15.4 | 14.5 | 5.84 | 33.1 | 29.5 | 10.88 | 36.4 | 32.1 | 11.81 |

Table 5 NB-IoT battery life with 200 bytes UL data and 50 bytes DL data for various values of MCL and UL reporting interval.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NB-IoT, 200 bytes UL, 50 bytes DL | | Battery life TN (year) | Battery life NTN (year) | Change (%) | Battery life TN (year) | Battery life NTN (year) | Change (%) | Battery life TN (year) | Battery life NTN (year) | Change (%) |
| MCL (dB) | | 164 | | | 154 | | | 144 | | |
| 2 hr | EDT | 1.4 | 1.4 | ~0 | 7.9 | 7.3 | 7.59 | 19.8 | 16.9 | 14.65 |
| 2 hr | RRC Resume | 1.1 | 1.1 | ~0 | 7.4 | 7.0 | 5.41 | 19.3 | 16.5 | 14.51 |
| 24 hr | EDT | 11.4 | 11.4 | ~0 | 29.0 | 26.2 | 9.65 | 36.4 | 32.1 | 11.81 |
| 24 hr | RRC Resume | 9.7 | 9.7 | ~0 | 28.5 | 25.7 | 9.82 | 36.3 | 31.9 | 12.12 |

Table 6 NB-IoT battery life with 50 bytes UL data and 50 bytes DL data for various values of MCL and UL reporting interval.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NB-IoT, 50 bytes UL, 50 bytes DL | | Battery life TN (year) | Battery life NTN (year) | Change (%) | Battery life TN (year) | Battery life NTN (year) | Change (%) | Battery life TN (year) | Battery life NTN (year) | Change (%) |
| MCL (dB) | | 164 | | | 154 | | | 144 | | |
| 2 hr | EDT | 3.4 | 3.3 | 2.94 | 13.4 | 12.0 | 10.45 | 22.2 | 18.5 | 16.67 |
| 2 hr | RRC Resume | 2.6 | 2.5 | 3.85 | 12.4 | 11.2 | 9.67 | 21.6 | 18.1 | 16.20 |
| 24 hr | EDT | 20.5 | 19.1 | 6.83 | 33.2 | 29.6 | 10.84 | 36.2 | 31.9 | 11.88 |
| 24 hr | RRC Resume | 17.8 | 16.7 | 6.18 | 32.7 | 29.1 | 11.01 | 36.0 | 31.8 | 11.67 |

**C.6 Nokia battery life analysis (R1-210832)**

In first step, GNSS measurement by UE are assumed to be ideally accurate (although there may be some issue as analysis above), then considering 50Bytes and 200Bytes packet, reporting (data) interval as 2hour or 1day, battery life reduction because of GNSS related power consumption will be as in Figure 1, where we assume a hot start >=1s and warm start >=5s and with other assumption as Table 2&3 aligned with [R1-157251, Nokia Networks, “NB IoT – Battery lifetime evaluation in standalone operation”, 3GPP RAN1 #83]. Annex A Table 4&5 provide the original results.

**Table 2 Assumption for requested time for each item in Tx/Rx**

|  |  |  |
| --- | --- | --- |
| Activity | State | ms |
| Synchronization | RX | 215 |
| MIB acquisition | Rx | 64 |
| Idle | 576 |
| PRACH | Tx | 160 |
| Idle | 640 |
| DCI + RAR | Rx | 72 |
| Msg3 | Tx | 340 |
| DCI + Msg4 | Rx | 72 |
| DCI (UL grant) | Rx | 36 |
| Report (50 bytes) | Tx | 1405 |
| Report (200 bytes) | Tx | 4648 |
| HARQ ACK | Rx | 36 |
| DCI | Rx | 36 |
| IP Ack | Rx | 200 |
| HARQ ACK | Tx | 288 |
| PDCCH monitoring | Rx | 1440 |
| Extra wait time | Idle | 22000 |

**Table 3 Assumption for battery capacity and battery power consumption**

|  |  |
| --- | --- |
| Battery capacity (Wh) | 5 |
| Battery power during Tx (mW) | 543 |
| Battery power for Rx (mW) | 90 |
| Battery power when Idle but not in PSS (mW) | 2.4 |
| Battery power in Power Save State (PSS) (mW) | 0.015 |
| battery power for GNSS Rx (mW) | **37** |

**Table 4 battery life reduction because of GNSS measurement**



**Figure 1 battery life reduction because of GNSS measuerement**

Another points that will reduce battery life for IoT over NTN is SIB reading for satellite ephemeris. If assuming power consumption for SIB reading is 90mW, then battery life reduction will be as in Figure 2.



**Figure 2 battery life reduction because of SIB reading for satellite ephemeris (90mW)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| packet size = 50Bytes |  | Reporting  interval (hour) | Number of reports per day | Rx time of GNSS measurement (ms) | Reduced battery life (%) |  | Reporting  interval (hour) | Number of reports per day | Rx time of GNSS measurement (ms) | Reduced battery life (%) |
|  |  | 2 | 12 | 1000 | 2.332 |  | 24 | 1 | 5000 | 6.329 |
|  |  | 2 | 12 | 2000 | 4.557 |  | 24 | 1 | 10000 | 11.905 |
|  |  | 2 | 12 | 3000 | 6.683 |  | 24 | 1 | 15000 | 16.854 |
|  |  | 2 | 12 | 4000 | 8.717 |  | 24 | 1 | 20000 | 21.277 |
|  |  | 2 | 12 | 5000 | 10.663 |  | 24 | 1 | 25000 | 25.253 |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| packet size = 200Bytes |  | Reporting  interval (hour) | Number of reports per day | Rx time of GNSS measurement (ms) | Reduced battery life (%) |  | Reporting  interval (hour) | Number of reports per day | Rx time of GNSS measurement (ms) | Reduced battery life (%) |
|  |  | 2 | 12 | 1000 | 1.105 |  | 24 | 1 | 5000 | 3.950 |
|  |  | 2 | 12 | 2000 | 2.186 |  | 24 | 1 | 10000 | 7.599 |
|  |  | 2 | 12 | 3000 | 3.244 |  | 24 | 1 | 15000 | 10.982 |
|  |  | 2 | 12 | 4000 | 4.279 |  | 24 | 1 | 20000 | 14.125 |
|  |  | 2 | 12 | 5000 | 5.292 |  | 24 | 1 | 25000 | 17.054 |

**Table 5 battery life reduction because of SIB reading for satellite ephemeris**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| packet size = 50Bytes |  | Reporting  interval (hour) | Number of reports per day | Rx time of NTN SIB (ms) | Reduced battery life (%) |  | Reporting  interval (hour) | Number of reports per day | Rx time of NTN SIB (ms) | Reduced battery life (%) |
|  |  | 2 | 12 | 20 | 0.116 |  | 24 | 1 | 20 | 0.066 |
|  |  | 2 | 12 | 30 | 0.174 |  | 24 | 1 | 30 | 0.099 |
|  |  | 2 | 12 | 40 | 0.232 |  | 24 | 1 | 40 | 0.131 |
|  |  | 2 | 12 | 50 | 0.289 |  | 24 | 1 | 50 | 0.164 |
|  |  | 2 | 12 | 60 | 0.347 |  | 24 | 1 | 60 | 0.197 |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| packet size = 200Bytes |  | Reporting  interval (hour) | Number of reports per day | Rx time of NTN SIB (ms) | Reduced battery life (%) |  | Reporting  interval (hour) | Number of reports per day | Rx time of NTN SIB (ms) | Reduced battery life (%) |
|  |  | 2 | 12 | 20 | 0.054 |  | 24 | 1 | 20 | 0.040 |
|  |  | 2 | 12 | 30 | 0.081 |  | 24 | 1 | 30 | 0.060 |
|  |  | 2 | 12 | 40 | 0.109 |  | 24 | 1 | 40 | 0.080 |
|  |  | 2 | 12 | 50 | 0.136 |  | 24 | 1 | 50 | 0.100 |
|  |  | 2 | 12 | 60 | 0.163 |  | 24 | 1 | 60 | 0.120 |

--- End of text proposal ---

# TP for Annex C: (Informative): Change history

--- Start of text proposal ---

**Annex D (Informative): Change history**

--- End of text proposal ---

# Conclusion

In this contribution, we provided Text Proposals for inclusion in TR 36.763 Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN) (Release 17) as follows:

TPs based on agreement as captured in Chairman RAN1#104-e report on AI 8.15.1, 8.15.2, 8.15.3, 8.15.4 for the following Agenda Items [1]

* Scenarios applicable to NB-IoT/eMTC
* Enhancements to time and frequency synchronization
* Timing relationship enhancements
* Enhancements on HARQ

# 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. R1-210XXXX, RAN1 Chairman’s Notes, V0.18, RAN1#104bis-e, January 2021
5. TR36.763 Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN), V0.1.0, RAN1#104bis-e, January 2021
6. R1-2103962, Moderator (MediaTek), Summary #3 of AI 8.15.1 Scenarios applicable to NB-IoT/eMTC Document for: Discussion and Decision, RAN1#104bis-e, April 2021
7. R1-2103964, Moderator (MediaTek), Summary #4 of AI 8.15.2 Enhancements to time and frequency, synchronization Document for: Discussion and Decision, RAN1#104bis-e, April 2021