3GPP TSG RAN WG1 #122 R1-250xxxx

Bengaluru, India, Aug 25th – 29th, 2025

**Agenda item:** 5

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Feature lead summary on SA4 LS on ULBC

**Document for:** Discussion and Decision

# Background

RAN1 has received the following LS from SA4 in R1-2505140:

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| --- |
| 3GPP SA4 has an ongoing feasibility study on Ultra Low Bitrate Speech Codec (FS\_ULBC) based on the approved study item description in [SP-250378](https://www.3gpp.org/ftp/tsg_sa/TSG_SA/TSGS_107_Incheon_2025-03/Docs/SP-250378.zip) including the following objective:  *Study GEO channel characteristics and derive service-related dependencies, e.g. bitrates, mouth-to-ear delay or loss/delay/jitter profiles.*  The service-related dependencies are essential for defining ULBC design constraints and for performance evaluation of candidate codecs.  SA4 plans to complete deriving the service-related dependencies by SA4#134 in November 2025. Given the short timeframe, SA4 has agreed to do the evaluation within SA4 under certain assumptions on, e.g. GEO NTN NB-IoT channel simulation parameters, the packet header overhead and the mouth-to-ear delay over the GEO channel.  SA4 kindly seeks confirmation that the underlying assumptions are representative of real-world deployments. Specific feedback is requested from RAN1, RAN2, RAN4, SA2 and CT1 on the assumptions for the simulation, which are documented in the attachment.  SA4 would like to invite feedback from satellite companies present in 3GPP on potential deviations observed in practical deployment with respect to the assumed parameters in 3GPP TR 38.821, which could be of relevance for the evaluation as documented in the attachment.  **To RAN1:**  **ACTION:**  Q1:SA4 kindly asks RAN1 to confirm the evaluation assumptions in the attachment, and provide feedback, if any.  Q2: In Table 6.1.3.3-1 of TR 38.821, how the RX G/T value (-31.6 dB/T) in the table or equivalently the antenna gain and noise figure for DL for NB-IoT with GEO are determined, whether it is a worst-case scenario, and whether SA4 can assume this value in the simulation? |

# Q1

The 1st question from SA4 is as follows:

Q1:SA4 kindly asks RAN1 to confirm the evaluation assumptions in the attachment, and provide feedback, if any.

## Input from companies

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| **Huawei** | * Use pi/2 BPSK for low MCS * Target BLER of 1% or 2% are enough for evaluation |
| **Vivo/SPDR** | * No issues. In general, RAN1 has evaluated 2% as the target BLER for voice. |
| **Samsung** | * For section 5.2.2.2 (Uplink simulation parameters), RAN1 believes that SET-2 and SET-3 UL SNRs should be further reviewed. Additionally, RAN1 considers 23dBm as the sole option based on Table 6.2.1-1 of 38.101-5, while -5.5 dBi is deemed the baseline given its realistic UE antenna gain as per RAN4 reply LS (R1-2208353). RAN1 also views 0 dB as the baseline for X value. * For section 5.2.2.3 (Downlink simulation parameters), RAN1 considers incorporating SET-2 and SET-3 UL SNRs further. Similarly, -5.5 dBi is established as the baseline due to its realistic UE antenna gain, as confirmed by RAN4 reply LS (R1-2208353). RAN1 views 0 dB as the baseline for Y value. |
| **Nokia** | * **RAN1 to reply to SA4 that the simulation parameters are in line with past RAN1 assumptions, but that π/2-BPSK or π/4-QPSK is applicable for single tone uplink transmissions, and that Doppler shift, not spread, was defined in TR 38.821.** |
| **Apple** | *UL CNR= -3.5dB is considered for UL with 15kHz SCS, PC3, and NF=7dB.*  *For VoIP over NB-IoT, 2% rBLER can be applied as the performance metric.* |
| **ZTE** | *RAN1 reply SA4 that UE is not required to monitor NPDCCH within the interval between DL NPDCCH and NPDSCH for single HARQ scenario. The example frame structure for dynamic scheduling is not applicable to the scenario where single HARQ process is used.* |
| **Xiaomi** | **Adopt the following CNR values as the baseline:**  **- UL CNR = 2.9dB, 0dBi UE antenna gain, 3.75kHz SCS, 1 tone, UE maximum TX power 23dBm**  **- DL CNR= -3.0dB, 0dBi UE antenna gain, 15kHz SCS, 12 tones, 1 UE receive antenna**  **Adopt 2% BLER as the fixed target for ULBC simulation**  **For TBS determination, wait for SA2 and RAN2 conclusions on the realism of the 1-byte MAC header.**  **Generate the channel model parameters based on the satellite elevation assumed in the link budget calculation.**  **Frame structure is provided by companies when proving their simulation results.** |
| **CATT** | **For the evaluation assumptions, from RAN1 perspective, these assumptions are reasonable** |
| **CMCC** | *For Q1, after reviewing the attachment, we have no strong view on the evaluation assumptions* |
| **Qualcomm** | **Proposal 1: For the response to Q1,**   * **RAN1 to highlight the following change: DL CNR=-3.3dB, 0dBi UE antenna gain, 15kHz SCS, 12 tones, 1 UE receive antenna, ~~UE maximum TX power 23dBm~~ noise figure of 7dB.** * **RAN1 to recommend to SA4 to consider the following parameters as the best case scenario:**   + **AWGN channel**   + **No shadow margin or scintillation loss.**   + **Noise figure lower than 7dB (e.g. 4dB)** |
| **Skylo** | RAN1 confirms that most of the link budget analysis and UL/DL simulation parameters used by the SA4 Audio SWG for the FS\_ULBC study align with TR 38.821 and TR 36.763.  However, RAN1 respectfully reminds the SA4 Audio SWG that while the optimistic C/N values from Set-1 (UL C/N of 2.6 dB and DL C/N of -3.3 dB) are valid, the more challenging C/N values from Set-2 (UL C/N of -2.2 dB and DL C/N of -8.5 dB) may be more practical for addressing worst-case scenarios, as detailed in the discussion paper R1-2506244.  It's suggested that the SA4 study could incorporate company-contributed satellite parameters, with a focus on addressing these worst-case scenarios to ensure broader support for NB-IoT devices in GEO environments for voice communications. |

## Feature lead recommendation

FL tried to capture the majority of the comments provided in the inputs, with the following exceptions:

* Apple and Xiaomi proposes to use the values of -3.0dB/-3.5dB and 2.9dB instead of -3.3dB and 2.6dB for downlink and uplink respectively. Since the values in the SA4 TR are the same as in TR 36.763 (and there is a minimal difference of up to 0.3dB), FL proposes to not capture this in the reply.
* We do not comment on issues related to other working groups (e.g. MAC header)
* The “frame structure” shown in the SA4 LS is explicitly labeled as “example frame structure”. Therefore, FL thinks there is no need to comment on this factor.

Some comments on the proposed reply. FL structures the response into two different parts:

* The 1st part of the response [C1] is based on factual information (e.g. information coming from technical reports or RAN1 specifications) that should not be controversial.
* The 2nd part of the response [C2] is based on input to this meeting for which RAN1 has no agreements (e.g. recommendations to SA4 on what to do). If there is consensus in any of these, it can get promoted to [C1].

*<FL note: [CX.Y] are just for referencing during the discussion, will be removed in the LS>*

The proposed reply to Q1 is as follows:

### Proposed reply to Q1:

[C1] On the evaluation assumptions, RAN1 generally agrees with the overall set of parameters selected by SA4, with the following comments:

* [C1.1] On the modulation order, RAN1 would like to highlight that if SA4 decides to evaluate MCS indices 0 and 1, those MCS indices use pi/2 BPSK for single tone transmissions.
* [C1.2] For the downlink CNR, the relevant UE parameter is noise figure (and/or G/T) instead of transmit power. RAN1 recommends SA4 corrects the following sentence:
  + DL CNR=-3.3dB, 0dBi UE antenna gain, 15kHz SCS, 12 tones, 1 UE receive antenna, ~~UE maximum TX power 23dBm~~ noise figure of 7dB.

[C2] While the parameters indicated by SA4 are in line with previous evaluations performed in RAN1 for NB-IoT NTN, some companies in RAN1 expressed that the observed performance in the field may vary depending on multiple factors. While RAN1 did not reach consensus on a new set of parameters to be used by SA4, the following aspects were discussed (and may be incorporated by SA4 in their X/Y terms):

* [C2.1] The UE noise figure in commercial implementations may be better than the 7dB documented in TR 36.763 (e.g. 4dB or G/T=-28.6 dB/K). At the same time, TR 36.736 also captures a noise figure of 9dB in the link budget.
* [C2.2] The scintillation loss of 2.2dB reflects the worst case scenario, and is only relevant for latitudes between -20 and 20 degrees. For most latitudes, the scintillation loss is negligible.
* [C2.3] The link budget incorporates a 3dB shadow margin, which in some cases (e.g. open sky) may be too conservative.
* [C2.4] Some devices with internal antennas may have a worse antenna gain than 0dBi. In particular, RAN1 has used an antenna gain of -5.5dBi in some of their evaluations.
* [C2.5] The severity of the multipath depends on the K-factor of the NTN-TDL-C Rician channel, which varies depends on elevation angle and environment. Larger K-factor values will improve the performance.
* [C2.6] TR 36.736 also captures Set-2 and Set-3 GEO satellite parameters, which are inferior in performance to Set-1.
* [C2.7] High power UE (e.g. up to 37dBm) can be included in the evaluations.
* [C2.8] In previous RAN1 evaluations related to voice, RAN1 has considered 2% BLER as the target performance metric.

### \*\* Discussion on Q1 \*\* Please provide your comments to the proposed response to Q1 in the table below. Highlight if you want to “promote” some of the [C2.x] items to the 1st part of the reply.

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | Q1 is “**SA4 kindly asks RAN1 to confirm the evaluation assumptions in the attachment, and provide feedback, if any**”. We have the following input to provide with respect to Q1:  **Section 5.2.2.2             Uplink simulation parameters**  **Modulation:** BPSK and QPSK for 1 tone, and QPSK for >1 tone as in described Table 10.1.3.2-1of TS 36.211 for NPUSCH Format 1.  **Number of tones:** 1 for 3.75kHz SCS and 1, 3, 6, and 12 for 15kHz SCS  **Number of allocated resources units (RUs):** Companies will report the number of allocated RUs for each simulation.  Voice bundling period: 40 ms\*, 80ms, 160ms, 320ms  NOTE: the 40ms bundling is not considered because for SCS 3.75kHz the minimum time-domain allocation is 32ms and it leaves insufficient time for downlink data (NPDSCH) and control (NPDCCH) transmissions in the same 40ms time interval. \* On the other hand, 40 ms bundling can considered for SCS 15 kHz since the minimum time-domain allocation for single-tone is 8 ms, whereas the minimum time-domain allocation for multi-tone is 4 ms, 2ms, and 1 ms for 3, 6, and 12 tones respectively.  **TBS values and PHY bitrates:** The TBS values are selected from table 16.5.1.2-2 for NB-IoT for NPUSCH Format 1in TS36.213 and the corresponding PHY bitrates and codec bitrate (assuming 7 bytes of packet header) are calculated for each bundling period. Companies will report the TBS value(s) used for each simulation.  **5.2.2.3 Downlink simulation parameters**  Only the parameters that are different from the uplink are listed here.  **Number of allocated NPDSCH subframes:** Companies will report the number of NPDSCH subframes for each simulation.  **TBS** **values and PHY bitrates**: The TBS values are selected from table 16.4.1.5.1-1 for NB-IoT for NPDSCH in TS36.213 and the corresponding PHY bitrates and codec bitrate (assuming 7 bytes of packet header) are calculated for each bundling period, and they are identical as those in clause 5.2.2.2. Companies will report the TBS value(s) used for each simulation.  **5.2.2.3 Frame structure**  If semi-persistent scheduling (SPS) is specified by RAN for NB-IoT NTN, an example frame structure is shown in Figure 5.2.2.3-2. ~~The NPDSCH now can be anywhere in the first 15ms (considering that a minimum gap of 1 ms to the NPUSCH needs to be maintained).~~ [Ericsson] Since the potential SPS design is completely open with several technical details to be discussed in RAN1 (Kick-off scheduled for RAN1# 124), for the moment it is enough keeping only the first sentence. |
| Xiaomi | Thanks FL for the good consolidation work. Instead of separating companies’ views as additional input, we would like to fix the values so that the Codec evaluations is aligned with the actual deployment scenario. Thus we prefer to discuss the terms listed below one by one and fix the X Y values in SA4 assumptions.   * [C2.1] The UE noise figure in commercial implementations may be better than the 7dB documented in TR 36.763 (e.g. 4dB or G/T=-28.6 dB/K). At the same time, TR 36.736 also captures a noise figure of 9dB in the link budget. * [C2.2] The scintillation loss of 2.2dB reflects the worst case scenario, and is only relevant for latitudes between -20 and 20 degrees. For most latitudes, the scintillation loss is negligible. * [C2.3] The link budget incorporates a 3dB shadow margin, which in some cases (e.g. open sky) may be too conservative. * [C2.4] Some devices with internal antennas may have a worse antenna gain than 0dBi. In particular, RAN1 has used an antenna gain of -5.5dBi in some of their evaluations. * [C2.5] The severity of the multipath depends on the K-factor of the NTN-TDL-C Rician channel, which varies depends on elevation angle and environment. Larger K-factor values will improve the performance. * [C2.6] TR 36.736 also captures Set-2 and Set-3 GEO satellite parameters, which are inferior in performance to Set-1. * [C2.7] High power UE (e.g. up to 37dBm) can be included in the evaluations. * [C2.8] In previous RAN1 evaluations related to voice, RAN1 has considered 2% BLER as the target performance metric. |

# Q2

The 2nd question from SA4 is as follows:

Q2: In Table 6.1.3.3-1 of TR 38.821, how the RX G/T value (-31.6 dB/T) in the table or equivalently the antenna gain and noise figure for DL for NB-IoT with GEO are determined, whether it is a worst-case scenario, and whether SA4 can assume this value in the simulation?

## Input from companies

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| --- | --- |
| **Huawei** | * G/T of -31.6 is not the worst case scenario * High power UE (e.g. up to 37dBm) should be included in the evaluation |
| **vivo/SPDR** | * -31.6dB/k is a moderate case * A better G/T of e.g. -28.6 (4dB NF) could be considered |
| **Samsung** | * In TR 38.821, the RX G/T value was calculated under the following assumptions: ambient and antenna temperatures are equal, ambient temperature is 290 K, RX antenna gain is 0 dBi, and noise figure is 7 dB. This does not represent a worst-case scenario with the following reasons,   1. Ambient temperatures can exceed 320 K in extreme regions like the Sahara Desert or Death Valley,   2. RX antenna gain is estimated at -5.5 dBi from RAN4 reply LS (R1-2208353), and   3. A noise figure of 9 dB is considered for other parameters in TR38.821. |
| **Nokia** | * **RAN1 to reply to SA4 that the G/T calculation is explained in TR 38.821 and that it is baseline value, which SA4 can also apply in their simulations.** |
| **Apple** | *RX G/T value (-31.6 dB/K) in TR38.821 is determined with the assumptions of 0dBi UE antenna gain, 7dB noise figure, and 290K temperature.* |
| **ZTE** | ***Proposal 2:*** *RAN1 reply SA4 that the value G/T=-31.6 dB/K in TR 38.821 is determined based on assumption of omnidirectional antenna with 0 dBi antenna gain and 7 dB noise figure.*  ***Proposal 3:*** *RAN1 reply SA4 that for IoT-NTN, G/T=-31.6 dB/K can be considered if assumption in TR 36.763 is baseline. Moreover, G/T=-28.6 dB/K can also be considered for simulation to reflect the capability of current commercial IoT device.* |
| **CATT** | **RX G/T value is derived from handheld terminal receive antenna gain, noise figure and antenna temperature, so from RAN1 perspective, it is not the worst case. But considering realistic application, SA4 can assume this value to be used in the simulation** |
| **CMCC** | **In Table 6.1.3.3-1 of TR 38.821, the RX G/T value (-31.6 dB/T) for DL for NB-IoT is calculated based on the Table 4.4-1 in TR 38.811 with better NF value of 7dB. The Table 4.4-1 in TR 38.811 represents the typical minimum RF characteristics of UE in satellite and aerial access networks in 2017 in which the NF value is assumed as 9dB. From our understanding, other RF characteristics with better values which would reflect the latest implementation can be considered in SA4’s future evaluations.** |
| **Qualcomm** | **Proposal 2: For the reply to Q2, RAN1 to reply the following:**   * **The value of G/T of -31.6 dB/K is obtained from the below equation, assuming , , and :**    + A black and yellow text      AI-generated content may be incorrect. * **36.763 has considered a worst case G/T of -33.6dB/K. RAN1 recommends SA4 uses this value as the worst case scenario (if desired for evaluation).** * **For a typical use case, RAN1 recommends SA4 use values of -31.6dB/K or higher.** |
| **Skylo** | The G/T value is determined by the formula specified in TR 38.811, Table 4.4-1, also documented in TR 38.821 clause 6.1.3.1. It should be noted that for S-band handheld devices, a 3 dB polarization mismatch must be considered. This mismatch occurs because a UE's omni-directional antenna uses linear polarization, while satellite antennas typically employ circular polarization. This factor impacts the link budget computation, resulting in an equivalent G/T of -36.6 dB/K under satellite coverage, which is more stringent than the nominal value of -33.6 dB/K specified in TR 38.811, Table 4.4-1, where NF of 9dB is assumed.  The G/T value of -31.6 dB/K presented in Table 6.1.3.3-1 of TR 38.821 is a result of specific link budget calculations assuming a NF of 7dB for PC3 (23 dBm) UE devices. Furthermore, RAN1's agreed link budget results, summarized in TR 36.763, clause 6.2.2, include contributions from various source companies and consider different noise figures, such as NF=7dB and NF=9dB. This suggests a range of possible scenarios that should be evaluated, with the lowest G/T value representing the most challenging conditions.  SA4 is encouraged to use the link budget parameters specified in TR 36.763, TR 38.821, and TR 38.811 as described in discussion paper R1-2506244 as a baseline. However, it is crucial that the simulations also incorporate company-contributed satellite parameters and prioritize addressing worst-case scenarios. |

## Feature lead recommendation

While companies agreed on how to calculate G/T (in line with TR 38.821) and how the value of -31.6dB/K is obtained, there seems to be divergent views on what values can be recommended as worst case scenario and typical. The discussion on what value to assume is similar to the one that was reflected in the reply to Q1.

The proposed reply to Q2 is as follows:

### Proposed reply to Q2:

The parameter of G/T is calculated as follows (per TR 38.821):

where is receive antenna gain, is noise figure, is ambient temperature, is antenna temperature, and is the received antenna gain.

*<Note from FL: The reply summarizes the section in 38.821 since the antenna gain description is targeting satellite antenna gain instead of UE antenna gain>*

For the value of -31.6dB/K, it is obtained with , , and

The value of -31.6 dB/K, while typically used in RAN1 evaluations, may not reflect the worst case scenario in the field, as indicated in the reply to Q1. RAN1 could not reach consensus on a value of G/T that would be representative of the worst case scenario in the field.

### \*\* Discussion on Q2 \*\* Please provide your comments to the proposed response to Q2 in the table below.

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| --- | --- |
| Company | Comment |
| Ericsson | Q2 is: “**In Table 6.1.3.3-1 of TR 38.821, how the RX G/T value (-31.6 dB/T) in the table or equivalently the antenna gain and noise figure for DL for NB-IoT with GEO are determined, whether it is a worst-case scenario, and whether SA4 can assume this value in the simulation?**” We have the following input to provide with respect to Q2:   * **How the RX G/T value (-31.6 dB/T) in the table or equivalently the antenna gain and noise figure for DL for NB-IoT with GEO are determined?**   G/T can be determined using equation 6.1.3.1-3 as described in TR 38.821. The value G/T = -31.6 dB/K is obtained under the following assumptions: Antenna gain (G\_R) = 0 dBi, noise figure (N\_f) = 7 dB, Ta = T0 = 290 K.   * **Whether it is a worst-case scenario, and whether SA4 can assume this value in the simulation?**   TR 37.763 assumes a noise figure value of 9 dB for link budget evaluations, in which case G/T = -33.6 dB/ K. Thus, in our understanding G/T = -33.6 dB/ K can be considered as an assumption for the worst-case scenario, whereas G/T = -31.6 dB/ K can be considered a value used for a typical scenario. For evaluation purposes, in our view SA4 can use the G/T value for a typical scenario, or both G/T values (i.e., G/T =  -31.6 dB/ K and G/T = -33.6 dB/ K) if the worst-case scenario were also intended to be evaluated. |
| Xiaomi | We think FL’s response reflects the current situation. But we would prefer RAN1 could set up a value for SA4 evaluations. |

# References

R1-2505211 Discussion on the SA4 LS on the simulation assumptions for ULBC Huawei, HiSilicon

R1-2505365 Draft reply LS on the RAN simulation assumptions for ULBC vivo

R1-2505366 Discussions on RAN simulation assumptions for ULBC vivo, Spreadtrum

R1-2505527 Discussion on SA4 LS on the RAN simulation assumptions for ULBC Samsung

R1-2505863 Discussion on LS from SA4 on voice over GEO Nokia, Nokia Shanghai Bell

R1-2505870 Discussion on SA4 LS on the RAN simulation assumptions for ULBC Apple

R1-2505941 Discussion on SA4 LS on the RAN simulation assumptions for ULBC ZTE Corporation, Sanechips

R1-2505979 Discussion on SA4 LS on the RAN simulation assumptions for ULBC Xiaomi

R1-2506043 Discussion on SA4 LS on the RAN simulation assumptions for ULBC CATT

R1-2506072 Discussion on Reply LS on the RAN simulation assumptions for ULBC CMCC

R1-2506170 On RAN assumptions for ULBC Qualcomm Incorporated

R1-2506244 Discussion on SA4 LS on the RAN simulation assumption for ULBC Skylo Technologies

R1-2506245 [Draft] Reply LS on the RAN simulation assumptions for ULBC Skylo Technologies