3GPP TSG-RAN Meeting #90e
December 7-11, 2020
Agenda Item: 9.7.5

RP-202746

Qualcomm

# Views on the Scope of NR RedCap WI

Qualcomm

# Requirements Agreed for R17 RedCap Devices

Sources: RP-201677 (SID for NR R17 RedCap), TR 38.875 (Study on Support of RedCap NR Devices)

## Generic Requirements

| | |
|---|---|
| **Device Complexity** | **Lower the device cost and complexity** as compared to high-end eMBB and URLLC devices of R15/R16 |
| **Device Size** | For most use cases, enables a device design with **compact form factor**. |
| **Deployment Scenarios** | Support all FR1/FR2 bands for **FDD and TDD** |

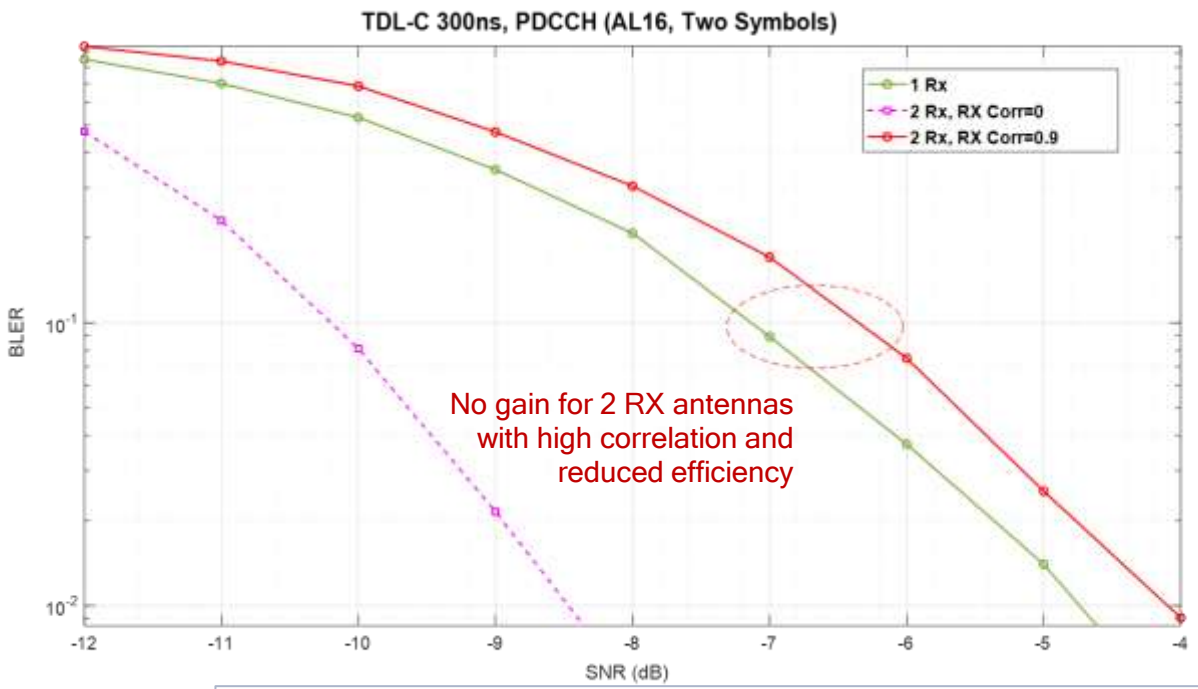
## Use Case Specific Requirements

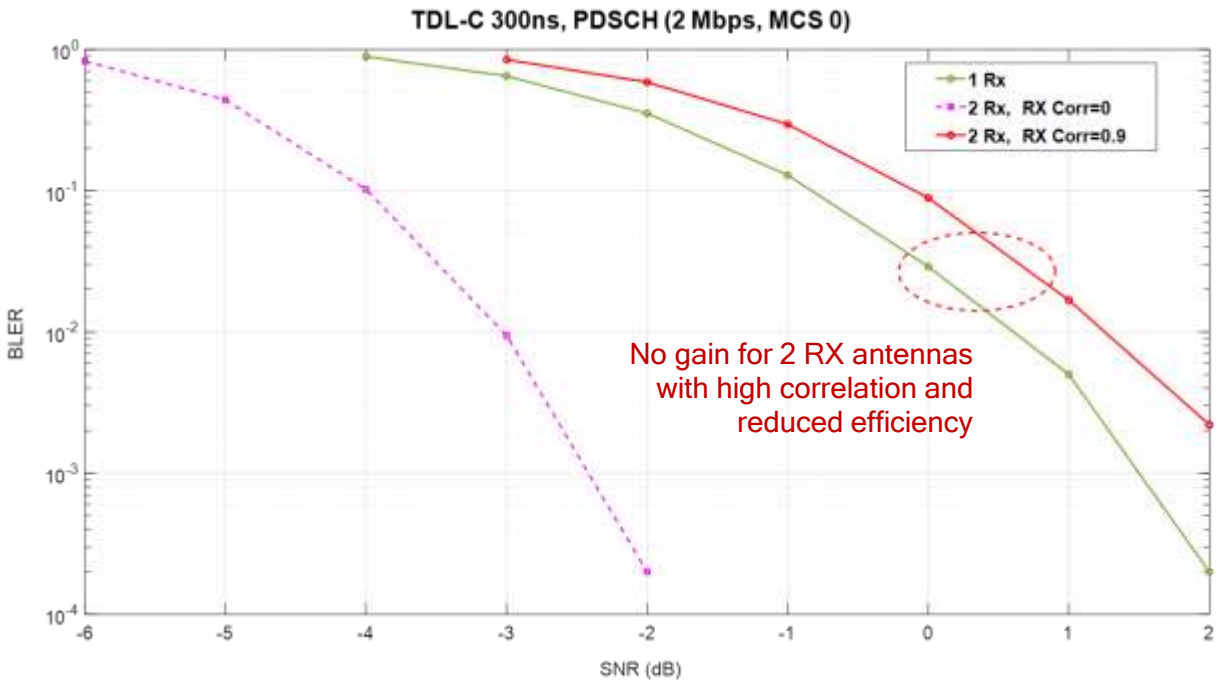
| Use cases | Wearable | Connected Industries | Smart City |
|---|---|---|---|
| **Example** | smart watches, rings, eHealth related devices, and medical monitoring devices | pressure/humidity/motion sensors, thermometers, actuators | surveillance cameras |
| **Bitrate** | Ref bitrate: 10-50/5 Mbps in DL/UL<br>Peak bitrate: Up to 150/50 Mbps in DL/UL | Ref bitrate: < 2Mbps (UL heavy) | Ref economic bitrate: 2-4 Mbps. 7.5-25 Mbps for high-end video (UL heavy) |
| **Latency** | ~ eMBB | <100ms<br>5-10 ms for safety related sensors | < 500ms |
| **Reliability** | ~ eMBB | 99.99% | 99%-99.9% |
| **Battery Life** | Multiple days (up to 1-2 weeks) | At least few years with sparse traffic | N/A |

# Objectives of R17 RedCap WI (RAN1)

- **Specify UE features and procedures to support reduced complexity and compact form factor**
  - support 1 RX antenna/branch as a minimum UE capability in FR1 (FDD &TDD bands) and FR2
  - support Type-A HD-FDD and FD-HDD in FR1 FDD bands
  - support DL/UL coverage recovery techniques to compensate for reduced BW/RX branch/antenna efficiency
  - support VoNR services
  - support NR R16/17 UE power saving solutions, including reduced PDCCH monitoring, PUR and EDT
- **Ensure co-existence with NR R15 and R16 UE**
  - re-use SSB/SIB1 BW and channel structure of NR R15
  - re-use waveform and RS of NR R15/16
  - re-use R15 MCS and CQI tables for qam64 and qam64-lowSE
  - support early indication of RedCap UE by RACH
- **Don’t promote market fragmentation of RedCap devices**
  - specify a common set of minimum UE capabilities to meet the use case specific requirements
    - at the same time, no need to set limits on maximum UE capabilities
  - focus on SA mode, single connectivity and single carrier operation

# Support 1 RX RedCap UE in FR1 FDD and TDD Bands



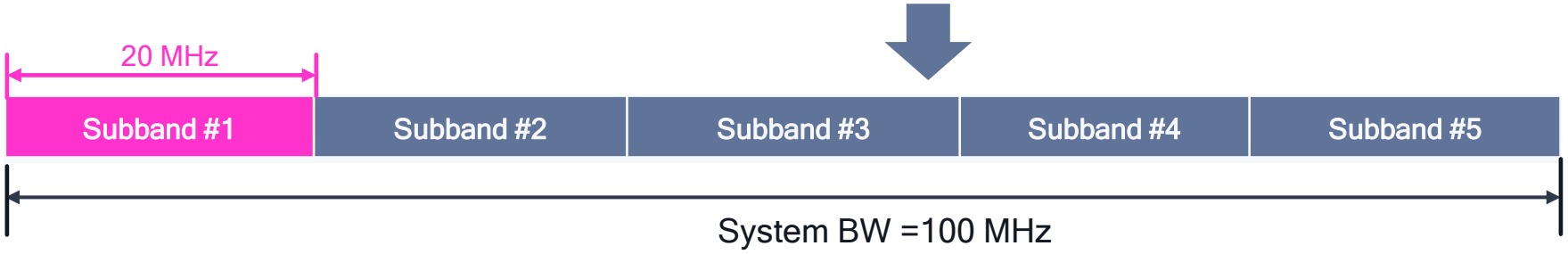

- Performance of PDCCH and PDSCH are simulated for 1 RX UE and 2 RX UE
- When 2 RX is supported, device size limitation of RedCap UE leads to high RX antenna correlation (> 0.7) and antenna efficiency loss
- RX antenna correlations are modeled by ULA MIMO correlation matrices (Reference: Section B.2.3, TS 38.101-4)
  - ULA LowCorr: α=0, β=0
  - ULA MediumCorr: α=0.3, β=0.9

## Observations

- Relative gain of 2 RX antennas w.r.t. 1 RX antenna can be negative, when RX antenna correlation and antenna efficiency loss are modeled
- X-pol antenna is NOT feasible for RedCap UE
- In addition, for interference limited scenarios, 2 RX gain over 1 RX is highly variable, gain can be as low as 0dB

# Questions on HW's SLS Results for RedCap Devices

- HW's SLS for Capacity and Spectral Efficiency Impacts of RedCap UE (Source: HW's emails sent to RAN1 reflector)
  - Assumptions
    - *"100MHz system bandwidth comprises five frequency blocks of 20MHz."*
    - *"Scheduled within one frequency block for both eMBB UE and RedCap UE"*
  - Evaluation Methodology
    - *"eMBB UEs and REDCAP UEs are randomly dropped in a cell. If the UE is REDCAP UE, it is fixed to only one frequency block, otherwise it is distributed to all 5 frequency blocks with the same UE location and equal traffic load for each block"*
  - Results
    - *"It is further observed substantial cell spectral efficiency loss about 30% due to UE Rx antenna reduced from four to two and DL modulation order restriction from 256QAM to 64QAM in FR1 and about 50% spectral efficiency reduction due to UE Rx antenna reduced from four to one and DL modulation order restriction from 256QAM to 64QAM in FR1."*




- *A RedCap UE is allowed to use subband#1 only*
- *An eMBB UE is allowed to use one subband only, but there is no restriction on the subband to be used*

## Observations

- In the worst case for eMBB UE, subband #1 is occupied by RedCap devices only
- Cell spectral efficiency reduction is upper bounded by 20%, assuming the spectral efficiency of RedCap devices is 0

➔ This contradicts with HW's SLS results, which indicates 50% SE loss for 1 RX RedCap UE and 30% SE loss for 2 RX RedCap UE

# Support 1 RX RedCap UE in FR1 FDD and TDD Bands

## Summary of Coverage Recovery for 1 RX RedCap UE

(Source: Section 9.1.5, TR 38.875)

- For RedCap UE with 1 Rx and reduced antenna efficiency, dependent on frequency bands and the assumption of DL PSD, the need for coverage recovery can be different
  - For carrier frequency of 4 GHz with DL PSD 24 dBm/MHz, coverage recovery may be needed for the downlink channels of Msg2, Msg4 and PDCCH CSS. A small or moderate compensation can be considered, where the square brackets indicate that the exact amount will depend on the techniques, scenarios, etc.:
    - [1 dB] for PDCCH CSS
    - [2-3 dB] for Msg4
    - [5-6 dB] for Msg2 without TBS scaling. It is noted that coverage loss for Msg2 can be compensated by using the existing TBS scaling technique.
  - For other carrier frequencies or DL PSD of 33 dBm/MHz, coverage recovery is not needed for the downlink channels if the target for coverage recovery is based on the MIL of the bottleneck channel for the reference NR UE.
  - It is noted that in the methodology for RedCap UE coverage recovery target determination, absolute ISD/MPL targets are not considered.
  - The determination of which channels require coverage recovery and the amount of coverage recovery depend on the choice of the target for coverage recovery.

## Observations

- According to LLS and SLS studies for 1 RX RedCap UEs in R17 SI, their impacts on coverage and network capacity are small
  - only 1 to 2 dB losses in DL coverage are observed (Section 9.1.5, TR 38.875) in LLS, compared to the bottleneck channel of reference NR UE
  - manageable change in the UPT, regardless the RedCap UE has 1 RX or 2 RX

**Proposal: In FR1, the minimum number of RX antenna/branch supported by a R17 RedCap UE is 1.**

# Support Type-A HD-FDD in FR1 FDD Bands

- Pros and cons of Type-A HD-FDD are analyzed in R17 RedCap SI
- TR 38.875 has captured the following benefits for Type-A HD-FDD
  - Power efficiency improvement
    - lower insertion loss of an HD-FDD UE may enable a higher power efficiency in the transmit chain and reduce power consumption
  - Good co-existence with FD-HDD UE during and after initial access
  - Minor performance impacts
    - spectral efficiency and capacity
    - instantaneous data rates for uplink or downlink
    - fulfilling latency and reliability requirements at least for one direction
  - Cost reduction
    - the average cost reduction achieved by Type A HD-FDD is ~7% but this scales up with multi-band (one band at a time) support

**Proposal: RAN1 and RAN4 to specify the spec changes for Type-A HD-FDD in WI phase**

- switching time needed for DL-to-UL and UL-to-DL
- DL/UL collision handling
- applicable bands and performance requirements (e.g. reference sensitivity, RRM requirements)

# Consideration of UE Processing Time Relaxation

- RedCap devices (at least a class of RedCap devices) should be compatible with future XR wearable use cases, therefore supporting Rel-15/Rel-16 processing times should remain in scope
- Relaxed processing time can be considered as an additional option
- Pros and cons of N1/N2 relaxation are analyzed in R17 RedCap SI
- According to TR 38.875:
  - Doubling N1 and N2 can achieve cost reduction of ~6%
  - Impact on UE power consumption depends on implementation and traffic characteristics
  - Some impact on latency and reliability have been identified
    - How significant the impact on latency depends on use cases and the scheduled number of retransmissions
  - Potential co-existence issues with legacy UEs during initial access, if early identification of RedCap UE in msg1 is not supported

**Proposal: UE processing time relaxation in terms of N1/N2 can be considered as an additional option in R17 RedCap WI**

- **RedCap devices (at least a class of RedCap devices) should remain compatible with future XR wearable use cases**

# Consideration of VoNR Support by RedCap Devices

- The current SID does not explicitly mention VoNR as an intended service for RedCap devices
  - Justification section mentions wearable devices as one of the use cases, but the description rather focuses on the intended data rates.
- VoNR support by RedCap devices, especially wearable devices, should be considered.
  - Could be mentioned in the objective section of the WI.
- While additional special designs may not be required, the following aspects should be taken into account in the WI.
  - Support for TB sizes optimized for different codec rates
  - Packet delivery delay / jitter
  - Interruption time due to mobility

**Proposal: Coverage recovery for RedCap devices should explicitly mention VoNR as a target service.**

The target scenarios and services include :

- [...]
- VoIP and eMBB service for FR1

# Scope of Coverage Recovery for RedCap UE

**Observations: R17 RedCap SI has identified coverage recovery is needed for the following channels**

- DL
  - PDCCH CSS
  - Msg2
  - Msg4
- UL
  - Msg3
  - PUSCH

**Conclusion: Both DL and UL coverage recovery should be considered for a RedCap device, including:**

- solutions specified in R17 coverage enhancement WI
- (low-SE MCS/CQI tables of NR R15)
- (low-PAPR DMRS of NR R16)