3GPP TSG RAN WG4 Meeting #110

Athens, Greece, February 26th – March 1st, 2024

R4-2402442

Views on Rel-19 RAN4 RF and OTA topics

Agenda Item:	14
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Introduction

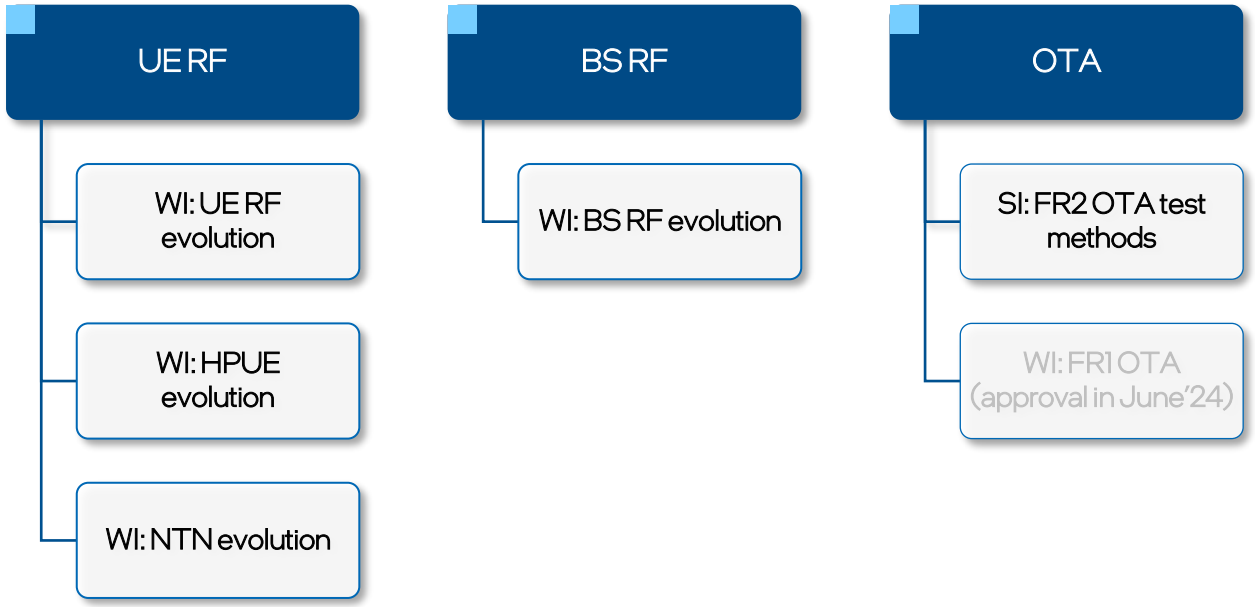
The general views on RAN4 Rel-19 SI/WI package are provided in R4-2402441

In the following slides we provided views on:

- Candidate RF/OTA topics identified in RAN #102 in RP-233918
- Potential scope and objectives of UE RF evolution WI and other RF/OTA-centric WIs

The following SI/WIs are recommended to be considered for RF/OTA areas:

- WI: UE RF evolution
- WI: HPUE evolution
- WI: NTN evolution
- WI: BS RF evolution
- SI: FR2 OTA test methods
- WI: FR1 OTA



Proposed scope for RAN4 Rel-19 RF/OTA

	Candidate objectives/scope	Comments
UE RF	• 6Rx for handheld/CPE/FWA • SRS IL compensation and reporting • Irregular channel bandwidth • [Power boosting and/or MPR reduction]	An umbrella WI focusing on FR1 UE RF topics. [2.0] RF TU per meeting.
HPUE	• Generic framework of support increasing UE power high limit for inter-band CA HPUE (only for TN) • PC1.5 UE for CA for 1) intra-band CCA with or without UL MIMO with 2Tx; 2) two band inter-band CA with 2Tx and 3Tx for handheld and FWA	A separate WI focusing on FR1 HPUE topics for different use cases and scenarios to avoid fragmented discussions across multiple WIs. [1.0] RF TU per meeting
NTN	• PC2 for NR/IoT NTN UE in NTN FR1 bands • [PC1 or PC1.5] for NR NTN UE in NTN FR1 bands	A separate project focusing on NTN HPUE aspects with [1.0] RF TUs. Can include other NTN-centric objectives (e.g., RRM/RF).
BS RF	• OTA test enhancement (to reduce the testing time) • EIRP mask for upper 6GHz	Small project with [0.5] RF TUs per meeting
UE RF BC simplifications	• Study on simplification of UE RF specification for band combination	Continuation of RAN4 work to simplify UE RF specification for BCs. Spectrum TUs can be reused.
OTA	• FR2 OTA: Dynamic OTA test methods	FR1 OTA: The work scope of FR1 OTA work can be discussed at a later stage (June'24) after completion of Rel-18 WIs performance part. FR2 OTA: Further studies on additional test methods are recommended. 0.5 – 1.0 TUs per meeting.

Views on RAN #102 candidate topics

Views on RAN #102 candidate topics

Summary (RAN#102)	Intel views
High Power UEs	
High power UE (HPUE) for CA 1. **PC1.5 UE for intra-band contiguous CA** with or without UL MIMO with 2Tx 2. **PC1.5 UE for two band inter-band CA** with 2Tx and/or 3Tx for handheld and FWA 3. **Generic framework** of support increasing UE power high limit for inter-band CA HPUE (only for TN) *Open issues:* o Further discussion on other type of HPUE CA band combinations. o Further discussion on whether to introduction of HPUE for EN-DC o Further discussion on whether to introduce PC1.5 for intra-band non-contiguous	**Medium priority** ✓ Prefer to keep a reasonable scope and focus on stable objectives identified in RAN#102. ✓ Additional scenarios listed in the open issues can be deprioritized and recommend to come back in mid-Rel-19 to check for possible scope extension. ✓ The work on Generic framework of support increasing UE power high limit for inter-band CA HPUE can be prioritized to ensure a long-term solution for future
High power UE (HPUE) for NTN 1. Introduce **PC2 for NR/IoT NTN UE** in NTN FR1 bands for both handheld and non-handheld (need confirmation on the co-existence) 2. Introduce **PC1 for NR NTN UE** in NTN FR1 bands for non-handheld (the study on co-existence is needed) 3. Introduce **PC1.5 for NR NTN UE** in NTN FR1 bands (the study on co-existence is needed) *Open issues:* o Need further discussion on whether the PC1.5 and PC1 are supported for non-handheld UE only or both handheld UE and non-handheld UE. o Need further discussion on whether IoT NTN UE can support PC1 and PC1.5. o Need further discussion on the prioritization of NTN work in terms of co-existence study. o Need further discussion on high power UE in NTN FR2 bands for non-handheld UE	**Medium priority** ✓ To reduce workload, recommend to down-select or prioritize between PC1 and PC1.5 for NR NTN based on NTN industry inputs and commercial needs. ✓ Focus on NTN FR1.

Views on RAN #102 candidate topics

Summary (RAN#102)	Intel views
UE RF	
Power boosting and/or MPR reduction 1. **Power boosting or MPR reduction for PC2/PC3 with ACLR relaxation** with BS indication (Study on whether and how much the requirement can be relaxed first and how often the power boosting can be done, and at least lower modulation order need be studied and FFS on higher modulation order) 2. **MPR reduction for** RedCap via relaxed emission requirements with BS indication (Study on whether and how much the requirement can be relaxed first, and at least lower modulation order need be studied) 3. **MPR reduction for UL contiguous CA in FR1/FR2** *Open issues:* o Including Pi/2 QPSK in the study and check whether there is RAN1 impact o Need further discussions on whether PAPR reduction is included. o Need further discussion on whether EVM will be relaxed. o Need further discussions on whether the power boosting or MPR reduction should be network transparent only	**Medium priority** ✓ The work can be beneficial to identify approaches to identify solutions to improve coverage for 5G-A and 6G ✓ Proposed enhancements are focused on a limited set of scenarios ✓ Rel-18 work on coverage achieved limited MPR benefits (0.5 – 1.0 dB) ✓ The set of candidate solutions is diverse and unstable, and potential performance benefits need studies. Recommend a study to down-select solutions and assess benefits/feasibility before introducing features. At least 9 months study is preferred.
6Rx UEs 1. **Investigate and enable 6Rx** on higher frequency bands (>2.5GHz) targeting at support of smartphone and FWA 2. Specify the **requirements to support SRS antenna switching** *Open issues:* o FFS on the MIMO layer to be supported. o Further discussions on the following potential objective: Improved SRS reporting for antenna switching usage	**High priority** ✓ 6Rx UEs support is one of the key enhancements, which can provide network capacity and coverage enhancement for a wide range of devices. ✓ SRS IL reporting framework shall be included in the scope (and can be extended to 4RX/8RX architectures) to allow networks to extract full benefits from multi-RX UE architectures. ✓ The work can focus on requirements with up to 4 MIMO layers. ✓ See slides 9-13 for more details.

Views on RAN #102 candidate topics

Summary (RAN#102)	Intel views
UE RF (cont.)	
3Tx UEs 1. Enable **3Tx for BCs of inter-band CA or EN-DC** with two bands for handheld UE 2. Support of **PC2 and PC1.5 for inter-band CA** or EN-DC with 3Tx 3. For HPUE which needs the new generic requirements 4. Support of high-power limit feature for inter-band CA or EN-DC with 3Tx *Open issues:* o FFS on how to handle the duplicated candidate objectives under 3Tx and HPUE CA	**Low priority.** 3Tx for single carrier was excluded in RAN #102 and the identified objectives for 3Tx CA/DC can be partially covered by "High power UE (HPUE) for CA" objective for 3 Tx with 2 bands in inter-band CA case. Other scenarios can be de-prioritized.
Uplink Tx switching enhancements 1. Specify UE requirements to enable **Tx switching** between cases, where **2 contiguous aggregated carriers on band A and 2 contiguous aggregated carriers on band B**, including both 1Tx-2Tx switching and 2Tx-2Tx switching. 2. 3Tx for 2 bands with UL Tx switching between 1T2T and 2T1T	**Low priority.** Small work scope is expected and can be included in case of operator commercial interest. Prefer focusing on "3Tx for 2 bands with UL Tx switching between 1T2T and 2T1T" only.
4Tx/8Tx requirements 1. Minimum requirements for **4Tx/8Tx with coherent transmissions** for FWA/CPE	**Low priority.** Feasibility of 4Tx/8Tx RF architectures is questionable and prior studies as fell as UE vendors confirmation of feasibility is needed
Other FR1 and FR2 enhancement 1. FR2 RF enhancement: UL256QAM for frequency > 39GHz in FR2-1 2. UL FR1-FR2 CA/DC performance: configurable UE-specific relative power limits for consistent UE behavior 3. Improved coverage for FR2: a new HPUE power class PC3bis for handheld UEs	Low priority

Views on RAN #102 candidate topics

Summary (RAN#102)	Intel views
BS RF	
1. **OTA test enhancement** (methods to reduce the testing time) 2. Core requirements/conformance test for **EIRP mask for upper 6GHz** 3. **Network RF specification simplification** (co-location and co-existence requirements)	**High priority.** Support all 3 objectives with the Obj 1 and 2 having higher priority
Enhancement of techniques related to spectrum utilization	
Study on further **simplification of UE RF specification** for band combination	**Low priority.** Meaningful to continue the work to simplify the specification. Potentially can be part of work on improving the CA/DC BCs maintenance (database) discussed in RAN #102. Can be allocated using Spectrum TUs.
Introduce specification support based on the optional solutions which were studied for the **irregular CBW** in the study item	**High priority.** RAN4 already concluded the SI on Irregular BW and specification support is needed to address operator request to allow more flexible network deployments. See slides 9-13 for more details.
Handling **fragmented intra-band blocks** as a single or multiple CC in the DL	**Medium priority.** Additional studies on feasibility and specification impacts are needed before proceeding with normative stage. Solutions may have impact on RAN1/2.
7~24GHz upper-mid band: Regulatory update, Technology consideration update	**Medium priority.** The work is helpful for the initial stage of 6G technology development. Can be considered in the start of Rel-20 (or late stage of Rel-19) with the focus on regulatory update.

WI: UE RF Evolution

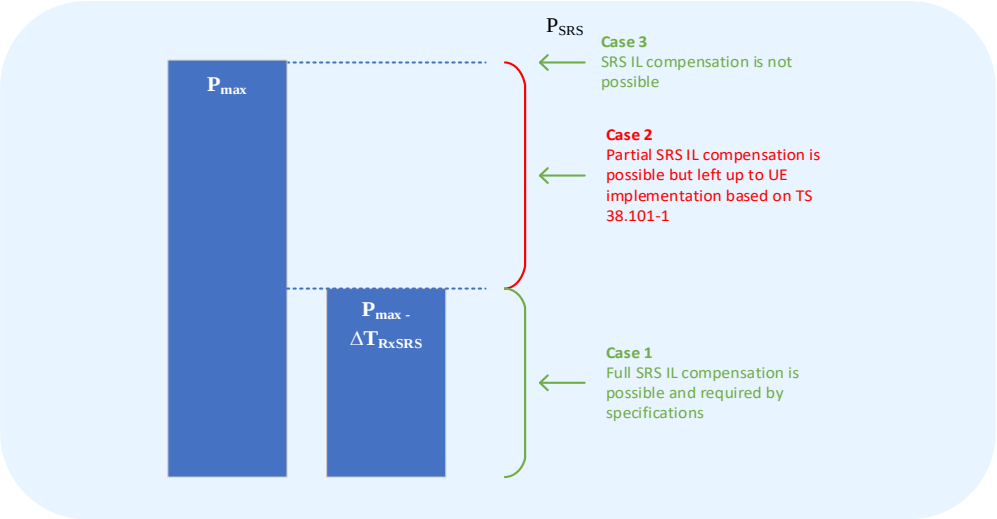
UE RF evolution (1)

SRS Insertion Loss compensation and reporting

Background

- The support of 8RX UEs was introduced in the scope of Rel-18 NR FR1 UE WI (NR_ENDC_ RF_FR1_enh2)
- Insertion Loss (IL) has a strong impact on the UL transmissions using 8RX architectures (R4-2303519)
- SRS Insertion loss for diversity branches might be different from the main branch and be up to 7.3 dB for 8RX UEs
- SRS antenna switching is an important feature to enable DL CSI acquisition for TDD systems
- SRS IL compensation is currently left up to UE implementation for power-limited UEs
- SRS IL may lead to an inaccurate channel estimation at gNB receiver, which could lead to incorrect SRS-based DL CSI estimation that would degrade the overall DL system performance (R1-2308458)
- No conclusions on enhanced solutions were reached for SRS IL compensation and handling in Rel-18

Recommend to consider topic in Rel-19 timeframe potentially merging with 6Rx, which is expected to have same technical issues



SRS IL compensation is left up to implementation for power-limited UEs (R4-2319810)

Candidate objectives

- *Study and introduce solutions for insertion loss compensation for SRS transmissions and UE assistance reporting for 2Rx, 4Rx and 8Rx FR1 UEs*

UE RF evolution (2)

FR1 UEs with 6RX antennas

Background

- Support of operation with up to 8RX antennas for CPE/FWA type of devices was introduced in Rel-18, while smartphone type of devices are equipped with up to 4RX.
- Further enhancement of the number of RX antennas at the UE side for NR can be considered to meet the market requests. 6Rx UEs support is one of the key enhancements, which can provide network capacity and coverage enhancement for a wide range of devices.
- To allow more flexibility for UE implementations support of 6RX shall be considered for different form factors including smartphone and CPE/FWA type of devices.

Candidate objectives

- *Enable 6Rx for smartphone/CPE/FWA form factors*
  - *Specify the UE RF requirements to support 6Rx*
  - *Specify the requirements to support SRS antenna switching with 6Rx*
  - *Specify RLM test cases with 6Rx*
  - *Specify UE demodulation performance and CSI requirements to support 6Rx (up to 4 MIMO layers)*

Power boosting and/or MPR reduction

Background

- A number of candidate solutions to improve MPR and/or achieve power boosting were proposed including
  - Power boosting or MPR reduction for PC2/PC3 with ACLR relaxation
  - MPR reduction for RedCap via relaxed emission requirements
  - MPR reduction for UL contiguous CA in FR1/FR2
  - MPR reduction with EVM relaxation
- The related Rel-18 work provided relatively small improvements of 0.5 – 1.0dB
- Proposed enhancements are focused on a diverse set of scenarios
- The need for HW changes at both UE and NW side may preclude wide roll-out in 5G networks.
- The work can still be beneficial to identify approaches to improve MPR for 6G. The set of candidate solutions is unstable, and potential performance benefits need studies. Recommend a study to down-select solutions and assess benefits/feasibility and make a decision on specification stage in mid Rel-19.

Candidate objectives

- *Study potential solutions for power boosting and/or MPR reduction*

UE RF evolution (3)

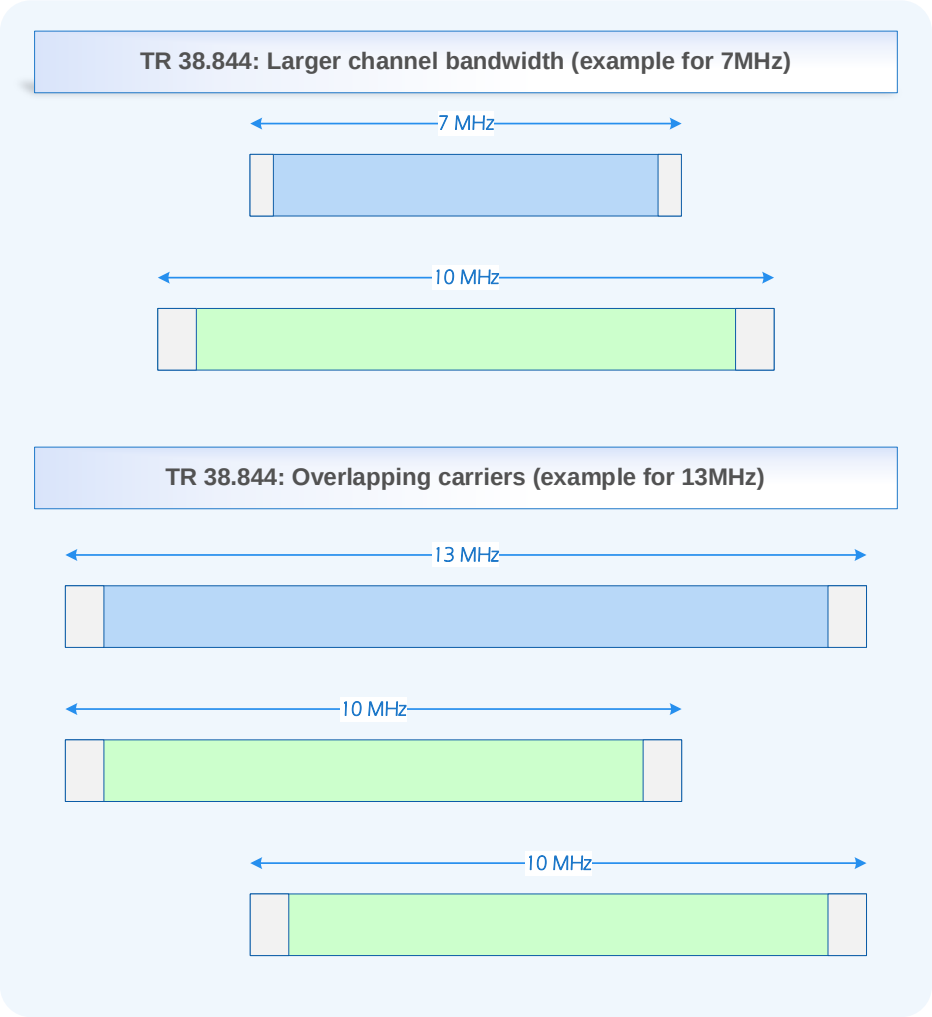
Irregular Channel Bandwidth

Background

- Increase spectrum utilization by allowing operators to flexibly use available spectrum blocks of any RB granularity instead of only traditional BW sizes at multiples of 5MHz.
- Several solutions were identified in the Rel-18 NR Irregular CBW SI (TR 38.844), but no follow up WI was approved.

Candidate objectives

- *Introduce specification support for the following irregular CBW methods*
  - *Larger Channel BW than licensed BW*
  - *Overlapping UE CBW from Network Perspective*
- *Address potential issues with initial access for irregular channel BW less than 10MHz*



UE RF evolution (4)

Proposed WI objectives

1. Study and introduce solutions for insertion loss compensation for SRS transmissions and UE assistance reporting for 2Rx, 4Rx and 8Rx FR1 UEs
2. Specify support of 6Rx on FR1 higher frequency bands (>2.5GHz) targeting at support of smartphone and FWA incl. single carrier and CA
   - Specify the UE RF requirements to support 6Rx
   - Specify the requirements to support SRS antenna switching with 6Rx
   - Specify RLM test cases with 6Rx
   - Specify UE demodulation performance and CSI requirements to support 6Rx (up to 4 MIMO layers)
3. Introduce specification support for irregular channel bandwidths for FR1
   - Specify the following methods identified in TR 38.844: 1) Larger Channel BW than licensed BW; 2) Overlapping UE CBW from Network Perspective
   - Address potential issues with initial access for irregular channel BW less than 10MHz
4. Study potential solutions and specification impacts for power boosting and/or MPR reduction incl. the following methods
   - Power boosting or MPR reduction for PC2/PC3 with ACLR relaxation
   - MPR reduction for RedCap via relaxed emission requirements
   - MPR reduction for UL contiguous CA in FR1/FR2

Other RF/OTA topics

Other RF/OTA topics

FR1 HPUE evolution

Background

- Multiple proposals submitted for R19 workshop and RAN #101 on extending the HPUE for CA and other scenarios.
- **A single umbrella item (FR1 HPUE WI)** is recommended for all HPUE topics to efficiently control the work scope and benefit from joint approach for handling adjacent technical problems.
- To control the workload additional scenarios listed in the open issues in RAN #102 can be deprioritized.
- **Generic framework**: the work can be prioritized over other objectives to ensure a long-term solution for future. A study stage may be needed to identify proper solutions.
- **PC1.5 UE for CA**: Consider to support both 2Tx and 3Tx. Deprioritize intra-band non-contiguous CA.

Candidate objectives

- **Generic framework** of support increasing UE power high limit for inter-band CA HPUE (only for TN)
- **PC1.5 UE for CA** for 1) **intra-band contiguous CA** with or without UL MIMO with 2Tx; 2) **two band inter-band CA** with 2Tx and 3Tx for handheld and FWA

BS RF evolution

Prioritized objectives

- Three key candidate objectives were identified in RAN #102
  - OTA test enhancement (methods to reduce the testing time)
  - Core requirements/conformance test for EIRP mask for upper 6GHz
  - Network RF specification simplification (co-location and co-existence requirements)
- WRC-23 concluded on the introduction of new **EIRP mask for upper 6GHz** and respective work shall be conducted by RAN4
- **OTA test time** can be much higher comparing to the conducted testing and additional studies and spec work to reduce the time, while striving to maintain a good level of coverage is beneficial

Candidate objectives

- **Core requirements/conformance test for EIRP mask for upper 6GHz**
- **BS OTA test time reduction** (as proposed in RP-232383)

Other RF/OTA topics

NTN HPUE

Background

- Extensive discussions on NTN HPUE took discussion in RAN#101/102 in the scope of RAN2-led NTN work item and the general conclusion to have a separate RAN4-led project was reached.
- A number of candidate objectives were identified in RAN #102 covering a wide set of scenarios.
- To control the RAN4 workload we recommend to down-select or prioritize between PC1 and PC1.5 for NR NTN based on NTN industry inputs and commercial needs and focus on NTN FR1.

Candidate objectives

- Introduce PC2 for NR/IoT NTN UE in NTN FR1 bands for both handheld and non-handheld (need confirmation on the co-existence)
- Introduce [PC1 or PC1.5] for NR NTN UE in NTN FR1 bands for non-handheld (the study on co-existence is needed)

FR2 OTA Test Methods

Recommend continuing the work on FR2 test methods enhancements to enable testing of new features and emulate realistic environment

Candidate objectives:

- Study dynamic OTA test methods
- Study test methods for STxMP for [non-handheld UEs] (if STxMP is included in the scope of FR2 multi-panel WI)

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