



Motivation for New WID on support of reduced capability NR devices



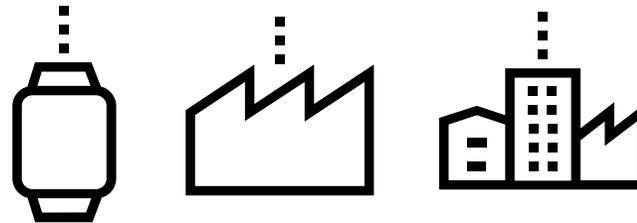
RedCap Use Cases



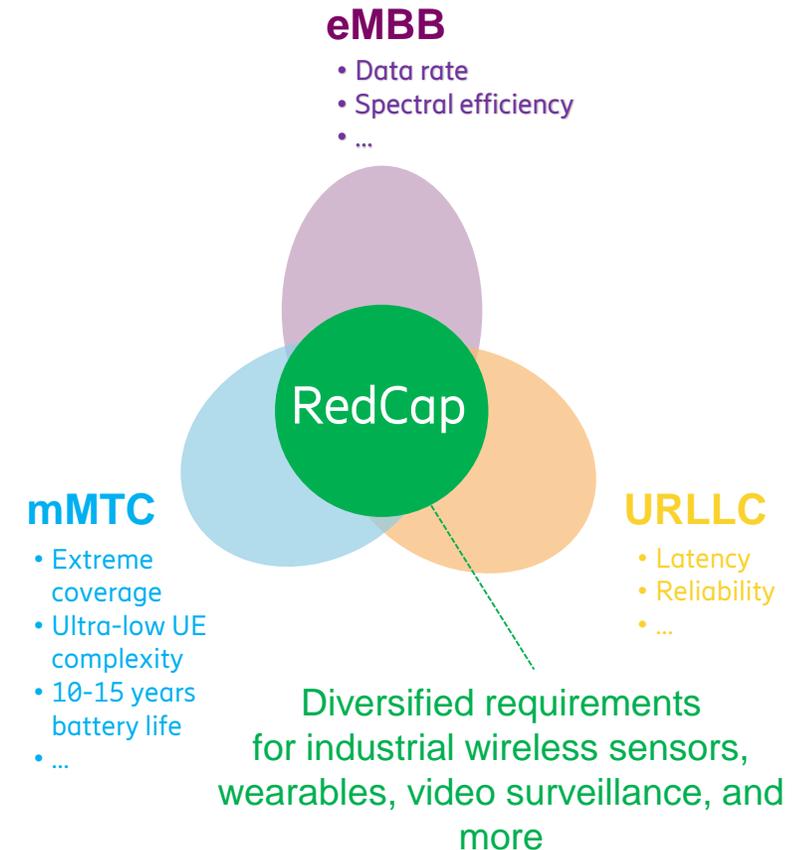
- Address use cases that are not best served by Rel-16 specifications

- Rel-17 RedCap use cases:

- Wearables
- Industrial wireless sensors
- Video surveillance



- Note: RedCap is not intended for LPWAN use cases

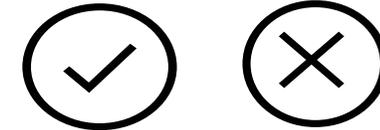


RedCap Generic Requirements/Considerations



Device Complexity

Lower device cost and complexity compared to high-end eMBB and URLLC devices



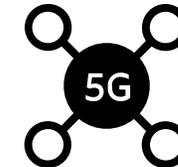
Device Size

Support wearable devices with reduced number of Rx branches in a compact form factor



Deployment Scenarios

Support all FR1/FR2 NR bands for FDD and TDD



Coexistence

Ensure coexistence with non-RedCap UEs



Specifications Impact

Reuse Rel-15 SSB bandwidth and minimize L1 changes



RedCap Use Case Specific Requirements

from TR 38.875 V0.1.0



- Industrial wireless sensors:
 - Communication **service availability is 99.99%**.
 - **End-to-end latency: <100 ms**; however for safety related sensors, latency requirement is lower, **5-10 ms**.
 - Reference bitrate is **less than 2 Mbps** (potentially asymmetric e.g. UL heavy traffic).
 - **Battery lifetime: at least few years**
- Video surveillance:
 - Reference economic video bitrate would be **2-4 Mbps, latency < 500 ms, reliability 99%-99.9%**.
 - High-end video, e.g. for farming, would require **7.5-25 Mbps**.
 - Traffic pattern is dominated by UL transmissions.
- Wearables:
 - Reference bitrate: **5-50 Mbps in DL and minimum 2-5 Mbps in UL**
 - Peak bitrate: **up to 150 Mbps for DL and up to 50 Mbps for UL**
 - Battery of the device should last several days (**up to 1-2 weeks**).

Impact on Coverage and Network Capacity

from TR 38.875 V0.1.0 & R1-2009293



- Coverage recovery

- With the complexity reduction techniques in the proposed WID (RP-202701), only PUSCH and Msg3 in FR1 require coverage recovery (≤ 3 dB).
 - No coverage recovery is needed in DL
 - No coverage recovery is needed in FR2

- Capacity impact

- For a given network radio resource utilization factor (e.g. $\sim 30\%$ or $\sim 50\%$ as studied), introducing RedCap users has minor or no impact on spectral efficiency and capacity, and little impact to the performance of co-existing eMBB users in the system

Complexity Reduction Techniques and Cost Reduction Estimates



Bandwidth reduction

Reduced minimum number of Rx branches

Reduced maximum number of DL MIMO layers

Relaxed maximum DL modulation order (FR1 only)

Combination of complexity reduction techniques	FR1 FDD	FR1 TDD	FR2
Total cost reduction	~58.7%	~58.3%	~47.5%

Cost reduction estimates, in terms of modem bill of materials, are based on combining the estimates of individual complexity reduction techniques in TR 38.875 V0.1.0 and R1-2009293.

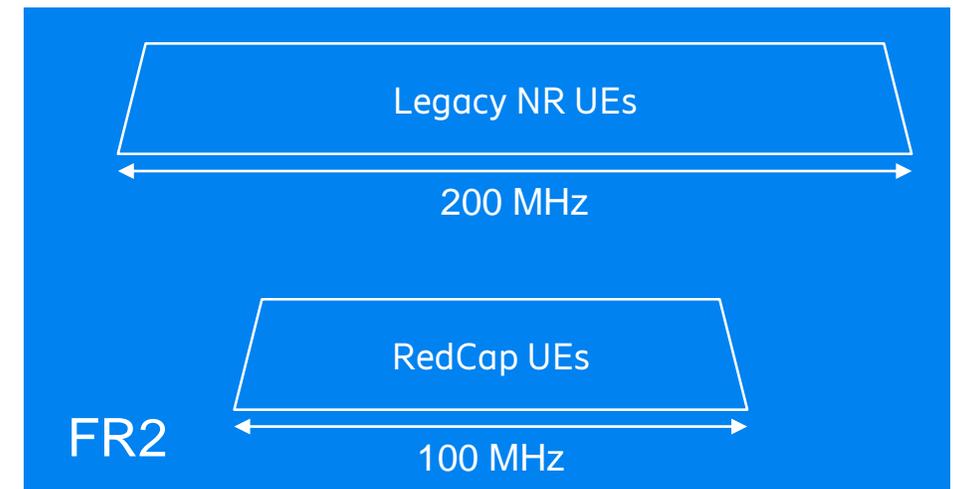
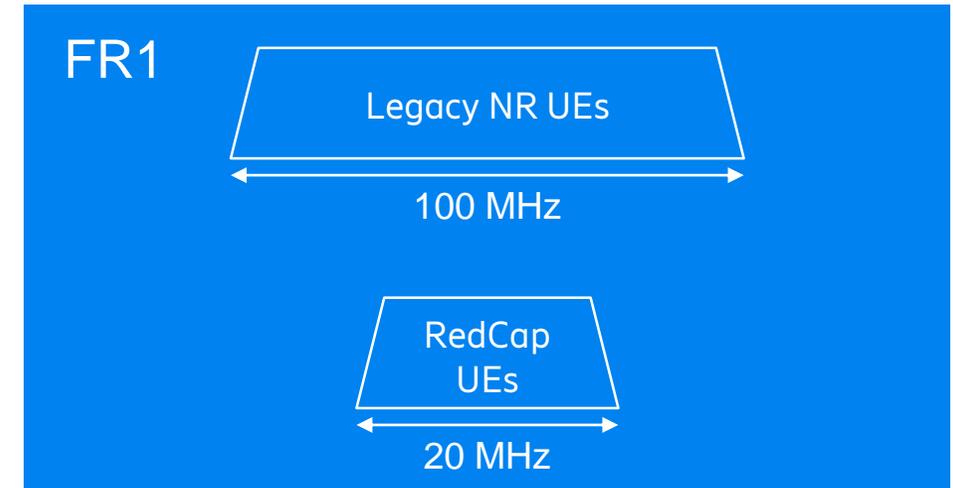
- The above corresponds to the minimum set of techniques recommended by RAN1 in TR 38.875 V0.1.0 clause 13.
 - Other techniques discussed in TR 38.875 V0.1.0 clause 13 can be discussed during RAN#90e, but in our view it seems unlikely that there can be consensus for including any of the more controversial ones in the WI scope.

Rel-17 WI Objectives (1/6)

- Specify support for **reduced maximum UE bandwidth**:
 - Maximum bandwidth of an FR1 RedCap UE during and after initial access is 20 MHz
 - Maximum bandwidth of an FR2 RedCap UE during and after initial access is 100 MHz

Reduced UE bandwidth	FR1 FDD (100 MHz → 20 MHz)	FR1 TDD (100 MHz → 20 MHz)	FR2 (200 MHz → 100 MHz)
Total cost reduction	~31.9%	~33.4%	~15.6%

from TR 38.875 V0.1.0, cost reduction, in terms of modem bill of materials, from reduced UE bandwidth only, without combining with other complexity reduction techniques



Rel-17 WI Objectives (2/6)



- Specify support for **reduced minimum number of Rx branches**:
 - For frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx branches, the minimum number of Rx branches supported by specification for a RedCap UE is 1.
 - The specification also supports 2 Rx branches for a RedCap UE.
 - For frequency bands where a legacy NR UE is required to be equipped with a minimum of 4 Rx branches, the minimum number of Rx branches supported by specification for a RedCap UE is 2.

Reduced minimum number of Rx branches	FR1 FDD (2Rx → 1Rx)	FR1 TDD (4Rx → 2Rx)	FR2 (2Rx → 1Rx)
Total cost reduction	~25.5%	~30.6%	~30.6%

from TR 38.875 V0.1.0, cost reduction, in terms of modem bill of materials, from reducing minimum number of Rx branches only without combining with other complexity reduction techniques

- 4Rx → 1Rx not desirable
 - Significant coverage impact
 - More RedCap UE spectral efficiency degradation compared to 4Rx → 2Rx

Rel-17 WI Objectives (3/6)



- Specify support for **reduced maximum number of DL MIMO layers**:
 - For a RedCap UE with 1 Rx branch, the maximum number of DL MIMO layers is 1.
 - For a RedCap UE with 2 Rx branches, the maximum number of DL MIMO layers is 2.

Reduced max number of DL MIMO layers	FR1 FDD (2 layers → 1 layer)	FR1 TDD (4 layers → 2 layers)	FR2 (2 layers → 1 layer)
Total cost reduction	~12.4%	~11.3%	~11.1%

from TR 38.875 V0.1.0, cost reduction, in terms of modem bill of materials, from reducing maximum number of DL MIMO layers only without combining with other complexity reduction techniques

Rel-17 WI Objectives (4/6)



- Specify support for **relaxed maximum modulation order**:
 - Support of 256QAM in DL is optional (instead of mandatory) for an FR1 RedCap UE.
 - Mandatory max DL modulation is 64QAM.
 - No other relaxations of maximum modulation order are specified for a RedCap UE.

Relaxed max DL modulation	FR1 FDD (256QAM → 64QAM)	FR1 TDD (256QAM → 64QAM)
Total cost reduction	~5.8%	~6.3%

from TR 38.875 V0.1.0, cost reduction , in terms of modem bill of materials, from relaxing maximum DL modulation only without combining with other complexity reduction techniques

- Relaxing DL modulation
 - Relatively small gain in complexity reduction, but also small standardization efforts and no coexistence impacts
- Relaxing UL modulation
 - Insignificant complexity reduction benefits

Rel-17 WI Objectives (5/6)



- Specify coverage recovery of up 3 dB for PUSCH and Msg3 in FR1 to compensate for coverage reduction due to device complexity reduction [RAN1, RAN4].
 - For FR1, the coverage recovery includes consideration of potential reduced antenna efficiency for wearables due to device size limitations as part of the antenna gains. The extent of additional recovery of coverage loss due to reduced antenna efficiency is limited to 3 dB
 - The techniques specified within the Coverage Enhancement WI should be considered first, and additional techniques are only specified as part of this WI if needed.
 - The relation with the Coverage Enhancement WI can be discussed and resolved in RAN#91e or later.

- The RedCap study has identified coverage recovery needs for certain scenarios (see slide 5)
- We believe the coverage recovery needs for PUSCH and Msg3 may be addressed by using the solutions that will be specified in the Coverage Enhancement WI

Rel-17 WI Objectives (6/6)



- Specify **higher layer support** for UE complexity reduction features and coverage recovery as needed [RAN2, RAN1].
 - Specify definition of RedCap UE type(s) including set(s) of L1 capabilities at least for RedCap UE identification and for constraining those UEs to the intended use cases.
 - Specify functionality that will allow RedCap UEs to be explicitly identifiable to networks and network operators and allow operators to restrict their access.
 - Specify necessary updates of UE capabilities (38.306) and RRC parameters (38.331).
 - Note: This objective may be revised in RAN#91e to take the outcome of the RedCap SI into account.
- The work in other WGs than RAN1 starts after RAN#91e.

