**Title:****[Post-117-AIoT-01] Email discussion on remaining Ambient IoT evaluation assumptions**

# Background

[Post-117-AIoT-01] – Xiaodong (CMCC)

Email discussion on remaining Ambient IoT evaluation assumptions from May 29 until June 5 (the weekend is a quiet period)

• Approval of note 1 of the link budget table (highlighted in yellow) in section 9.4.1.1 of R1-2405696.

• Approval of the link level simulation table (highlighted in yellow) in section 9.4.1.1 of R1-2405696.

# Post-117 email discussion proposals

The proposals under discussion are summarized in a document (V001) in section 2, which is now available in draft folder (Please find the link below).

 [https://www.3gpp.org/ftp/tsg\_ran/WG1\_RL1/TSGR1\_117/Inbox/[Post-117]/[AIoT-01](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_117/Inbox/%5BPost-117%5D/%5BAIoT-01)]

I suggest dividing email discussion into 3 phases.

* Phase 1: Company to input comments to the 2 proposals (May 29 UTC 00:01 ~ May 30 UTC 00:00)
* Phase 2: Update the proposals and provide another round of comments (May 30 UTC 00:01~ May 31 UTC 23:59)
* Phase 3: Update the proposals again and try to stabilize the proposals (June 3 ~ June 5)

## link budget table

**[H][Proposal1-v1]**

Agreement

The link budget table is updated as follows (the yellow parts are not agreed and will be discussed by email),

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| **(0) System configuration** |
| [0A] | Scenarios | D1T1-A1/A2/B/CD2T2-A1/A2/B/C | D1T1-A1/A2/B/CD2T2-A1/A2/B/C |
| [0A1] | CW case | N/A | 1-1/1-2/1-4/2-2/2-3/2-4 |
| [0B] | Device 1/2a/2b | Device 1/2a/2b | Device 1/2a/2b |
| [0C] | Center frequency (MHz) | 900MHz (M), 2GHz (O) | 900MHz (M), 2GHz (O) |
| [0D] | Topology/Pathloss model | For D2T2:* [0D]-Alt1: InF-DL NLOS
* [0D]-Alt2: InH-Office LOS

For D1T1:* InF-DH NLOS
 | For D2T2:* [0D]-Alt1: InF-DL NLOS
* [0D]-Alt2: InH-Office LOS

For D1T1:* InF-DH NLOS
 |
| **(1) Transmitter** |
| [1D] | Number of Tx antenna elements / TxRU/ Tx chains modelled in LLS | For BS:- 2(M) or 4(O) antenna elements for 0.9 GHzFor Intermediate UE:- 1(M) or 2(O)  |  1 |
| [1E] | Total Tx Power (dBm)  | * For BS in DL spectrum for indoor
	+ [1E]-R2D-Alt1: 33dBm(M),
	+ [1E]-R2D-Alt2: 38dBm(O),
	+ [1E]-R2D-Alt3: 24dBm(M)
	+ Companies to report if PSD constraints are imposed (company to report the condition for applying PSD constraints in Row [5A]: Other notes)
* For UL spectrum for indoor,
	+ [1E]-R2D-Alt4:23dBm (M)
	+ [1E]-R2D-Alt5:26dBm(O)
 | * For device 1/2a:
	+ [1E]-D2R-Alt1: (For scenarios ‘B’)
		- The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value and other related factors.
	+ [1E]-D2R-Alt2: (For scenarios ‘A1’ and ‘A2’)
		- The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss.
* For device 2b: (For scenarios ‘C’)
	+ [1E]-D2R-Alt3: -20 dBm(M)
	+ [1E]-D2R-Alt4: -10 dBm(O)
 |
| [1E1] | CW Tx power (dBm) | N/A | For scenario ‘A1’, ‘A2’ and ‘B’* Report a value from the candidate values [1E]-R2D-Alt1/[1E]-R2D-Alt2/[1E]-R2D-Alt3 from [1E]-R2D if CW in DL spectrum
* Report a value from the candidate values [1E]-R2D-Alt4/[1E]-R2D-Alt5 from [1E]-R2D if CW in UL spectrum.

Note: only applicable for device 1/2a |
| [1E2] | CW Tx antenna gain (dBi) | N/A | * Company to report, the value equals to
	+ UE Tx ant gain, or
	+ BS Tx ant gain

Note: only applicable for device 1/2a |
| [1E3] | CW2D distance (m) | N/A | For scenarios ‘B’* + D1T1-B:
		- 5m,
		- 10m,
		- 20m
		- CW2D distance is derived assuming CW node is located with the same position as ‘R1’ in ‘A1’ scenario
	+ D2T2-B:
		- 5m,
		- 10m,
	+ FFS other values

For scenarios ‘A1’ and ‘A2’* + Calculated (see note 1), (i.e., CW2D distance is calculated by assuming CW2D pathloss = D2R pathloss)

Note: only applicable for device 1/2aNote: companies to report which value(s) are evaluated. |
| [1E4] | CW2D pathloss (dB) | N/A | Calculated (see note1)Note: only applicable for device 1/2a |
| [1E5] | CW received power (dBm) | N/A | Calculated (see note1)Note: only applicable for device 1/2a |
| [1F] | Transmission Bandwidth used for the evaluated channel (Hz) | 180kHz(M), 360kHz(O), 1.08MHz(O) | Refer to LLS table [1a] |
| [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(M)
* For intermediate UE, 0 dBi
 | * For A-IoT device, 0dBi
 |
| [1H] | Ambient IoT backscatter loss (dB) due to Modulation factor  | N/A | * OOK: 6 dB
* PSK: 0 dB
* FSK: Y dB

It is applicable for device 1 and 2aCompanies to report and justify their assumptions for Y.Companies to report in row 3D if they assume any additional related loss. |
| [1J] | Ambient IoT on-object antenna penalty | Not applicable | 0.9dB or 4.7dB |
| [1K] | Ambient IoT backscatter amplifier gain (dB) | N/A | * 10 dB (M)
* 15 dB (O)

Note: Only for device 2a |
| [1N] | Cable, connector, combiner, body losses, etc. (dB) | * For BS, X dB, X <=3 to be reported by companies with justification provided in row 5A
* For intermediate UE, 1 dB
 | N/A |
| [1M] | EIRP (dBm) | Calculated (see Note 1)FFS: any limitation of the EIRP subject to future discussion | Calculated (see Note 1) |
| **(2) Receiver** |
| [2A] | Number of receive antenna elements / TxRU / chains modelled in LLS | Same as [1D]-D2R | Same as [1D]-R2D |
| [2B] | Bandwidth used for the evaluated channel (Hz) | Refer to LLS table [1b] ED bandwidth | Refer to LLS table [2a] [receiver bandwidth?] |
| [2C] | Receiver antenna gain (dBi) | same as [1G]-D2R | Same as [1G]-R2D |
| [2X] | Cable, connector, combiner, body losses, etc. (dB) | N/A | Same as [1N]-R2D |
| [2D] | Receiver Noise Figure (dB) | For RF-ED receiver* 20dB, Device 2
	+ FFS other values

For IF/ZIF receiver* 15dB, Device 2
 | For BS as reader* 5dB

For intermediate UE as reader* 7dB
 |
| [2E] | Thermal Noise power spectrum density (dBm/Hz) | -174 | -174 |
| [2F] | Noise Power (dBm) | Calculated (see Note 1) | Calculated (see Note 1) |
| [2G] | Required SNR/CNR | Reported by companies for Budget-Alt2 | Reported by companies for Budget-Alt2 |
| [2H] | Ambient IoT on-object antenna penalty | 0.9dB or 4.7dB | Not applicable |
| [2J] | Budget-Alt1/ Budget-Alt2 | Budget-Alt1/ Budget-Alt2 (see note1) | Budget-Alt2 |
| [2K] | CW cancellation (dB) | N/A | Companies to report for scenario A2/A1/B for BS and intermediate UE.Note: * Only applicable for device 1/2a
* The value provided is for the unmodulated single-tone CW. The impact of a multi-tone CW, e.g., assuming an [X] dB difference, is FFS
 |
| [2K1] | Remaining CW interference (dB) | N/A | Calculated (see Note 1)Note: only applicable for device 1/2a |
| [2K2] | Receiver sensitivity loss(dB) | N/A | Calculated (see Note 1)Note: only applicable for device 1/2a |
| [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1, * For device 1 (RF-ED), for example:
	+ {-30dBm, -36dBm, -40dBm, etc}
* For device 2 (RF-ED), for example:
	+ {-40dBm, -45dBm, etc}

For Budget-Alt2,* Calculated (see note1)
 | Calculated (see Note 1)Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used |
| **(3) System margins** |
| [3A] | Shadow fading margin (dB) | For D1T1: 4 dBFor D2T2: 3dB for InH-LOS7.2dB for InF-DL-NLOS | For D1T1: 4 dBFor D2T2: 3dB for InH-LOS7.2dB for InF-DL-NLOS |
| [3B] | polarization mismatching loss (dB) | 3 dB | 3 dB |
| [3C] | BS selection/macro-diversity gain (dB) | 0 dB FFS: other values are not precluded | 0 dBFFS: other values are not precluded |
| [3D] | Other gains (dB) (if any please specify) | Reported by companies with justification | Reported by companies with justification |
| **(4) MPL / distance** |
| [4A] | MPL (dB) | Calculated (see Note 1) | Calculated (see Note 1) |
| [4B] | Distance (m) | Calculated (see Note 1) | Calculated (see Note 1) |
| **（5）Other**  |
| [5A] | Other notes | Companies to report | Companies to report |

*<Editor Notes: Note 1 will be updated once the table has stabilized >*

Note1 (for email discussion): calculated values in the Table XXXX are derived according to the followings,

[1M]:

* For R2D,
	+ [1M] = [1E] + [1G] - [1N] - FFS: [1J]
* For D2R
	+ Device 1:
		- [1M] = [1E] + [1G] - [1H] - [1J]
	+ Device 2a:
		- [1M] = [1E] + [1G] + [1K] - [1H] - [1J]
	+ Device 2b:
		- [1M] = [1E] + [1G] - [1J]

[2F]:

* [2F] = [2D] + [2E] +*lin2dB*([2B])

[2G]

* For the R2D LLS for ED, CINR/CNR is reported, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and interference (if any) power spectral density in the device ED channel bandwidth.

[2J]

* For R2D link in the coverage evaluation, for device 1
	+ Budget-Alt1 is used (note: receiver architecture is RF ED)
* For R2D link in the coverage evaluation for device 2,
	+ *Budget-Alt1* is used if receiver architecture is RF ED
	+ *Budget-Alt2* is used if receiver architecture is IF/ZIF ED
* Note1a: this does not preclude to have LLS for device 1 and 2 R2D link with RF-ED if needed.
* Note1b: For device 2 R2D link with RF-ED, *Budget-Alt1* is mandatory, *Budget-Alt2* is optional.
* Note1c: this does not imply all M values are achievable with the sensitivity given by *Budget-Alt1* for RF ED
* Note1d: For device 2 with an RF ED-based receiver on the R2D link, if the receiver sensitivity derived from *Budget-Alt2*, assuming a noise figure of [X dB], exceeds the receiver sensitivity based on *Budget-Alt1*, then *Budget-Alt2* is applied.

[2K1]:

* FFS:
	+ Alt1: [2K1] = [1E1] + [1E2] - [2K] or
	+ Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K]

[2K2]:

[2L]:

* For R2D and *Budget-Alt2*,
	+ [2L] = [2G] - *lin2dB*([2B] / [1F]) + [2F]
	+ Note 1e: the term ‘*lin2dB*([2B] / [1F])’ is applied due to scaling from CNR/CINR to SNR/SINR.
* For D2R,
	+ [2L] = [2G] + [2F] + [2K2], device 1/2a
	+ [2L] = [2G] + [2F], device 2b

[4A]

* [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D]
* Note 1f: For scenarios ‘A1’ and ‘A2’, The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,
	+ TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]) for device 1,
	+ TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]) for device 2

|  |  |  |
| --- | --- | --- |
| **Company** | **Which item?** | **Comments** |
| Company A | [1M] | Example….., |
| Huawei, HiSilicon | [1M] | The [1J] is not relevant to R2D anymore, thus propose the following update:[1M]:* For R2D,
	+ [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~
* For D2R
	+ Device 1:
		- [1M] = [1E] + [1G] - [1H] - [1J]
	+ Device 2a:
		- [1M] = [1E] + [1G] + [1K] - [1H] - [1J]
	+ Device 2b:

[1M] = [1E] + [1G] - [1J] |
| Huawei, HiSilicon | [2G] | [2G] is now agreed as “reported by companies”, not calculated, there is nothing else to discuss, hence it can be removed from this email discussion. |
| Huawei, HiSilicon | [2J] | Similar comments as 2G, [2J] is not calculated by others and just methodology alternatives. Since when to use Alt1/Alt2 have already been agreed and in [2L] there will be details of each Alt1, this item can be removed from this email discussion. |
| Huawei, HiSilicon | [2K1] | We think Alt2 should be the way to proceed, since the CW interference will be used to calculate sensitivity loss. Thus, propose the following update:[2K1]:* ~~FFS:~~
	+ ~~Alt1: [2K1] = [1E1] + [1E2] - [2K] or~~

Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K] |
| Huawei, HiSilicon | [4A] | The [4A] calculation is fine but the note seems need to be update1. To avoid duplicated/contradict to previous agreement, suggest to have some editorial change.2. Add missing parameters.The overall updates are as follows:[4A]* [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D]
* Note 1f: For scenarios ~~‘A1’ and ‘A2’,~~ where ~~T~~the Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,
	+ ~~TBC~~ For D2R: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]+2\*[3C]+2\*[3D]+2\*[1G]-[1J]-[2L]+[2C]-[1H]) for device 1,

~~TBC~~ For D2R: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B] +2\*[3C]+2\*[3D]+2\*[1G]-[1J]-[2L]+[2C]-[1H]+[1K]) for device 2a |

## link level simulation tabl

It is suggested to discuss the following link level simulation table. The text is marked red/green compared to the agreements in RAN1#116bis are for information.

Note: The green part is agreement in RAN1#117. The red part is revised text after RAN1#116bis.

And moderator suggest let’s focused on the text with red color.

**[H][Proposal2-v1]**

The link level simulation table is updated as follows,

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Parameters** | **Assumptions** | **Company result1** | **Company result 2** |
|  | **R2D/D2R common parameters** |  |  |
| **[0a]** | Carrier frequency | Refer to link budget template |  |  |
| **[0b]** | SCS | 15 kHz as baseline |  |  |
| **[0c]** | Block structure | Blocks as agreed in 9.4.2.3, or other blocks reported by companies |  |  |
| **[0d]** | Channel model | <Editor’s Note: will be updated according to the agreements made for channel model> |  |  |
| **[0e]** | Delay spread | ~~[30, 150] ns~~* An RMS delay spread of 30 ns and [150] ns is considered for TDL-A channel model.
* An RMS delay spread of 30 ns is considered for TDL-D channel model.
 |  |  |
| **[0f]** | Device velocity | 3 km/h |  |  |
| **[0g]** | Number of Tx/Rx chains for Ambient IoT device | 1 |  |  |
| **[0h1]** | BS | Number of antenna elements | 2 or 4 |  |  |
| **[0h2]** | Number of TXRUs | 2 or 4 |  |  |
| **[0j1]** | Intermediate UE | Number of antenna elements | 1 or 2 |  |  |
| **[0j2]** | Number of TXRUs | 1 or 2 |  |  |
| **[0m]** | Reference data rate | ~~[0.1, 1, 5] kbps~~[0.1] kbps (M), [1] kbps (M), [7] kbps (O), [large value] (O) |  |  |
| **[0n]** | Message size | {20 bits, 96 bits, 400 bits} are considered for message size.* Note: companies to report the M value and chip length used for each message size
 |  |  |
| **[0p]** | BLER target | 1%, 10% |  |  |
| **[0q]** | Sampling frequency | ~~<Editor’s Note: will be updated according to the agreements made for Sampling frequency >~~Sampling frequency is 1.92 Msps.Initial SFO (Sampling Frequency Offset) (Fe):* [0.1 ~ 1] \* 10^5 ppm ~~for device 1, reported by company~~
* ~~[0.1 ~ 1] \* 10^4 ppm for device 2, reported by company~~

The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.FFS: Accuracy after clock calibration for device 2.FFS: CFO for device 2b.Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design. |  |  |
| **[0r]** | Device 1/2a/2b | Options are as follows,* Device 1, RF-ED
* Device 2a, RF-ED
* Device 2b, RF-ED/IF-ED/ZIF

<Editor’s Note: will be updated according to agreements from 9.4.1.2> |  |  |
|  | **R2D specific parameters** |  |  |
| **[1a]** | Transmission bandwidth | 180 kHz as baseline |  |  |
| **[1b]** | ~~FFS:~~ ED bandwidth | The ED bandwidth is the bandwidth for calculating the noise/interference (if any) power:For evaluations, the value(s) of ED bandwidth is 20 MHz for RF-ED, [180] kHz for IF/ZIF receiver. Note: this does not imply that a A-IoT device supports sampling clock rate as large as RF ED bandwidth. |  |  |
| **[1c]** | ~~FFS:~~ BB LPF | [X]-order Butterworth/RC filter with cutoff frequency at ~~[Y] kHz,~~ half of R2D transmission bandwidth.Companies to report X = {3, 5}. |  |  |
| **[1d]** | Waveform | OOK waveform generated by OFDM modulator |  |  |
| **[1e]** | Modulation | OOKCompanies to report, e.g., OOK-1, OOK-4 with M chips per OFDM symbol |  |  |
| **[1f]** | Line code | Companies to report, e.g., Manchester, PIE |  |  |
| **[1g]** | FEC | No FEC as baseline |  |  |
| **[1h]** | ADC bit width | 1-bit for device 14-bit for device 2 |  |  |
| **[1j]** | Detection/decoding method for Line code | Companies to report |  |  |
|  | **D2R specific parameters** |  |  |
| **[2a1]** | Transmission bandwidth ~~(w.r.t. D2R data rate)~~ | ~~[FFS: 15kHz, 180kHz]~~* **[2a1]-Alt1:**
	+ DSB
	+ X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.
	+ The value is for two sidebands, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~.
* **[2a1]-Alt2:**
	+ SSB
	+ X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.
	+ The value is for one sideband, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~.
* The value of X ~~and Y~~ is as follows, to be down-select from alternative 1 and 2
	+ Alternative 1:
		- X = {15 (M), 180 (O)}
		- ~~Y =180~~
	+ Alternative 2:
		- X ~~and Y~~ reported by companies,
			* the value may be related to, e.g.,
				+ Reference data rate
				+ Coding scheme
				+ Repetition
				+ With or without SFS
				+ SSB or DSB
 |  |  |
| **[2a2]** | [OOK/BPSK/BFSK chip rate]  | Companies to report  |  |  |
| **[2a3]** | Receiver bandwidth | D2R receiver bandwidth is the bandwidth used at the reader side to filter out the D2R signals for calculating noise and interference (if any) power. * Assume the receiver matches the transmitter's modulation, i.e., to receiver uses SSB when transmitter uses SSB, receiver uses DSB when transmitter uses DSB.

Companies to report the value. |  |  |
| **[2b]** | Waveform (CW) | Companies to report waveform, e.g., unmodulated single tone, multi-tone(multiple unmodulated single tone) |  |  |
| **[2d]** | Modulation | Companies to report modulation, e.g., OOK, BPSK, BFSK |  |  |
| **[2e]** | Line code | Companies to report, e.g., Manchester encoding, FM0 encoding, Miller encoding, no line coding |  |  |
| **[2g]** | FEC | Companies to report, e.g., CC, No FEC |  |  |
| **[2h]** | ADC bit width | Companies to report, e.g., 11-bit |  |  |
| **[2j]** | D2R receiver  | ~~FFS: Reader receiver, e.g., coherent receiver / non-coherent receiver~~Companies to report, e.g., coherent receiver / non-coherent receiver |  |  |
|  | **Other assumptions** |  |  |
| **[3a]** | Other assumptions | To be reported by company |  |  |
| **[3b]** | Note: Companies to report required SINR/SNR/CINR/CNR according to BLER target. |  |  |

|  |  |  |
| --- | --- | --- |
| **Company** | **Which item?** | **Comments** |
| Company A | [0m] | Example….., |
| Huawei, HiSilicon | [0m] | We are fine with the proposal in general and would like to clarify our understanding that the intention of this LLS table is for coverage evaluation (in relation to Budget-Alt2). In that sense, we think focus on small values (0.1 kbps, 1 kbps) is enough for coverage evaluation. Further we understand data rate in link level simulation may not be achieved exactly same as reference data rate defined here in the table due design aspects of line coding chip length, FEC, repetition etc. Thus the simulation may be just approximately close to the data rate. |
| Huawei, HiSilicon | [0q] | We are supportive of the proposal. |
| Huawei, HiSilicon | [1c] | We are supportive of the proposal. |
| Huawei, HiSilicon | [2a1] | We are supportive of [2a1]-Alt1 since for D2R we understand DSB should be the choice which can be supported by all devices. We are also supportive of Alternative 1, since Alternative 2 is not a full list and will be derived from other design agenda items. |
| Huawei, HiSilicon | [2a2] | We are fine to add [2a2] |
| Huawei, HiSilicon | [2a3] | We are fine with the proposal and as we stated above, we think DSB should be the choice for D2R. |