3GPP TSG RAN WG1 Meeting #112bis-e R1-230xxxx

e-Meeting, April 17th – April 26th, 2023

**Title: [Draft] Reply LS to RAN4 on LP WUR architectures**

**Response to: R1-2302287 /** **R4-2303712**

**Release: Rel-18**

**Work Item: FS\_NR\_LPWUS**

**Source: [RAN1]**

**To: RAN4**

**Cc:**

**Contact person: [Sigen Ye]**

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**Send any reply LS to: 3GPP Liaisons Coordinator, mailto:3GPPLiaison@etsi.org**

**Attachments:** **None**

# 1 Overall description

RAN1 would like to thank RAN4 for the reply LS on low-power wake-up receiver architectures, and would like to provide the following feedback on the clarification questions from RAN4 ~~based on the progress until RAN1#112~~.

1. **Whether IoT/wearables/smartphone UE types are all considered for LP-WUR design**

[RAN1 response]

* Yes, IoT/wearables/smartphone UE types are all considered for LP-WUR design, according to the following agreement made in RAN1#112:

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| **Agreement**The following characteristics for target use cases are considered in the study item:* IoT cases including e.g., industrial wireless sensors, controllers, actuators and etc, including the following characteristics,
	+ FFS: latency
	+ primary for small form devices
	+ power-sensitive
	+ static, nomadic or limited mobility
* Wearable cases including e.g., smart watches, rings, eHealth related devices, and medical monitoring devices etc.,
	+ FFS: latency
	+ primary for small form devices,
	+ power-sensitive
	+ low/medium speed, FFS: high speed
* eMBB cases including e.g., XR/smart glasses, smart phones and etc.,
	+ FFS: latency
	+ devices form is various and not restricted
	+ power-sensitive
	+ low/medium speed, FFS: high speed

Note: other use cases/characteristics are not precluded if any. |

1. **Power consumption, coverage and SNR targets**

[RAN1 response]

* RAN1 has not reached any agreements on LP-WUR power consumption targets. RAN1 is still studying it.
	+ For the power consumption of LP-WUR, the following power model was agreed for evaluation purpose. Note that the power consumption is defined as the relative power w.r.t. the deep sleep state of the main radio following the non-RedCap UE power model defined in Section 8.1 of TR 38.840. The UE power model for RedCap UEs can be found in Section 6.2 of TR 38.875.

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| **Agreement**The following power model for LP-WUR is used for evaluation for FR1,

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| **Power State** | **Relative Power (unit)** | **Transition energy:****(unit multiplied by ms)** | **Ramp-up timeTLR, ramp-up (ms)** |
| **Off** | 0.001 | [TLR, ramp-up \*(PON+POFF)/2] | TLR, ramp-up = FFS, and company to report TLR, ramp-up FFS: Relation between Receiver architecture and its relative power and value of TLR, ramp-up |
| **On** | ~~0.005/~~0.01/~~0.02/0.03/~~0.05/0.1/~~0.2/~~0.5/1/2/4FFS: If other values are needed |

FFS: whether further categorization/sub-categorization is needed and how. |

* RAN1 has not reached any agreements on the coverage and SNR targets for LP-WUR. RAN1 is still studying these aspects.
	+ For evaluation of the coverage of LP-WUS, RAN1 has agreed to use MIL as the metric, with more details in the following agreement.

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| **Agreement**For evaluation of the coverage of LP-WUS, the methodology and assumptions in R17 CovEnh SI (described in TR38.830) is reused as baseline.* MIL is used as the metric for LP-WUS coverage evaluation
* urban (2.6GHz/4GHz), rural(700MHz) scenario for FR1 are considered to be evaluated, others (e.g., FR2) are not precluded.

Note: For IoT/wearables devices, refer to R17 Redcap SI TR38.875 if the assumptions differ from TR38.830.Companies report any other assumptions which differ from the TR38.875/ TR38.830, e.g., Tx and Rx lossCompanies are encouraged to compare LP-WUS with at least PDCCH for paging, PUSCH, others are not precluded.FFS: Target coverage of LP-WUS |

1. **Max occupied RB number in channel bandwidth for LP-WUS, for 1.4MHz and 5MHz RF bandwidth case**

[RAN1 response]

* For the bandwidth of LP-WUS, RAN1 has agreed on the following:

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| **Agreement**For the purpose of study, the BW of one LP-WUS is not greater than X (FFS X is 5 or 20) MHz for FR1, study further * whether BW of LP-WUS is configurable (implicitly or explicitly)
* size of guard band [FFS: within or outside of BW X], if any
* whether there is different X for Idle, Connected, Inactive modes

FFS: Whether FR2 is included in the scope of LP-WUS SI |

* RAN1 has not discussed the RF bandwidth of 1.4MHz for LP-WUS, and has not reached any conclusion on the maximum occupied RB number in 5MHz RF bandwidth case for LP-WUS. As the starting point for link-level simulations of LP-WUS, RAN1 has agreed on the following for LP-WUS bandwidth, the guard band and the filter.

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| LP-WUS BW | Option 1:* 5MHz including subcarriers for guard band
* 4.32MHz (i.e.,12 RBs) for LP-WUS transmission for 30kHz SCS

Option 2:* {2.16, 4.32} MHz including subcarriers for guard band
* 1.44MHz, 2.88MHz (i.e.{4, 8} RBs) for LP-WUS transmission for 30kHz SCS

FFS: other options are up to companies to reportGB is symmetrically placed on each side of LP-WUS |
| Filter  | X-th Order filter (e.g. Butterworth, Chebyshev, …) with Y MHz bandwidth,* X = {3, 5}
* Companies to report Y

Companies to report any other assumptions if needed |

1. **Possible supported SCS for LP-WUS, if applicable**

[RAN1 response]

* RAN1 has reached the following agreement on SCS:

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| **Agreement**For MC-ASK or MC-FSK waveform generation, SCS of a CP-OFDM symbol used for LP-WUS generation can be the same as SCS used for other NR transmissions in CP-OFDM symbol overlapping in time with, study whether SCS can be different, also study* FDM/TDM multiplexing with other NR transmissions
* link performance
* impact to legacy UEs
* impact on gNB
 |

* In addition, as the starting point for link level simulations for LP-WUS, RAN1 has agreed on the following assumptions for LP-WUS:

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| Configuration for LP-WUS signal | For OOK/FSK waveform,* Option 1a: M=1 and SCSs = 15kHz (same as NR signal)
* Option 1b: M=1 and SCSs = 30kHz (same as NR signal)
* Option 2a: M =2/4/8 for SCS = 15KHz (same as NR signal)
* Option 2b: M =2/4/8 for SCS = 30 kHz (same as NR signal)
* Option 3: M=1 and SCSs = 60kHz/120kHz/240kHz
* Note: M is referred to the definition of “M” in the agreements for OOK-1/2/3/4 and FSK-1/2

For OFDM: FFS, e.g., ZC sequenceOther options are up to companies to report |

1. **Whether WUS can be located in a band separate from the UE’s NR band**

[RAN1 response]

1. **Whether FR1 is considered as first priority frequency range**

[RAN1 response] Yes, FR1 is considered as first priority frequency range in RAN1, and it is still FFS whether FR2 should be included in the scope of the SI.

1. **Whether in-band power boosting of LP-WUS is considered from RAN1 perspective**

[RAN1 response]

* RAN1 is considering as part of evaluation, the in-band power boosting of LP-WUS. As the starting point for link level simulations for LP-WUS, RAN1 has agreed on the following for the modelling of adjacent subcarrier interference. RAN1 would appreciate feedback from RAN4, if any, on the power boosting assumptions made in RAN1.

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| Adjacent subcarrier interference | * PDSCH mapped on resources other than that for WUS and guard band;

EPRE of LP-WUS / EPRE of PDSCH =ρ, where ρ=0 dB as baseline, ρ= {3, 6} dB as optional |

RAN1 will inform RAN4 if further progress is made on any of the aspects above, and would appreciate input from RAN4 on these aspects, if any.

# 2 Actions

**To RAN4:**

**ACTION:** RAN1 respectfully asks RAN4 to take the above into consideration.

# 3 Dates of next TSG RAN WG1 meetings

TSG RAN WG1 Meeting #113 May 22-26, 2023 Incheon, KR

TSG RAN WG1 Meeting #114 August 21-25, 2023 Toulouse, FR