3GPP TSG-RAN WG1 Meeting #102-e Tdoc R1-20xxxxx

e-Meeting, August 17th – 28th, 2020

**Agenda Item: 8.6.1**

**Title: FL summary #5 for Potential UE complexity reduction features for RedCap**

**Source: Moderator (Ericsson)**

**Document for: Discussion, Decision**

# 1 Introduction

This document summarizes contributions [1] – [30] which were submitted to AI 8.6.1 plus a few relevant contributions [31] – [35] that were submitted to other agenda items under AI 8.6.

This document also captures this RAN1#102-e email discussion:

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| [102-e-NR-RedCap-01] Email discussion/approval – Johan (Ericsson)   * By 8/20 – high priority * By 8/26 – medium * By 8/28 – last check |

FL summary #1 was provided in [R1-2007090](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2007090.zip). The following agreements were made in an online (GTW) session:

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| Agreements:   * For cost/complexity reduction analysis, the RF-to-baseband cost ratio for an FR1 UE is assumed to be 40:60. * For cost/complexity reduction analysis, the RF-to-baseband cost ratio for an FR2 UE is assumed to be approximately 50:50.   **Conclusion:**   * The study of reduced number of UE (physical) antenna elements and panels in FR2 is not prioritized in the RedCap study item.   Agreements:   * For RedCap UEs in FR1,   + The baseline UE bandwidth capability is 20 MHz, which can be assumed during the initial access procedure.   + Discuss further by email whether there is an issue or a necessity in achieving up to 150Mbps assuming a 20MHz and rank 1 transmission. |

FL summary #2 was provided in [R1-2007177](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2007177.zip). The following agreements were made via email:

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| Agreements:   * For the purpose of evaluation, the UE processing time in terms of N1/N2 can be assumed to be doubled compared to those of capability #1, i.e.,   + N1 = 16, 20, 34, and 40 symbols for 15, 30, 60, and 120 kHz SCS (assuming only front-loaded DMRS)   + N2 = 20, 24, 46, and 72 symbols for 15, 30, 60, and 120 kHz SCS   Agreements:   * Study of relaxed UE processing time related to CSI computation is not prioritized in the RedCap study item. |

FL summary #3 was provided in [R1-2007269](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2007269.zip). The following agreements were made in an online (GTW) session:

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| Agreements:   * For FR1 DL, study relaxation of maximum mandatory modulation to 64QAM instead of 256QAM. * For FR1 UL, study relaxation of maximum mandatory modulation to 16QAM instead of 64QAM. * For FR2 DL, study relaxation of maximum mandatory modulation to 16QAM instead of 64QAM. * For FR2 UL, study relaxation of maximum mandatory modulation to 16QAM instead of 64QAM. * Restriction to 1 or 2 MIMO layers in DL can be studied. * No TBS restriction is considered in this SI beyond the implicit TBS restrictions resulting from reduced UE bandwidth or reduced number of MIMO layers. |

FL summary #4 was provided in [R1-2007302](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/R1-2007302.zip). The following agreements were made via email:

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| Agreements:   * Assume the detailed cost breakdown for FR1 FDD/TDD and FR2 in the table below:  |  |  |  |  | | --- | --- | --- | --- | | **Functional block** | **FR1 FDD (2Rx)** | **FR1 TDD (4Rx)** | **FR2** | | **RF** | | | | | Antenna array for FR2 |  |  | ~33% | | Power amplifier | ~25% | ~25% | ~18% | | Filters | ~10% | ~15% | ~8% | | RF transceiver (including LNAs, mixer, and local oscillator) | ~45% | ~55% | ~41% | | Duplexer / Switch | ~20% | ~5% | ~0% | | **Baseband** | | | | | ADC / DAC | ~10% | ~9% | ~4% | | FFT/IFFT | ~4% | ~4% | ~4% | | Post-FFT data buffering | ~10% | ~10% | ~11% | | Receiver processing block | ~24% | ~29% | ~24% | | LDPC decoding | ~10% | ~9% | ~9% | | HARQ buffer | ~14% | ~12% | ~11% | | DL control processing & decoder | ~5% | ~4% | ~5% | | Synchronization / cell search block | ~9% | ~9% | ~7% | | UL processing block | ~5% | ~5% | ~7% | | MIMO specific processing blocks | ~9% | ~9% | ~18% |   Agreements:   * In potential cost evaluations for a UE, it is assumed that the multi-band support affects the RF cost but not the baseband cost significantly. * In the TR, at least include a qualitative statement; relevant numerical results can also be considered. |

The issues in this document are color coded like this:

1. High priority
2. Medium priority
3. Low priority

This version of the document contains updated FL proposals tagged FL6. Compared to the previous version of the document (FL summary #4), this document is cleaned up and only contains the sections with FL5 or FL6 tags.

# 7 UE complexity reduction features

## 7.2 Reduced number of UE Rx/Tx antennas

### 7.2.2 Analysis of UE complexity reduction

In addition to reduction in cost/complexity benefits, the contributions [1, 2, 3, 4, 5, 7, 8, 9, 12, 15, 16, 17, 21, 25] have also highlighted that the reduction in number of UE Rx antennas is also beneficial in terms of reducing the size/form factor for devices, such as wearables in FR1.

The contribution [27] has indicated that form factor consideration does not justify 1 Rx for RedCap, especially in FR2. It is mentioned in [1] that reducing only the Rx (branches) has limited impact on reducing the device size in FR2. In [29], it is mentioned that in FR2 depending on the power, complexity, and form factor of the RedCap UE, 1Rx or 2 Rx may be selected.

**Q 7.2.2-1: Most companies agree that the reduced number of Rx antennas is beneficial in terms of reducing the device size. Should this benefit be captured in TR 38.875?**

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| **Company** | **Comments** |
| FUTUREWEI | As commented in 6.1-4, this is OK but is low priority. The lower carrier frequencies should be in the statement. |
| Ericsson | FR1: Yes, we agree that benefit in terms of reduced device size can be captured in the TR.  FR2: No. In our view, reducing only the Rx antennas (i.e., branches) will have limited impact on reducing the device size. We are also, however, open to receiving and take into consideration more input from UE vendors on this aspect. |
| Sierra Wireless | Yes. |
| Spreadtrum | Yes |
| ZTE,Sanechips | Yes. For both FR1 and FR2 it should be beneficial. |
| Panasonic | Yes. On FR2, as there are different views, these views can be captured. |
| Vivo | Yes. |
| Samsung | Yes. |
| OPPO | Yes. For both FR1 and FR2 it should be beneficial. |
| Xiaomi | Yes. The benefit of device size should be captured in the TR for both FR1 and FR2. For wearable device, the device size is one crucial factor. |
| CMCC | Yes |
| Huawei, HiSilicon | As device size reduction is not the target, this shall not be used to justify the reduction of RedCap to e.g. 1Rx as indicated in a few contributions and is also not critically needed to be captured. It can be captured but the above information would then also be necessary to be captured together.  Also, it needs to clarify that reduction of baseband MIMO layers does not reduce the device size. |
| TIM | It is a very delicate issue. We are more worried by performance loss, even if we understand that size reduction can be used for portable and Iot devices. |
| Sequans | Agree with Huawei – can be captured but with necessary clarifications. |
| Lenovo, Motorola Mobility | Yes |
| Intel | Yes, certainly for FR1, not necessarily for FR2. |
| Nokia, NSB | Yes |
| Qualcomm | The benefit of device size reduction should be captured in TR for RedCap UE, for both FR1 and FR2 (if any). |
| CATT | Yes for FR1, FFS for FR2. |
| DOCOMO | Yes for FR1. FFS for FR2 due to a few observations so far and the conclusion made in a RAN1#102-e online (GTW) session |
| LG | Yes. Can be refined for FR2 with further inputs in the follow-up discussions/meetings. |
| SONY | Yes. |
| InterDigital | Yes. |
| FL3 | All responses agree to capture this in the TR for FR1. Most but not all responses also agree to capture this for FR2. A few responses want to capture that device size reduction is not an objective in the RedCap SI and that this benefit should not be used to justify reduction to e.g. 1 Rx.  Proposal 7.2.2-1:   * Capture in TR 38.875 that reduced number of UE Rx antennas is beneficial in terms of reducing the device size in FR1.   + Study further if the reduced number of Rx antennas is beneficial in terms of reducing the device size in FR2. * Capture in TR 38.875 that device size reduction is not an objective for the RedCap SI. |
| vivo | Fine with the 1st bullet but do not agree with the 2nd bullet. We all know that for wearables the device size is an critical aspect, and we have the following statement in the SID justification. This is an design requirement in our view, and the complexity reduction schemes shall be available to achieve this requirement.  *Finally, wearables use case includes smart watches, rings, eHealth related devices, and medical monitoring devices etc. One characteristic for the use case is that the device is small in size.* |
| Samsung | OK with the first bullet.  We don’t agree with second bullet. |
| Panasonic | Fine with the proposal. |
| OPPO | OK with the first bullet.  We don’t agree with second bullet. |
| Qualcomm | We would like to second the opinion of Vivo. The SID explicitly mentions “Device size” in the generic requirements for RedCap UE, which is copied below:  ***Device size: Requirement for most use cases is that the standard enables a device design with compact form factor.***  If we agree on the 2nd bullet in FL3 proposal, it means the solutions we plan to study will miss the generic requirements for NR Rel-17 RedCap UE. Furthermore, one consequence of missing the requirements/objective of “compact form factor” is the de-prioritization of the wearables supporting FDD bands with 1 RX antenna. |
| SONY | Support opinion of vivo and Qualcomm.  We also had this agreement from RAN1#101e:   * *Use the TR 36.888 methodology for UE cost/complexity evaluation as a starting point and determine what major updates are needed.* * *Cost/complexity breakdowns can be separate for FR1 and FR2 if found beneficial.* * *Include antenna parts at least in the cost/complexity breakdown for FR2.* * *Potential benefits in terms of reduced device size can be mentioned where applicable in the TR (e.g. in the section on reduced number of antennas), but the SI will not aim to quantify such benefits.*   We think it would be worth mentioning the reduced device size benefits of reduced antennas based on the agreement above and the comments from vivo and Qualcomm |
| Spreadtrum | We are fine with this proposal. |
| Xiaomi | OK with the first bullet.  Don’t agree the second bullet.  From the perspective of product, compact device size is a real need. In addition, “relatively low-end services with the requirement of small device form factors” is mentioned in the Justification of the SID, hence the objective of Reduced number of UE RX/TX antennas from our understanding includes at least part of the small device size reduction. |
| Sequans | Fine with the proposal as is.  Compact form factor is indeed a requirement for some of the targeted use cases as stated in SID and we understand that first bullet intention is to capture observations regarding this aspect. However, size reduction compared to legacy NR UE is not an objective in RedCap SI like cost/complexity reduction, power saving and coverage recovery. Second bullet makes sure to clarify this. |
| Ericsson | We are fine with this proposal. |
| Sierra Wireless | We are Ok with 1st bullet.  We don’t’ agree with 2nd bullet. |
| LG | Fine with the first bullet and do not agree with the second bullet.  The device size itself may not be an objective of the SI, however, the compact form factor is one of generic requirements that should apply to all use cases. |
| FL5 | Most companies agree to capture the first bullet of Proposal 7.2.2-1 in the TR. There are also many companies that do not agree to the second bullet. Perhaps the following updated version can be considered.  Proposal 7.2.2-1-v2:   * Capture in TR 38.875 in the next meeting that reduced number of UE Rx antennas is beneficial in terms of reducing the device size in FR1.   + Study further if the reduced number of Rx antennas is beneficial in terms of reducing the device size in FR2. * ~~Capture in TR 38.875 that device size reduction is not an objective for the RedCap SI.~~ |
| OPPO | We are fine with Proposal 7.2.2-1-v2 |
| FUTUREWEI | OK if can be agreed now, but if any concern this is low priority and can be handled next meeting. |
| vivo | Fine with proposal 7.2.2-1-v2 |
| Huawei, HiSilicon | Suggest  Proposal 7.2.2-1-v2:   * Capture in TR 38.875 in the next meeting that reduced number of UE Rx antennas may be beneficial in terms of reducing the device size in low-frequency bands, .e.g. below 1.8G within FR1; reduction of baseband MIMO layers does not reduce the device size.   + Study further if the reduced number of Rx antennas is beneficial in terms of reducing the device size in FR2. * ~~Capture in TR 38.875 that device size reduction is not an objective for the RedCap SI.~~ |
| Samsung | We support proposal 7.2.2-1-v2 from FL.  We think even in high frequency bands for FR1, reduced number of UE Rx antennas is also beneficial interns of reducing the device size. We cannot agree with the suggested update from Huawei by listing the bands. And the impact on baseband MIMO layers is a separated discussion. No need to add there. |
| MediaTek | We don’t think device size reduction is an objective for the RedCap SI. However, for the sake of progress we can accept the proposal by including the modifications from Huawei. |
| Ericsson | Fine with Proposal 7.2.2-1-v2 |
| FL6 | Proposal 7.2.2-1-v2:   * Capture in TR 38.875 in the next meeting that reduced number of UE Rx antennas is beneficial in terms of reducing the device size in FR1.   + Study further if the reduced number of Rx antennas is beneficial in terms of reducing the device size in FR2. * ~~Capture in TR 38.875 that device size reduction is not an objective for the RedCap SI.~~ |
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### 7.2.3 Analysis of performance impacts

Concerning the impact on performance, several contributions observe that a reduced number of antennas impacts coverage, spectral efficiency, power consumption, data rate, PDCCH blocking probability, latency, reliability, and number of users supported.

The downlink coverage loss reported in the contributions are summarized in Table 2. Some contributions (e.g., [22, 23, 29]) have cited their companion paper under AI 8.6.3 for the quantitative values of coverage loss and have not included them as part of their complexity reduction paper under AI 8.6.1. Those values are, however, not included in Table 2.

**Table 1: Estimation of downlink coverage loss from reduced number of UE Rx antennas in FR1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Contribution** | **FR1 FDD**  **2 Rx  1 Rx** | **FR1 TDD**  **(4 Rx  2 Rx)** | **FR1 TDD**  **(4 Rx  1 Rx)** | **FR2**  **(2 Rx  1 Rx)** |
| [1] | SSB: 4.7 dB  PDCCH (AL16): 3.7 dB  PDSCH: 4.0 dB | SSB: 3.0 dB  PDCCH (AL16): 3.2 dB  PDSCH: 3.0 dB | SSB: 6.9 dB  PDCCH (AL16): 6.2 dB  PDSCH: 6.2 dB | SSB: 3.7 dB  PDCCH (AL16): 3.9 dB  PDSCH: 3.8 dB |
| [2] | PDCCH (AL16): 3.08 dB  PDSCH (5 Mbps): 4.34 dB  PDSCH (10 Mbps): 5.07 dB | - | - | - |
| [3] | 3-6 dB | 3-6 dB | - | - |
| [5] | - | 3 dB\* (AWGN)  \* loss in fading channels may be larger | 5.5 dB-6 dB\* (AWGN)  \* loss in fading channels may be larger | - |
| [6] | PDSCH: 4.0 dB  PDCCH (AL16): ~4.0 dB | PDSCH: 3.2 dB  PDCCH (AL16): ~3.2 dB | PDSCH: 7.2 dB  PDCCH (AL16): ~7.2 dB | - |
| [8] | PDCCH (AL16): 2.6 dB | PDCCH (AL16): 2.3 dB | PDCCH (AL16): 5.6 dB | - |
| [9] | - | SSB: 2.44 dB  PDCCH: 6.48 dB (AL1); 5.52 dB (AL2); 5.32 dB (AL4); 3.47 dB (AL8); 2.59 dB (AL6)  PDSCH: 3.85dB | SSB: 5.51 dB  PDCCH: 13.83 dB (AL1); 12.12 dB (AL2); 9.58 dB (AL4); 7.28 dB (AL8); 6.09 dB (AL6)  PDSCH: 9.83dB | - |
| [15] | - | - | >6 dB | - |
| [17] | PDCCH (AL16): ~4 dB  PDSCH: ~4dB | - | PDCCH (AL16): ~10dB  PDSCH: ~4dB | PDCCH: ~4 dB |
| [19] | PDCCH: 3.63 dB (AL=16); 4.59 dB (AL=4) | PDCCH: 2.9 dB (AL=16); 3.93 dB (AL=4) | PDCCH: 6.56 dB (AL=16); 8.52dB (AL=4) | - |
| [27] | - | - | ~7dB | - |

The above values for performance loss depend on the exact simulation assumptions used by different companies, including on channel conditions, performance requirement for different channels, etc. These are either provided in the above cited papers, or in their respective companion papers on coverage recovery. In [7, 18, 22, 23, 25], it has also been stated qualitatively that there will be coverage loss due to reduction in Rx antennas. In [4], it is noted that the impact of coverage is limited due to reduced Rx as it is shown in the coverage study that NR is UL coverage limited. In [17], it is also noted that longer acquisition time for SSB detection is expected, and that no coverage impact is expected for PUSCH due to reduction in number of Rx antennas.

Several contributions have also identified other impacts when reducing the number of Rx antennas:

**Data rate/throughput:**

* P1: [1, 2, 5, 7, 9, 18] have indicated that there will be negative impact on DL data rate/throughput when reducing the number of Rx antennas. The main reason is that reducing the number of Rx antennas will also reduce the number of transmission layers that can be transmitted in the DL.

**Latency and reliability:**

* P2: In [29], it is observed that for FR2, support of 1 Rx antenna at the UE can satisfy the latency requirements for industrial wireless sensors and video surveillance cameras (with 100 MHz).
* P3: In [7], it is observed that reducing the number of receive antennas does not affect latency and reliability.

**Power consumption:**

* P4: [19] has indicated that there is less contribution to power saving for 2 Rx****1 Rx
* P5: [2] and [16] have noted that power consumption is also saved by fewer RF chains and by less complexity of multi-antenna processing
* P6: [1, 5, 6, 7, 20, 23] have noted that although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules, due to longer reception time needed for downlink channels, the power consumption will be increased.

**Spectral efficiency/network capacity loss:**

* P7: [1, 2, 3, 4, 6, 7, 9, 13, 17, 19, 20, 23, 25], especially [2], report a loss in spectral efficiency of ~30% for 2 Rx****1 Rx.
* P8: In [6], it has been reported that loss is spectral efficiency (sector/cell edge) is 23-33% for 2 Rx****1 Rx, 39-41% for 2 Rx****2 Rx, and 53-60% for 4 Rx****1 Rx.
* P9: In [4], it is also noted that the impact can be managed by network by access control mechanism.

**PDCCH blocking probability:**

* P10: [7] and [20] have noted that there will be increase in PDCCH blocking probability. This is due to use of higher Als in order to compensate for the performance degradation from a reduced number of Rx antennas.

**Number of users supported:**

* P11: In [29], it is observed that for FR2, the number of users that can be supported is impacted by almost 50% if the number of UE Rx antennas is reduced from 2 to 1. It is also observed that 1 Rx antenna at the UE may be able to support a high number of users.

The discussion on bottleneck channels and coverage recovery techniques to compensate for the performance loss can be taken under AI 8.6.3, and are left out of the discussion in this section. Some contributions have also noted the impact of device size limitations on potential reduced antenna efficiency. The resulting performance impact can also be studied under AI 8.6.3, and has not been considered in this section.

**Q 7.2.3-1: Does the list (P1, P2, …, P11) above capture the most important performance impacts that need to be considered for UE antenna reduction? If not, what other aspects need to be added?**

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| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | N | The most important observation is the very large number of dB loss, especially from 4 to 1 RX. Perhaps some range in [ ] can be agreed for now, and can be revised by next meeting. Note that the table 2 is incorrect in that it says COVERAGE LOSS, which is not correct. These are performance degradations, but since the system is both UL limited and not designed to exactly match the MCL of the UL limited channel, there may not be coverage loss.  A minor point: it would be helpful, in addition to the numbers in P7/8, to say why the loss occurs. I.e., spectral efficiency will be reduced from having to use more robust MCS, repetitions, etc. |
| Ericsson | Y | Yes, beside coverage impacts and coverage recovery aspects, which are treated under the AI 8.6.3 according to the meeting agenda. |
| Sierra Wireless | Y |  |
| Spreadtrum | Yes |  |
| ZTE,Sanechips | N | It seems the above list does not include impact for coverage, it is strange. |
| Panasonic | Y |  |
| vivo | N | We DO NOT agree with the following   * P4: From FR2 power model in TR38.840, there is 30% power saving gain from 2Rx to 1Rx, which is significant. In FR1, such power scaling model is missing and should be developed. There is no evidences in fact shown in [19] that reducing from 2Rx to 1Rx has no big contribute to power saving and cost reduction. * P6: This has to be evaluated with proper power model developed for RedCap Ues with realistic traffic model * P7/P8/P11: This has to be evaluated with realistic evaluation assumptions, in [4] we proposed the following factors to be considered for a fair comparison. We hope that in this meeting we can align the evaluation methodologies and assumptions so that companies can bring results to the next meeting. We see same discusion point is caputred in the summary of [102-e-NR-RedCap-03] section 2.3, suggest we have this discussion only in one place. * Ratio between Redcap and normal UE is not higher than 1:1 * Different traffic models for Redcap (IM traffic for wearables) and normal Ues (FTP traffic)      * Performance metrics:   + UPT to measure the performance impact to normal Ues   + Cell served throughput to measure the system capacity |
| Samsung | N | P1 (data rate) we can focus on whether the data rate can be achieved rather than provide negative impact.  We don’t think the P11 needs to be captured separated from network capability. In P11, “It is also observed that 1 Rx antenna at the UE may be able to support a high number of users.” Should be removed.  P4 and P5 need to be merged and be consistent.  Coverage analysis can be added |
| OPPO | N | Share similar view as vivo |
| Xiaomi | N | Share similar view with vivo |
| CMCC | Y |  |
| Huawei, HiSilicon | Partially Y | The questions (same issue for “performance impact” in other sections) may be misleading.  The aspects (KPIs) mentioned above can be considered while whether the observations drawn from each proponent can be directly captured in the TR or not may need further discussion. Some observations are conflicting with each other. So if the question is “to be considered”, Y; but some of the ‘P’ from list (P1, P2…) including the numbers/results/observations may need more verification. Hereafter, we take the ‘P’ that are agreeable to us. |
| TIM | N | We tend to share vivo, Samsung, zte, OPPO, XIAOMI views |
| Sequans | Y | In addition to coverage impact of course.  For P1, final focus should be on whether target data rates can be achieved considering combination of parameters (UE antennas, MIMO, etc) – but exact impact of UE antenna reduction should be considered and analysed also independently. |
| Lenovo, Motorola Mobility | Y |  |
| Intel | Y | In terms capturing the impact, the list covers all fundamental effects.  However, it is not clear if the proposal intends to capture these points directly in TR. We assume not, but it’d be good to get a clarification. We would have concerns with capturing some of the quantitative evaluation results that may need further verifications or subject to updates to assumptions, etc. |
| Nokia, NSB | Y |  |
| MediaTek | Y |  |
| Qualcomm | Y |  |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | Y | Minor questions for clarification:  Question for P8: Is it 4Rx🡪2Rx instead of 2Rx🡪2Rx?  Question for P6: Does this mean the overall or net power consumption increase? Further clarification would be helpful. |
| SONY | Partial Y | In terms of capturing the impact, we support P1🡪P11. We agree with the sentiment from Intel. The list covers the fundamental aspects. At a later time, we need to agree on some quantitative / qualitative text for the TR.  We understand that capturing P1->P11 would still leave the door open to capturing other impacts. Use of a single antenna will impact polarisation diversity when receiving SSB. This will lead to deterioration in SSB performance and either impact SSB coverage or acquisition time. We want to be able to capture evaluation results related to these issues in a future meeting.  So, we support capturing impacts P1-P11, capturing other impacts is not precluded. |
| InterDigital | Y | In addition to the impact on coverage. |
|  |  |  |

**Q 7.2.3-2: Which of the identified performance impacts in the list above (P1, P2, …, P11) are the most critical ones to be captured in TR 38.875 for UE antenna reduction?**

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| --- | --- |
| **Company** | **Comments** |
| Example | P1, P2 |
| FUTUREWEI | Should capture:P1,P6,P7,P8,P11 (only first sentence)  No strong feeling: P4, P10  Should not capture:  P2 and P3, these are misleading as it misses the main point that latency is increased and reliability is at risk. In some cases maybe can still meet for a single RedCap UE, but in a system with many RedCap and legacy UE not clear.  P5 is part of P6  P9 is more relevant for coexistence, but not really needed in the RAN1 led part of the TR.  P11 second sentence “high number” should not be included |
| Ericsson | P1, P6, P7 (only the first part) and P10 are in our view critical to capture in the TR, and there may already be enough inputs to draft a text proposal for the TR.  Regarding P8 and P11, in our view spectral efficiency/network capacity loss is an important impact that need to be captured in the TR, but this can be quantified after evaluations have been carried out for AI 8.6.3.  Regarding P2 and P3, although important to capture latency and reliability in the TR, more inputs/evaluations are needed to identify the degree of impact. |
| Sierra Wireless | P1, P6, P7, P8, P11 |
| Spreadtrum | P1, P7, P10 |
| ZTE,Sanechips | Coverage, P1, P6, P7 |
| Panasonic | P1, P6, P7 |
| vivo | As commented in the previous question, in this meeting we suggest to discuss the SLS evaluation methodologies and assumptions so that companies can bring results to the next meeting for a fair comparison. Then we decide which are the important observations to be captured in the TR. |
| Samsung | P1, P3, P7 or P8, P9, P10 |
| OPPO | P3,P5 |
| Xiaomi | P3, P7, P9  For P1, we agree with the data rate is one metric for performance analysis. But when judging whether there is positive or negative impact, we should consider whether the requirement of data rate is fulfilled or not rather than considering whether there is data rate reduction. |
| CMCC | P1,P4,P7,P6,P10 |
| Huawei, HiSilicon | P1, P7/P8 as general requirements (data rate, SE, capacity) required in the SID; P10 can be considered for this specific aspect (as agreed can be considered for specific technique).   * Latency and reliability is important to be captured while the current observation from P2 and P3 needs further verification; * P11 is also related to capacity however the two observations it includes seems unclear. The first part is agreeable.   P4~P6 is not critical to be captured, since power consumption can also be achieved by MIMO layer adaptation as adopted in R16 power saving. |
| TIM | We tend to share VIVO view. SLS are of utmost importance to understand many of the impacts on coverage and capacity losses. |
| Sequans | P1, P6, P7/P8, P10, P11 and coverage of course |
| Lenovo, Motorola Mobility | P1, P7, P8 |
| Intel | P1, P7 or P8, P10. For latency/reliability and power consumption related observations, it may be better to have more data-points.  Also, at least for P1, P2/P3, P6, P10, appropriate clarifications or caveats need to be added w.r.t. whether the apparent degradation in performance may be acceptable with sufficient margin for the prioritized use-cases. |
| Nokia, NSB | P1, P6, P7, P8, P10, and link-level degradation (i.e. coverage loss) |
| Mediatek | P1, P6, P8, P10 |
| Qualcomm | P2, P3 and P9.  P1 and P7 can be captured, together with the performance requirements for RedCap devices. It is worth noting that the use cases of RedCap device target reduced peak data rates (and reduced spectral efficiency). How to support reduced peak rate (throughput) with reduced cost is one of the design goals of RedCap UE. For wearable devices deployed in FR1 FDD bands, reduced number of RX antennas is mandated by the device size constraint. |
| CATT | P1, P7, P8, P11 |
| DOCOMO | P1, P7, P8, P10, P11 |
| LG | P1~P9 are critical. Those are trade-offs to be captured in the TR in a well-balanced manner. Okay to capture all the performance impacts as well. |
| SONY | We don’t really see the need to downselect which performance impacts are captured. In future meetings, other performance impacts could be identified. |
| InterDigital | P1, P6, P7, P10 |
|  |  |

Based on the responses in this section, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For reduced number of antennas, the following performance impacts (which have been slightly rephrased compared to above in some cases for improved clarity) should be captured in the TR according to at least half of the 24 responses to Q 7.2.3-2.   * P1: There will be negative impact on DL data rate/throughput when reducing the number of Rx antennas. The main reason is that reducing the number of Rx antennas will also reduce the number of transmission layers that can be transmitted in the DL. * P6: Although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules, due to longer reception time needed for downlink channels, the power consumption will be increased. * P7/P8: Loss in spectral efficiency * P10: There will be increase in PDCCH blocking probability. This is due to use of higher ALs in order to compensate for the performance degradation from a reduced number of Rx antennas.   Furthermore, the following additional potential performance impact was identified in several responses to Q 7.2.3-1.   * P12: DL link performance degradation   Proposal 7.2.3-1:   * For reduced number of antennas, at least the following performance impacts can be captured in the TR.   + P1: There will be negative impact on DL data rate/throughput when reducing the number of Rx antennas. The main reason is that reducing the number of Rx antennas will also reduce the number of transmission layers that can be transmitted in the DL.   + P6: Although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules, due to longer reception time needed for downlink channels, the power consumption will be increased.   + P7/P8: Loss in spectral efficiency   + P10: There will be increase in PDCCH blocking probability. This is due to use of higher ALs in order to compensate for the performance degradation from a reduced number of Rx antennas.   + P12: DL link performance degradation |
| **Company** | **Comments** |
| vivo | We do not agree any of above at this stage.  We should agree on a set of common evaluation assumptions so that the system impact due to introduction of complexity reduction features for RedCap can be properly evaluated. There is on-going discussion in 8.6.3 for a set of SLS assumptions, we should prioritize the evaluation assumption discussion in this meeting so that companies can bring results to the next meeting and the corresponding observation can be drawn in the next meeting. |
| Samsung | For P6, we like to have following update:   * P6: Although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules, due to longer reception time needed for downlink channels, the power consumption ~~will~~ may or may not be increased.   We think whether the power consumption will be increase or not depends also on the traffic, and many other configuration, e.g. PDCCH SS. |
| OPPO | Don’t agree with P6. Before quantitative analysis, we can’t get such observation. |
| Qualcomm | We do not agree with FL3 proposals as above.  In theory, reducing the number of RX antennas will reduce the spatial multiplexing gain and spatial diversity gain, which is obvious to us. However, when we investigate the performance impacts of reduced number of RX antennas, it is necessary to define a performance target first. On the other hand, the potential loss in spatial multiplexing/diversity gain can be compensated for in frequency domain, e.g. by considering a wider BWP subject to the constraint of max UE BW.  As mentioned before in Q 7.2.2-1, reducing the number of RX antennas can reduce the device size at least in FR1. On the other hand, the SID explicitly mentions “Device size” in the generic requirements for RedCap UE  ***Device size: Requirement for most use cases is that the standard enables a device design with compact form factor.***  Therefore, we need to study solutions that enable “compact form factor” and meet the target data rates/latency requirements. To this end, we need to discuss the assumptions for SLS and how to draw reasonable conclusions from the SLS results. |
| Spreadtrum | We tend to agree with Samsung.  Regarding the power consumption (P6), even though we have the antenna scaling method in TR 38.840 for power saving, it is hard to evaluate the impact of power consumption for antenna reduction considering the “longer reception time” based on the scaling methods. On the other hand, MIMO layer reduction is more related to the “longer reception time”. But scaling for MIMO layer reduction may be absent in the scaling methods. Anyway, we think the current P6 is general, and we are fine for it. |
| Xiaomi | We tend to agree with vivo’s comments.  For progress, we can accept P7/P8 and P12. For the other items, further evaluation is needed |
| Huawei, HiSilicon | Ok with FL proposal except for the first part of P6, “Although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules,” which is not always correct, since power consumption can also be achieved by MIMO layer adaptation as adopted in R16 power saving. |
| SONY3 | We see this list (and corresponding lists in other sections) as being a list of things that we will capture in the TR in RAN1#103e (or more generally, at a future meeting). i.e. we see this list as being a list of aspects (KPIs) [ref: Huawei comment 7.2.3-1] that can be captured in the TR.  The merit of having this list is that companies can perform a more thorough analysis of the impacts identified in this list between now and RAN1#103e. It would also be helpful if companies could think about structuring their Tdocs to directly propose numbers / observations for items P1, P6, P7/8, P10, P12.  We are OK if the TR does finally capture P1, P6, P7/8, P10, P12. |
| Ericsson | Fine with the proposal. |
| Sierra Wireless | We are Ok with the proposal. |
| FUTUREWEI\* | The very first performance impact needs to be a sentence on the dB losses for 4 to 2, 2 to 1, and 4 to 1. It can be with [] and updated next meeting. Others are OK.  It is not OK to only include positive statements on technique. If a balanced view is not achieved now then should wait till next meeting. Samsung revision “may or may not” could be a way to go. |
| ZTE,Sanechips\* | It seems P12 includes P1, maybe can move P1 into one sub-bullet of P12. |
| CATT | Fine with the proposal except for P6. |
| Lenovo, Motorola Mobility | In general fine with the proposal. For P6, prefer to use the wording as Samsung proposed. |
| Intel | Fine with the proposal except for P6 and P12. Effectively, P1 and P12 should be combined, and in fact, even P7/P8 are strongly correlated observations to P1/P12. These need to be resolved/combined.  For P6, we can accept it with the intention of the modification from Samsung; we would suggest to rephrase it a bit as below:  P6: Although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules, due to longer reception time needed for downlink channels, the power consumption ~~will be increased~~ may increase for certain combinations of traffic and channel conditions.”. |
| LG | We are OK with the proposal in general. But, we are open to revise P6 or FFS. |
| FL5 | Many companies do not agree to capture P6. A few companies proposed update to P6. For the other bullets, there were fewer concerns. Perhaps the following updated proposal can be considered.  Proposal 7.2.3-1-v2:   * For reduced number of antennas, at least the following performance impacts can be captured in the TR in the next meeting.   + P1: There will be negative impact on DL data rate/throughput when reducing the number of Rx antennas. The main reason is that reducing the number of Rx antennas will also reduce the number of transmission layers that can be transmitted in the DL.   + ~~P6: Although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules, due to longer reception time needed for downlink channels, the power consumption will be increased.~~   + P7/P8: Loss in spectral efficiency   + P10: There will be increase in PDCCH blocking probability. This is due to use of higher ALs in order to compensate for the performance degradation from a reduced number of Rx antennas.   + P12: DL link performance degradation |
| FUTUREWEI | OK, We assume dB degradations etc will be added to these as well for e.g. P12. |
| vivo | As commented before, we do not agree now to capture the above without proper SLS evaluations. We should finalize the SLS assumptions in 8.6.3 this meeting and observations should be draw next meeting based on the evaluation results. |
| Huawei, HiSilicon | Fine |
| Samsung | We also prefer to draw observations with more evaluation results in next meeting. |
| MediaTek | We agree with the proposal. |
| Ericsson | We are fine with the proposal. As mentioned in the above comments from other companies, the TR should contain numerical results for e.g. DL link performance degradation. |
| FL6 | Proposal 7.2.3-1-v2:   * For reduced number of antennas, at least the following performance impacts can be captured in the TR in the next meeting.   + P1: There will be negative impact on DL data rate/throughput when reducing the number of Rx antennas. The main reason is that reducing the number of Rx antennas will also reduce the number of transmission layers that can be transmitted in the DL.   + ~~P6: Although the reduction in Rx antenna can reduce power consumption in the RF and the baseband modules, due to longer reception time needed for downlink channels, the power consumption will be increased.~~   + P7/P8: Loss in spectral efficiency   + P10: There will be increase in PDCCH blocking probability. This is due to use of higher ALs in order to compensate for the performance degradation from a reduced number of Rx antennas.   + P12: DL link performance degradation |
|  |  |

### 7.2.4 Analysis of coexistence with legacy Ues

Several contributions [1, 3, 5, 7, 17] have analyzed coexistence issues with legacy Ues. The finding can be listed as follows:

* C1: there will be coexistence impact depending on the coverage recovery solutions and other enhancements (e.g., early RedCap indication in RACH) adopted for RedCap during the initial access stage [1, 3, 17]
* C2: blocking impacts if RedCap UE need to use higher aggregation levels for PDCCH reception [3].
* C3: there will be coexistence issues if common physical channel is used for both legacy Ues and RedCap Ues [5]
* C4: No coexistence impact [7]

**Q 7.2.4-1: Does the list above (C1, C2, C3, C4) capture the most important coexistence impacts that need to be considered for UE antenna reduction? If not, what other aspects need to be added?**

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| --- | --- |
| **Company** | **Comments** |
| FUTUREWEI | No. C1 is misleading in that it implies that there is COVERAGE LOSS and that solutions and enhancements will be agreed. It also implies that these solutions themselves will eliminate the coexistence issue which is not correct.  Something like statement C3 should be a first one, that states the system treating the Ues the same will mean conservative handling of all Ues. Then a replacement for C1 can state that early identification can reduce this conservative handling, but the enhancements themselves would also have coexistence impacts (such as from partitioning the PRACH preamble space).  C2 is fine.  ‘no impact’ (C4) should not be considered in the list of impacts. |
| Ericsson | Yes |
| Spreadtrum | Yes |
| ZTE,Sanechips | Yes |
| Panasonic | Our contribution [18] mentioned RAN4 RRM performance impact. The network deployment (cell planning) corresponds to Rel.15 and 16 UE would assumes RAN4 performance of RRM, which is based on 2 Rx. If RedCap Ues would not have similar to Rel.15/16 Ues on RRM, the network deployment may be required to be adjusted. |
| Vivo | We think C1 and C3 are talking about the same thing. C2 already covered in previous section, it should not be captured twice. |
| Samsung | Yes for C1,C2,  C3 should be further clarified on which common channel(s) |
| OPPO | yes |
| Xiaomi | Yes, but we think the coexistence impact could be solved |
| CMCC | Yes |
| Huawei, HiSilicon | Similar issue exists: the observations are not aligned with each other, e.g. C4 wrt others.  C1 may be too general and it actually applies to every case (whenever an enhancement is applied there may be impact to legacy.)  In general:   * with reduction of UE antenna, the system spectrum efficiency is reduced and total resource available for legacy Ues can be impacted, and * C3 |
| TIM | Detailed coexistence analysis should be perfomed. C4 is almost impossible😊 |
| Sequans | Yes |
| Lenovo, Motorola Mobility | Yes |
| Intel | It seems aspects like cell spectral efficiency, user capacity, system OH aspects are combined into coexistence issues. In this regard, we tend to agree with C4.  Certainly, as in discussed in previous questions related to (P1, …P11), there would be impact to system spectral efficiency and related metrics, but these should not be seen as “coexistence issues”. Legacy and RedCap Ues with fewer antennas can still coexist just fine, just with possibly lower system spectral efficiency. Otherwise, we are capturing same effects multiple times. |
| Nokia, NSB | Yes |
| MediaTek | Not C4.  Yes for C3, C2 and C1 with some modifications as proposed by FUTUREWEI. |
| Qualcomm | Yes |
| CATT | Yes |
| DOCOMO | Yes |
| LG | Yes |
| SONY | Our view was that C1, C2, C3 are not coexistence impacts. The system can be configured such that C1, C2, C3 do not happen. Hence we observed C4 in our contribution.  We do agree with other companies that we cannot capture C4 and {C1,C2,C3} together: that isn’t logical.  If we view coexistence as including issues that cause the system to be configured differently, then we are OK to capture C1, C2, C3. |
| InterDigital | Yes. |
|  |  |

**Q 7.2.4-2: Which of the identified coexistence impacts in the list above (C1, C2, C3, C4) are the most critical ones to be captured in TR 38.875 for UE antenna reduction?**

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| --- | --- |
| **Company** | **Comments** |
| Example | C1, C2 |
| FUTUREWEI | Revised C3, replacement of C1, and C2 need to be included. |
| Ericsson | C2.  Depending on potential solutions, e.g., for UE identification and coverage recovery, C1 and C3 might be coexistence issues to consider. |
| Spreadtrum | C1, C2, C3 |
| ZTE,Sanechips | C1, C2,C 3. |
| Panasonic | Our view is RRM impact and the corresponding network planning can be the largest impact. |
| Vivo | C1 |
| Samsung | C1,C2, |
| OPPO | C1 C3 |
| Xiaomi | C1, but what is the “coverage recovery solutions and other enhancements” is not clear to us now. |
| CMCC | C1,C2,C3 |
| Huawei, HiSilicon | Assuming SE will anyway be captured, C3 is probably the clearest one so far that needs to be considered. |
| TIM | C4 for sure is very improbable. See also previous table. |
| Sequans | C1, C2, C3 |
| Lenovo, Motorola Mobility | C1, C3. |
| Intel | None at this point (see response to previous question). |
| Nokia, NSB | C1, C2, C3 |
| MediaTek | C3, C2 and C1 |
| Qualcomm | C1 and C3 can be considered.  C2 needs further study, especially when compact DCI is supported for RedCap UE. |
| CATT | C1, C2 |
| DOCOMO | C1, C2, C3 |
| LG | C1, C3 |
| SONY | C1, C2, C3 |
| InterDigital | C1, C2, C3. |
|  |  |

Based on the responses in this section, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For reduced number of antennas, the following coexistence impacts (which have been slightly rephrased compared to above in some cases for improved clarity) should be captured in the TR according to at least half of the 24 responses to Q 7.2.3-2.   * C1: There can be coexistence impact depending on the coverage recovery solutions and other enhancements (e.g., early RedCap indication in RACH) that may be adopted for RedCap during the initial access stage. Note that depending on the outcome of discussions taking place under AI 8.6.3, no coverage recovery may be needed to compensate for the performance loss due to reduced number of UE Rx antennas. In this case, C1 need not be captured in TR 38.875. * C2: Blocking impacts if RedCap UE need to use higher aggregation levels for PDCCH reception. * C3: There will be coexistence issues if common downlink physical channels are used for both legacy UEs and RedCap Ues. This is because the system treating the Ues the same will mean conservative handling of all Ues.   Proposal 7.2.4-1:   * For reduced number of antennas, at least the following coexistence impacts can be captured in the TR.   + C1: There can be coexistence impact depending on the coverage recovery solutions and other enhancements (e.g., early RedCap indication in RACH) that may be adopted for RedCap during the initial access stage. Note that depending on the outcome of discussions taking place under AI 8.6.3, no coverage recovery may be needed to compensate for the performance loss due to reduced number of UE Rx antennas. In this case, C1 need not be captured in TR 38.875.   + C2: Blocking impacts if RedCap UE need to use higher aggregation levels for PDCCH reception.   + C3: There will be coexistence issues if common downlink physical channels are used for both legacy Ues and RedCap Ues. This is because the system treating the Ues the same will mean conservative handling of all Ues. |
| **Company** | **Comments** |
| vivo | C1/C2/C3 are not agreeable, we should identify the coverage problem first and before drawing any conclusion. And this discussion seems to be more suitable for 8.6.3. |
| Samsung | For C3, because even DL common channels are shared, whether it will have coexistence issues depends on gNB scheduling and deployment choice. We don’t think it will have any problem of coexistence. As compromise, we like to directly state what the issues are as below:  C3: The system needs to treat the Ues the same and it may require conservative handling of all Ues for common downlink physical channels. |
| Qualcomm | We do not need to agree on C1, C2 and C3 at this meeting. Further evaluation/analysis are needed before we make conclusions. |
| Spreadtrum | We are fine with this proposal. |
| Xiaomi | Since C1,C2,C3 highly depend on the coverage recovery solution or additional design, before we have clear view on these potential coverage recovery solutions or additional design, it is too early to draw such conclusion in the TR |
| Huawei, HiSilicon | In general Ok with FL proposal. We are not in favour of Samsung’s version of C3, since it directly imposes limitation on network which we consider is actually a coexistence impact. |
| SONY3 | We see this list (and corresponding lists in other sections) as being a list of things that we will capture in the TR in RAN1#103e (or more generally, at a future meeting). The merit of having this list is that companies can perform a more thorough analysis of the impacts identified in this list between now and RAN1#103e. It would also be helpful if companies could think about structuring their Tdocs to directly propose numbers / observations for items C1, C2, C3.  We are OK with capturing C1 / C2 / C3. However we think these are “limitations on configuration” issues, not coexistence issues. Adopting a 10kHz SCS for Redcap would be a coexistence issue, but choosing a lower MCS for common downlink physical channels (C3) is not a coexistence issue. |
| Ericsson | C1, C2 are fine. C3 is also fine. But certain clarifications might be good. For example, in our view “common downlink physical channels” only include “PDCCH/PDSCH”, not SS/PBCH. And it helps adding to the end of the sentence “before the UE capabilities are known to the network”. |
| FUTUREWEI\* | Disagree with Sony’s interpretation more “binary” view of coexistence impacts. As brought up both meetings so far in discussion on the skeleton of the TR, impacts from supporting redcap and legacy NR in the system need to be captured. If there are both redcap and legacy UEs in the system and the redcap makes scheduling more complicated, more conservative, more crowded, etc, then it should be included. The coexistence subsection is the best place.  OK with C2 and C3. C1 can probably wait, it is conditional anyway. |
| CATT | Fine with C1 and C2. For C3, we do not see the coexistence issue but just a potential spectral efficiency issue. |
| Lenovo, Motorola Mobility | Fine with C1, C2. For C3, we have similar view with Ericsson that the common channels only include “PDCCH/PDSCH”. |
| Intel | Agree with SONY and as mentioned also in our response to Q 7.2.4-1, C1, C2, C3 should not be treated as coexistence issues – they relate to performance, and already covered in the “performance impact”-related proposal (specifically, P1, P7/P8, and P10). So, we cannot agree to classifying the |
| LG | We are OK with C1, C2, and C3. |
| FL5 | No clear consensus in this meeting |

Furthermore, the following can be considered.

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| --- | --- |
| FL3 | The following additional potential coexistence impacts were identified in the responses to Q 7.2.4-1.   * C5: Due to the RAN4 RRM performance impact, the network deployment (cell planning) may be required to be adjusted. * C6: The system spectrum efficiency is reduced and the total resource available for legacy Ues can be impacted.   Question 7.2.4-3:   * Which ones, if any, of C5 and C6 should be captured in the TR as coexistence impacts for reduced number of antennas? |
| **Company** | **Comments** |
| vivo | C5 should be evaluated, did not see any simulation results. And this is again related to the bottleneck channel identification, from our results, there is no issue to be solved for SSB so there should be no impact to RRM. Furthermore, C5 is more suitable to be discussed in 8.6.3  C6 is related to Q 7.2.3-2, again, a common evaluation assumption should be agreed first. |
| Samsung | We think coverage recovery is to recovery the coverage similar as regular Ues. So, we don’t agree on C5.  We think C6 already captured in P7/8, we don’t think this is coexistence impact.  In all, we don’t think either C5 or C6 need to be captured in TR. |
| Panasonic | Capture C5 with the modification: Due to the RAN4 RRM performance impact, the network deployment (cell planning) may be required to be adjusted **if number of RX antenna is reduced to one**. |
| OPPO | Don’t agree with C5. Coverage recovery can solve the coverage issue. |
| Spreadtrum | We think both C5 and C6 should be captured in the TR. |
| Xiaomi | For C5, maybe we can leave this issue to RAN4 discussion  For C6: The total resource available for legacy Ues may or may not be impacted, so we suggest to keep the wording, “The system spectrum efficiency is reduced” only. On the other hand, the impact on the spectral efficiency is already mentioned in P7/P8, we don’t need to repeat this problem in C6. In summary, we don’t think C6 is needed. |
| Huawei, HiSilicon | Both can be acceptable. |
| SONY3 | We don’t see these as coexistence issues. |
| Ericsson | C6 |
| Sierra Wireless | We agree with C6.  For C5, based on CovEnh results so far, the UL is by far the limiting coverage factor so until we do the link budget which we should not make any agreements  that cell planning may be required to be adjusted. |
| FUTUREWEI\* | OK. C5 can be identified and earmarked for RAN4. C6 here would relate to sims with a certain percentage of redcap and legacy UEs so ok to capture now or after more results. It should be obvious that including redcap Ues may disproportionally reduce the capacity for legacy Ues as the redcap Ues consume more resources for the same traffic as legacy Ues. |
| ZTE,Sanechips\* | Agree with Samsung on C6. We also think C6 already captured in P7/8, we don’t think this is coexistence impact. |
| CATT | We don’t agree with C5. |
| Intel | We do not agree with either C5 or C6 as coexistence issues. C5 relates to spec-efforts, not a technical issue; while C6 is yet another variation of repeating P1/P12/P7/P8, which do not need to be repeated again. |
| LG | We think C6 can be captured. |
| FL5 | No clear consensus in this meeting |

## 7.3 UE bandwidth reduction

### 7.3.1 Description of feature

For FR1, most of the contributions under AI 8.6.1 [1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31] consider 20 MHz maximum UE bandwidth in FR1. Contributions [5, 15, 16, 28] consider maximum UE bandwidth larger than 20 MHz as additional options in FR1.

For FR2, contributions [1, 3, 4, 5, 6, 8, 9, 11, 12, 13, 16, 17, 18, 19, 23, 24, 25, 26, 27, 28, 29, 31, 35] discuss 50 MHz and/or 100 MHz maximum UE bandwidth options in FR2. Contributions [4, 5, 8, 12, 16, 29] prefer maximum RedCap UE bandwidth 100 MHz, whereas contributions [1, 6, 11] prefer 50 MHz. Contribution [3] points out it might be desirable to preserve the economy of scale for the “normal” 200 MHz NR UE.”

Contribution [1, 3, 15, 22, 30] explicitly states that same bandwidth is considered for DL and UL. Contribution [1, 5, 20, 22, 30] also consider the same BW for RF and baseband. Contribution [22, 30] further states the same bandwidth for data and control channels. Contribution [8, 15] discusses whether asymmetric DL/UL bandwidth might be considered for certain use cases.

**Q 7.3.1-1: Can TR 38.875 focus on the scenario where the same maximum UE bandwidth applies to both DL and UL, both RF and baseband, and both data and control channels?**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | Y | Including this main case is already agreed. No need to spend time on bandwidth proposals between 20 and 100 MHz for FR1. The target is “up to” and various combinations of modulation and MIMO layers can hit the peak data rate. Other proposals may have been considered in the “888” days but are not so promising for NR. Given the limited time unless most companies want to include we should work on completing other aspects of the study. |
| SONY | N | UL bandwidth could be larger than DL bandwidth as UL bandwidth is not a significant cost driver.  Having a wider RF bandwidth than baseband bandwidth could lead to better coexistence, so we would like this to be further studied.  There could be coexistence benefits for having a different control bandwidth to data bandwidth, so we would like to consider this. |
| Ericsson | Y |  |
| Sierra Wireless | Y |  |
| DOCOMO | Y |  |
| InterDigital | Y. |  |
| Spreadtrum | Partially Yes | UE BW of data and control channel can be different. Data BW reduction can reduce cost further. |
| ZTE,Sanechips | Y |  |
| Sharp | Y |  |
| Panasonic | Y |  |
| vivo |  | In FR1 we agree that UE should support 20MHz, however some RedCap Ues may also support larger BW at least in DL to achieve a higher data rate, e.g. 40MHz in DL but 20MHz in UL can also be considered. |
| Samsung | Y |  |
| LG | Y | The focus should be set to the case where the max UE bandwidth applies to all. |
| OPPO | N | Share similar view as Sony. For some use case, such as video surveillance, UL bandwidth can be large than DL, this can help to reduce the UE’s cost. |
| Xiaomi | Y for FR and baselined, data and control  N for DL and UL | We are OK with same maximum bandwidth for RF and baseband, both data and control. But considering asymmetric DL/UL bandwidth was already supported in NR, we don’t see very strong motivation to preclude it. |
| CMCC | Y |  |
| Huawei, HiSilicon | Y | It is important to have a baseline assumption for BW as 20Mhz for FR1 for further study on other related aspects. |
| TIM |  | Asymmetric DL/UL bandwidth might be considered for certain use cases. |
| Sequans | Y | Primary focus should be on same maximum UE bandwidth. Going into asymmetric may lead to too detailed analysis (e.g. splitting cost of UL and DL in the processing) which may be counterproductive, depending on the accuracy of the cost breakdown (if agreed). |
| Lenovo, Motorola Mobility | Y |  |
| Intel | Y |  |
| Nokia, NSB | Y |  |
| MediaTek | Y |  |
| Qualcomm | Y |  |
| CATT | Y |  |
| FL |  | All responses except for one agree that the SI should only focus on the scenario where the same maximum UE bandwidth applies to both RF and baseband. One response indicates that wider RF bandwidth than baseband bandwidth could lead to better coexistence, so they would like this to be further studied.  All responses except for two ones agree that the SI should only focus on the scenario where the same maximum UE bandwidth applies to both data and control channels. One response indicates that there could be coexistence benefits for having a different control bandwidth to data bandwidth. Another response indicates that there is a cost benefit in reducing the data channels bandwidth further.  All responses except for three ones agree that the SI should only focus on the scenario where the same maximum UE bandwidth applies to both DL and UL. Three responses indicate that asymmetric DL and UL maximum bandwidth can also be considered.  Proposal 7.3.1-1:   * For RedCap Ues, the same maximum UE bandwidth in a band applies to both RF and baseband.   + This maximum UE bandwidth applies to both data and control channels.   + This maximum UE bandwidth is assumed for both DL and UL as a baseline for complexity analysis. |
| Qualcomm |  | We are ok to support the proposal of FL. |
| MediaTek |  | Fine with the proposal. |
| Spreadtrum |  | We think UE BW of data and control channel can be different. Data BW reduction can reduce cost further. As a compromise, we can accept this proposal, but we suggest changing the wording “UE bandwidth” to “UE channel bandwidth”. |
| Xiaomi |  | We would like to update the second bullet a bit. We suggest to add the sentence ”Asymmetric DL and UL maximum UE bandwidth is not precluded ” |
| OPPO |  | The 2nd sub-bullet shall be removed. For some scenario/use case, larger UL-bandwidth than DL can be studied. |
| LG |  | We are okay with this proposal. |
| Lenovo, Motorola Mobility |  | Fine with the proposal. |
| CATT |  | Fine with the proposal. |
| Nokia, NSB |  | We are fine with the proposal |
| SONY |  | Since this is a study item, we think that it would be reasonable to *study* issues such as (1) whether UE BW of data / control can be different, (2) whether UL BW can be different to DL BW, (3) whether initial access phase BW can be different to the connected mode bandwidth. If there are significant advantages to any of these, we might then want to note those advantages in the TR.  The current proposal makes it sound like we are making some decision on what a Redcap UE is rather than how it is studied.  Our proposed proposal is:   * For the baseline complexity analysis of RedCap Ues, the same maximum UE bandwidth in a band applies to both RF and baseband.   + This maximum UE bandwidth applies to both data and control channels.   + This maximum UE bandwidth is assumed for both DL and UL.   + Complexity analyses with other mixes of bandwidths are not precluded |
| Sequans |  | We are fine with this proposal. |
| Intel |  | We are fine with the proposal with the understanding that this is only as baseline for complexity analysis and does not restrict further considerations on different BWs between DL and UL. |
| FL2 |  | Since some responses expressed a wish to study other bandwidth combinations, the proposal has been updated in the following way.  Proposal 7.3.1-1-v2:   * For the baseline complexity analysis of RedCap Ues, the same maximum UE bandwidth in a band applies to both RF and baseband.   + This maximum UE bandwidth applies to both data and control channels.   + This maximum UE bandwidth is assumed for both DL and UL.   + Complexity analyses with other mixes of bandwidths are not precluded |
| FUTUREWEI | ? | We prefer the previous proposal. If this proposal means non-baseline will be included in the TR, we don’t agree. If this proposal means there is no agreement one way or another on including non-baseline, we can accept. |
| Huawei, HiSilicon |  | We also prefer the previous proposal, or at least given the agreements of ‘baseline UE bandwidth capability’, the tone does not need to backwards to a complexity-analysis level. So suggest to revise the head to “For the baseline UE bandwidth capability”. We can live with the last sub-bullet of cases that are not precluded, since there is a wish to study. |
| SONY |  | We are OK with the updated proposal. In response to Futurewei: our understanding is that the proposal doesn’t imply agreement / non-agreement on including non-baseline complexity analyses. |
| Sierra Wireless |  | We agree with the proposal |
| Nokia, NSB |  | We are fine with the proposal |
| Qualcomm |  | We are fine with FL2 proposal. |
| Intel |  | Fine with the proposal |
| FL3 |  | The FL understanding is the same as the one expressed by Sony, i.e. that Proposal 7.3.1-1-v2 does not imply any agreement or non-agreement on including non-baseline complexity analyses. |
| vivo |  | Fine with the proposal |
| Samsung |  | Fine with FL2. More prefer original proposal. |
| Panasonic |  | Fine with the proposal v2. |
| LG |  | We are fine with the proposal |
| OPPO |  | Fine with the proposal v2. |
| Spreadtrum |  | It is fine that the maximum UE BW assumption in the FL2 is used for baseline complexity analysis. In our view, here the maximum UE BW may only mean the maximum UE channel BW as defined in 38.101. We still think reducing the data BW, i.e. the number of PRB allocated to PDSCH/PUSCH, is beneficial to cost reduction. |
| Xiaomi |  | We are OK FL2 proposal |
| Ericsson |  | We are fine with the proposal. |
| FL4 |  | The first part of the first sentence in the proposal has been updated in line with one of the responses.  Proposal 7.3.1-1-v3:   * For the baseline UE bandwidth capability of RedCap UEs, the same maximum UE bandwidth in a band applies to both RF and baseband.   + This maximum UE bandwidth applies to both data and control channels.   + This maximum UE bandwidth is assumed for both DL and UL.   + Complexity analyses with other mixes of bandwidths are not precluded. |
| SONY |  | This is a study item and we should be agreeing on what is studied. We don’t want to agree on what the bandwidth capability of a Redcap UE is at this stage: that can be done in the work item. Hence we prefer the FL3 proposal (Proposal 7.3.1-1-v2).  We understand that the FL4 update was made based on the comment from Huawei / HiSi, where it was stated that “*at least given the agreements of ‘baseline UE bandwidth capability’, the tone does not need to backwards to a complexity-analysis level*”. There is presumably a typo in that text. In any case, we don’t understand what that text means and don’t see it as a reason to change the FL3 proposal that 11 companies agree with.  If the problem is the phrase “complexity analysis” in the proposal, then as a compromise, could we adopt the following proposal?  Proposal 7.3.1-1-v3.1:   * For the ~~baseline UE~~ bandwidth capability of the baseline RedCap UE~~s~~ that is studied, the same maximum UE bandwidth in a band applies to both RF and baseband.   + This maximum UE bandwidth applies to both data and control channels.   + This maximum UE bandwidth is assumed for both DL and UL.   + ~~Complexity analyses with~~ Studies of other mixes of bandwidths are not precluded. |
| Samsung |  | We are fine with the Proposal 7.3.1-1-v3 from FL. |

The following agreements were made in a RAN1#102-e online (GTW) session:

|  |
| --- |
| Agreements:   * For RedCap Ues in FR1,   + The baseline UE bandwidth capability is 20 MHz, which can be assumed during the initial access procedure.   + Discuss further by email whether there is an issue or a necessity in achieving up to 150Mbps assuming a 20MHz and rank 1 transmission. |

**Q 7.3.1-2a: For RedCap Ues in FR1, is there an issue or a necessity in achieving up to 150Mbps assuming a 20MHz and rank 1 transmission?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | N | This was already addressed at RAN, the target is a soft one with the addition of “up to”. RAN1 should absolutely not spend time trying to revert the RAN decision to make this a hard target. In the RAN discussion it was even clarified, twice, for this exact example, that the TR can simply report the data rate that the 20MHz rank 1 case supports.  Since discussing further is counter to the decision in RAN, we disagree that this is even a medium priority question.  Technically, we do not feel that 150Mbps is needed, good performance for wearables can be achieved with half that peak data rate. Average data rates in any case will be much lower.  Commercially, as was already also discussed at length in previous ran and ran1 meetings, more native (single) carrier bandwidths means more RedCap device types and more fragmentation of the market. 20MHz is sufficient for FR1. An intermediate bandwidth will also not provide much cost reduction.  Finally, we do not expect RedCap Ues to be prohibited or restricted from implementing other NR features, even if these other features are not the focus of the study. So if for whatever reason higher peak data rates are desired, there are several optional features which can be supported that increase data rate. |
| DOCOMO | N | It is obvious that 150Mbps cannot be achieved assuming a 20MHz and rank 1 transmission. Optional capability to achieve the data rate (e.g., 2 MIMO layer or 40 MHz BW) can be reported after the initial access and that should be separated from the definition of RedCap UE type. |
| Panasonic | N | We don’t see an issue nor a necessity to achieve up to 150MHz assuming a 20MHz and rank 1 transmission. Two MIMO layers can be used to achieve 150 Mbps if 2 RX antenna and rank 2 transmission are supported by the UE. |
| LG | N | There is actually an issue in achieving up to 150Mbps assuming a 20MHz and rank 1 transmission because it cannot be achieved.  For the necessity in achieving up to 150Mbps, from our perspective, it seems to be an overkill and we don’t see a problem with the peak bit rate being reduced e.g., by half. Unless there is a consensus on the support of 150Mbps, we don’t think we need to further consider/study the UE bandwidth larger than 20MHz for FR1. |
| Huawei, HiSilicon |  | No conclusion needed for the question (we objected this during GTW but was not taken into account, nevertheless, the agreement does not necessarily lead to a conclusion). In addition to the comment from e.g. FUTUREWEI that clearly 20Mhz\*1Rank is not designated for the hard peak data rate, the SID has requirements not only on data rate, but also on latency, SE, coverage etc and they need to be further studied together. |
| Ericsson | N | In our view, the baseline RedCap UE in FR1 does not need to reach 150 Mbps. Additional optional features beyond the RedCap UE baseline capabilities can be added if one wishes to reach 150 Mbps. The SI should only focus on baseline RedCap UE capabilities. |
| Sequans | Y/N | On issue, we don’t see any if 2 RX antennas can be supported by the UE.  On necessity, we think RAN is more appropriate to decide and we have already in SID the necessity in achieving up to 150 Mbps for wearables. SID states “*the intention is to study a UE feature and parameter list with lower end capabilities … to serve the three use cases*” while the “*up to 150 Mbps for downlink*” is provided “*as a baseline*” within wearables “*Use case specific requirements*” |
| SONY | N | 150Mbps doesn’t need to be achieved in the DL for all Redcap devices. As Ericsson state, features to support 150Mbps can be optional. |
| InterDigital | N | Agree that additional features can be supported to achieve 150 Mbps and baseline RedCap UE does not have to achieve it. |
| FL3 |  | The general view in the responses seems to be that it is not a showstopper for 20 MHz with single layer that it cannot reach 150 Mbps. The SID says “up to 150 Mbps” and it can be expected that the targeted use cases can usually be adequately served with a lower peak rate. Optional support of peak rate enhancements on top of the basic RedCap capabilities is not precluded.  Proposal 7.3.1-2a:   * Conclusion: For RedCap UEs in FR1, there is no issue if the UEs do not achieve 150Mbps. |
| vivo |  | Our understanding of “up to 150Mbps” is that not all RedCap UEs are mandated to support 150Mbps, however, the spec should provide a solution so that some “Hign-end” RedCap UE can reach 150Mbps.  The current FL3 proposal seems to imply that 150Mbps is not a target anymore for the whole SI, which seems to change the scope of SI. |
| Samsung |  | Better to state the conclusion in the other way, as:  It is not required all the RedCap UEs in FR1 achieve 150Mbps peak data rate for DL. |
| Panasonic |  | Regarding 7.3.1-2a, we share the view with vivo. To achieve 150 Mbps or such order peak data rate is required. |
| OPPO |  | Share similar view as vivo and samsung |
| Qualcomm |  | We think it might not be necessary for wearable UE with 1 RX antenna and max UE BW of 20 MHz to support 150 Mbps on DL. However, the conclusion is too strong and conflicts with the wording in the SID. |
| Sequans |  | Updated proposal might not be in line with SI scope. We don’t think RAN1 is appropriate to decide on if there is issue (necessity) if RedCap UEs do not achieve 150Mbps – what we can decide is if there is issue (problem) achieving this target given a set of possible features.  Since the original question leading to this proposal had to do with study or not of additional BW option for FR1, larger than 20MHz, (supported by only 4 companies as seen in summary above), we think that it is more fitting to provide a conclusion that no problem is seen to achieve up to 150Mbps on DL with 20MHz max BW, because increased (possibly optional) capability, e.g. 2RX antennas / rank 2 MIMO, can be used. |
| Huawei, HiSilicon |  | We still don’t think any conclusion is needed but…suggest  There is issue but it is not required for 20MHz with 1Rx UE in FR1 to achieve 150Mbps peak data rate for DL. |
| SONY3 |  | Similar views to those generally expressed above. Some “type” of Redcap UE should support 150Mbps (e.g. 2RX, rank 2 MIMO), but not all “types” of Redcap UE need to support 150Mbps.  Please don’t read too much into our use of the word “type”…. |
| Ericsson |  | We are fine with the conclusion. Also fine with Samsung’s suggestion. |
| Sierra Wireless |  | We strongly agree with the proposal. We do prefer Samsung’s rewording of the conclusion. |
| FUTUREWEI\* |  | This is not a priority, already discussed at RAN. No issue. Could possibly be reworded per Qualcomm concern to say “some UEs”. But in any case in the updated SID it is a soft and not hard target.  Will not read too much into Sony’s use of type 😊 |
| CATT |  | Fine with Samsung’s suggestion. |
| Intel |  | We would be fine with the suggested version from Samsung. |
| LG |  | We are okay with the FL’s proposal. We are also okay to leave the optional support of 150Mbps FFS? |
| FL5 |  | No clear consensus in the meeting |

**Q 7.3.1-3: Should TR 38.875 include more bandwidth options in FR2 in addition to 50 MHz and 100 MHz? If yes, what additional bandwidth options?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | N | Including 50MHz is a sufficient example for the long list of impacts and issues, no need to include another similar value. We had proposed last meeting to include a value just large enough (say in 70-80MHz) to avoid all of the issues with 50MHz, but 100MHz also avoids those issues.  As part of the TR analysis for 50 and 100 MHz we should say something like “a value of X MHz in FR2 will avoid these issues with 50MHz, but would require effort in RAN4 to define a new bandwidth.” (same comment we made in the May meeting GTW when accepting 50 and 100MHz) |
| SONY | Y | We are basically OK with considering 50MHz / 100MHz bandwidth. However, as per the answer to Q7.3.1-1 / Q7.3.1-2, we would like to consider wider RF bandwidths and / or control channels having a bandwidth of greater than 50MHz / 100MHz. |
| Ericsson | N |  |
| Sierra Wireless | N |  |
| DOCOMO | N |  |
| InterDigital | N. |  |
| Spreadtrum | No |  |
| ZTE,Sanechips | No | BTW, only support 100Mhz option |
| Sharp | N | As commended by FUTUREWEI, additional bandwidth options would require RAN4’s effort on defining a new one, considering current RAN4 specification only define the transmission bandwidth configuration as 50M, 100M, 200M, and 400M. |
| Panasonic | N |  |
| Samsung | N | No need. |
| LG | N | Considering supported channel bandwidths in FR2, the next bandwidth to consider will be 200MHz. Supporting larger than 100MHz will only bring a minor cost/complexity reduction from normal NR devices. We prefer not to consider the UE max bandwidth wider than 100MHz for redcap Ues for FR2. |
| OPPO | N |  |
| Xiaomi | N |  |
| CMCC | N |  |
| Huawei, HiSilicon | Partially Y | Our preference is 100Mhz only for FR2. A new channel bandwidth as e.g. 80Mhz as FUTUREWEI proposed can also be considered if RAN4 is willing to do such efforts. Overall, the main motivation is to minimize the specification impact. |
| TIM | Y |  |
| Sequans | N |  |
| Lenovo, Motorola Mobility | N | No need to have more bandwidth options, but UE could be configured with smaller size BWP. |
| Intel | N | In fact, we suggest to focus on 100 MHz case (similar views as Futurewei here). Note that operation with smaller active BWPs in connected mode is always possible by NW configuration and not precluded. |
| Nokia, NSB | N | We believe the requirements can be satisfied with 50MHz / 100MHz BW |
| MediaTek | N |  |
| Qualcomm | Y | We can consider smaller bandwidths for active BWP (e.g., 20 MHz). The UE may be able to switch to smaller BW after initial across to save power. For example, data rates for industrial wireless sensors may not need the full 100MHz BW used for initial access and can choose to limit its BW to conserve power. |
| CATT | N |  |
| FL |  | Most responses indicate the 50 MHz and 100 MHz options are enough. Two responses suggest focussing only on the 100 MHz option.  One response indicates that they are fine with considering the 50 MHz and 100 MHz options but indicates interests in considering wider RF bandwidths and/or control channels having a bandwidth of greater than 50MHz / 100MHz.  Two responses indicate an interest in a bandwidth smaller than 100 MHz but larger than 50 MHz to avoid some of the issues with 50MHz. One of these responses proposes a note to capture this aspect: “A value of X MHz in FR2 will avoid these issues with 50MHz but would require effort in RAN4 to define a new bandwidth” (there is a similar suggestion in response to Q7.3.4-3 which is captured as a new coexistence aspect).  One response indicates that there is a power-saving benefit in allowing the UE to switch to a smaller BW after initial access.  Since RAN1#101-e, we have the following agreement:   * For FR2, study 50MHz and 100 MHz maximum UE bandwidth at least for initial access   + Other bandwidths FFS   Based on the received responses, perhaps it would be possible to remove the FFS from the previous agreement.  Proposal 7.3.1-3:   * For FR2, study 50MHz and 100 MHz maximum UE bandwidth at least for initial access.   + Other bandwidths are not studied further within this SI. |
| Qualcomm |  | We are fine with this proposal as long as the common understanding is that the “*Other bandwidths are not studied further within this SI*” applies to initial access only, i.e., other “post initial access” BW can be studied. Otherwise, the FL proposal needs further discussion. |
| MediaTek |  | Fine with the proposal. |
| OPPO |  | Fine with the proposal. |
| LG |  | We are okay with this proposal. |
| Lenovo, Motorola Mobility |  | Fine with the proposal. |
| Huawei, HiSilicon | N | To minimize the specification impact, our preference is still 100Mhz only for FR2. |
| CATT |  | Fine with the proposal. |
| Nokia, NSB |  | We are fine with the proposal |
| ZTE,Sanechips |  | We are OK to keep the door open for 50Mhz, but it’s better to prioritize 100Mhz , given the meeting time left. |
| Sequans |  | Fine with the proposal, but we also believe that as next step, as done for FR1, we should also conclude soon and prioritize one option for FR2. |
| Intel | N | We prefer to focus on 100 MHz for FR2. From complexity analysis so far (in following section), the benefit from 50 MHz compared to 100 MHz is practically non-existent:   * “Based on these estimates, the cost saving from reducing the UE bandwidth from 200 MHz to 100 MHz is no greater than 23%” * “Based on these estimates, the cost saving from reducing the UE bandwidth from 200 MHz to 50 MHz is in the range of 15%-32% The middle of this range is 23.5%”   On the other hand, it is clear that the impact to spec efforts, performance impact, and scheduling/network operation are significant.  Thus, given the timeline at hand, we do not think it is appropriate to spend time on the 50 MHz option for FR2. Further justification to motivate continuing study of 50 MHz is necessary. |
| InterDigital | Y | Agree with the proposal. |
| FL2 |  | Compared to the earlier version of the proposal, in the following versions of the proposal, it is clarified that the sub-bullet concerns initial access, as proposed in one response.  There are two versions of the proposal, one version that continues to consider both 50 MHz and 100 MHz (“v2”) and another version that down-selects to 100 MHz (“v3”). Only one of the two versions of the proposal can be agreed.  Proposal 7.3.1-3-v2:   * For FR2, study 50 MHz and 100 MHz maximum UE bandwidth at least for initial access.   + Other bandwidths for initial access are not studied further within this SI.   Proposal 7.3.1-3-v3:   * For FR2, study 100 MHz maximum UE bandwidth at least for initial access.   + Other bandwidths for initial access are not studied further within this SI. |
| FUTUREWEI | ? | We support v3. As Intel pointed out, there are a number of issues and little gain for 50MHz, doing the full analysis for 100MHz would save time.  Seems no need for v2 compared to the previous agreement. |
| Huawei, HiSilicon |  | V3 as commented previously. |
| Sierra Wireless |  | We feel strongly that we need to choose one BW to provide economies of scale. 100MHz will provide a higher data rate without a significant cost impact. Also, 50MHz will need more specification work which is challenging given our limited time/online meetings. Thus, we strongly support V3 as it gets us much farther, but we can accept V2 if that is all we can agree to this meeting. |
| ZTE,Sanechips |  | Support V3. Considering the available meeting time, it’s better to narrow down this time. |
| Ericsson |  | We support v2.  Both 50 MHz and 100 MHz should be studied, and the TR should capture the pros and cons of these two bandwidth options. A few companies have pointed out that the 50 MHz bandwidth option may have RAN1 specifications impact or cannot support some of the existing SSB/CORESET#0 configurations. However, we see it as a performance degradation issue, rather than specs or coexistence issue. As we show in our contribution [1], the network can still configure 57.6 MHz SSB bandwidth and 69.12 MHz CORESET#0 bandwidth, but there is a performance degradation in PDCCH, which is less than 1.7 dB for AL 16. An important question to answer during the SI is whether the benefit in UE cost/complexity reduction can justify the loss in link performance. We hope that the TR can capture pains versus gains so that a recommendation at the end of the SI can be made on solid foundation. For the WI, we do support that only one bandwidth option is specified. |
| Nokia, NSB |  | We support v2  We should first do the study using the proposed complexity breakdown to see the difference. Then we can see whether the additional specification impact and performance degradation would justify 50 MHz. |
| Qualcomm |  | We support v3  As explained in our paper, 50 MHz may have many issues in terms of performance (PBCH, PDCCH, etc…), coverage (AL16 support), UE implementation (mux patterns 2 and 3), PDCCH blocking, etc… However, the gain in going from 100 to 50 MHz BW is not significant, hence the above mentioned issues with 50 MHz cannot be justified. |
| DOCOMO |  | We support v2  While our preference is supporting 100 MHz only, as agreed previously, we should study both 50MHz and 100MHz at least for initial access. After that we can down-select one of them in WI phase. |
| Intel |  | We are supportive of v3 as we do not see the “pain vs. gain” margin low enough to justify pursuing the 50 MHz option – as discussed before, the cost/complexity benefits would be rather limited while requiring significant spec impact, and still cause performance losses and quite severe scheduler restrictions. |
| NEC |  | We support v3  As RAN4 spec for 50 MHz with 240 kHz SCS is not available, additional RAN4 study/work is required and feasibility is unknown for 50 MHz CBW. |
| Lenovo, Motorola Mobility |  | We support v2. Same view with Nokia, needs to study the cost breakdown at first. Besides, it is unclear to us if there will be much standard impact caused by 50MHz. It might be handled by implementation, or it might be related with how we address coexistence issues during initial access. |
| vivo |  | We support v3. |
| Samsung |  | We support v2. We already had agreement in previous meeting. We don’t see the need to remove one of BW. We should focus on study for both BW for FR2. We are ok to exclude other BW for this meeting, i.e., update for FFS part only.  Agreements:   * For FR2, study 50MHz and 100 MHz maximum UE bandwidth at least for initial access   + Other bandwidths FFS |
| Panasonic |  | We support v2. Same view as Nokia and Lenovo. |
| LG |  | We support v2.  Even though we have doubt that 50MHz BW can support SSB/CORESET 0 configurations smoothly, we need to study both 50 MHz and 100 MHz at least now that it is the SI phase. |
| OPPO |  | Slightly prefer to support V2 to study 50MHz in FR2. |
| FL4 |  | The responses are split 50/50 between Proposal 7.3.1-3-v2 and Proposal 7.3.1-3-v3, so the FL recommendation is to continue working in line with the RAN1#101e agreement, i.e.:   * For FR2, study 50MHz and 100 MHz maximum UE bandwidth at least for initial access   + Other bandwidths FFS |
| FUTUREWEI\* |  | We (still) support v3, as there are a number of issues and little gain for 50MHz, and doing the full analysis for 100MHz would save time. One compromise would be to capture the qualitative aspects but then do no more analysis/simulation.  No need to spend GTW for v2 compared to the previous agreement. |
|  |  |  |

### 7.3.3 Analysis of performance impacts

Contributions [1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 15, 16, 17, 18, 20, 21, 27, 28, 29] analyze the performance impact in FR1 due to bandwidth reduction from 100 MHz to 20 MHz.

**Data rate:**

* P1: There is peak data rate reduction due to bandwidth reduction [7, 18]
* P2: 20 MHz bandwidth can either achieve or sufficiently close to achieve data rate requirements for all targeted use cases [2, 3, 6, 8, 21, 27]
* P3: 64QAM without MIMO achieves greater than 80 Mbps in DL [5, 13, 29, 13]
* P4: 64QAM without MIMO achieves greater than 50 Mbps in UL [13, 29]
* P5: 16QAM without MIMO achieves greater than 40 Mbps in UL [13, 29]
* P6: A UE bandwidth of 20MHz without MIMO cannot achieve DL peak bit rate of 150Mbps. To achieve 150 Mbps in DL, either MIMO, CA, or larger bandwidth than 20 MHz is needed. [3, 5, 9, 12, 15, 16, 27, 28, 29]
* P7: A DL peak rate of 150Mbps is not possible with TDD, 20MHz UE BW, and 64 QAM [13]

**Latency:**

* P8: The latency can be increased if the large messages need to be segmented into multiple transport blocks and sent over multiple slots. But, for the use cases that are considered in this study, the latency associated with increased transmission time (due to the reduced bandwidth) is likely to be insignificant compared to the latency associated with the DRX functionality. [7]

**Reliability:**

* P9: Reliability should not be impacted as it is envisaged that BLER targets can still be achieved at a reduced bandwidth. [7]

**Power consumption:**

* P10: Power saving benefit: [4, 5, 6, 15, 20,]

**Spectral Efficiency:**

* P11: Minimal spectral efficiency degradation [6, 7, 17]
* P12: CORESET#0 capacity before RRC connection setup and impact as such on spectral efficiency [17, 20]

**PDCCH blocking probability**

* P13: PDCCH blocking probability may increase [20]

**Coverage:**

* P14: PDSCH performance degradation (based on the same data rate target) [9]
* P15: Minor or no coverage loss [1, 6, 7, 17]

Some of performance impact identified above can be expected also in FR2

Contributions [1, 4, 5, 6, 9, 12, 16, 18, 19, 23, 26, 27, 28, 29] identify the performance impact due to UE bandwidth reduction in FR2.

Impacts common to 50 MHz and 100 MHz

* P16: In FR2, both maximum UE bandwidth 50 MHz and 100 MHz can meet the peak data rate requirement. [5, 6]
* P17: SSB/CORESET acquisition time can be impacted if the UE bandwidth is reduced [28]
* P18: Misalignment between Redcap UE’s receiving bandwidth and PDSCH scheduling bandwidth [16]
* P19: Severely limiting the gNB scheduler in managing load on the initial DL BWP [12]

Impacts identified specific to 50 MHz UE bandwidth

* P20: UE may not be able to receive AL 8 or 16 for certain CORESET#0 configurations [26, 29]
* P21: PDCCH blocking probability [4, 5, 9, 16, 18, 27, 28, 29]
* P22: Reduce the number of users that can be supported by almost 50% if the maximum UE BW is reduced from 100 MHz to 50 MHz [29]
* P23: Lower mean SINR compared to the 100 MHz case [29]
* P24 Regarding PBCH performance degradation, contributions [1, 6, 23] analyze the loss.
  + very modest [1]
  + < 1 dB [23]
  + 0.6 dB [6]
* P25: Regarding PDCCH performance degradation when CORESET#0 is configured to 69.12 MHz, contributions [1, 6] analyze the loss.
  + 1.5-1.7 dB [1]
  + Not expected to have a significant impact to system performance [6]

**Q 7.3.3-1: Does the list (P1, P2, …, P15) above capture the most important performance impacts that need to be considered for bandwidth reduction in FR1? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | Y | Was the intent to stop at P15? |
| Ericsson | Y |  |
| Sierra Wireless | Y |  |
| Spreadtrum | Yes |  |
| ZTE,Sanechips | Y |  |
| Panasonic | Y |  |
| vivo |  | FR1  For data rate: we think P1/2/6/7 are important ones.  For latency: fine with P8  For reliability: fine with P9  For power consumption: fine with P10  For spectrum efficiency: fine with P11. P12 is conditional, the issue may happen if the RedCap UEs cannot be offloaded to other BWPs  For PDCCH blocking: P13 is conditional, the block may increase if the RedCap Ues cannot be offloaded to other BWPs.  For coverage: P14 and P15 seems contradictive to each other? |
| Samsung |  | To align with other feature on whether to add coverage analysis  Some observations needs to be further discussed and revisited. |
| OPPO | Yes |  |
| Xiaomi | Y |  |
| CMCC | Y | One little comment about P21, we don’t analyse the PDCCH blocking probability in our contribution, and the contribution index [19] can be removed as the following  • P21: PDCCH blocking probability [4, 5, 9, 16, 18, 27, 28, 29] |
| Huawei, HiSilicon | Y |  |
| TIM |  | Detailed simulations should be performed in order to understand impacts on system capacity, spectral efficiency, coverage loss, latency and reliability losses |
| Sequans | Yes |  |
| Lenovo, Motorola Mobility | Y |  |
| Intel | Y |  |
| Nokia, NSB | Y |  |
| MediaTek | Y |  |
| Qualcomm | Y |  |
| CATT |  |  |
| DOCOMO | Y |  |
| LG | Y |  |
| SONY | Y |  |
| InterDigital | Y |  |
|  |  |  |

**Q 7.3.3-2: Which of the identified performance impacts or aspects in the list above (P1, P2, …, P15) are the most critical ones to be captured in TR 38.875 for bandwidth reduction in FR1?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Example | P1, P2 |
| FUTUREWEI | Should capture:  P1, P2, P4, P11/14/15 should probably be combined into a small performance loss statement (no mention of COVERAGE LOSS)  No strong feeling:  P8,9  Should not capture:  P3, 5 as related to another technique which, if included, should be analysed on top of bandwidth reduction  P6,7: The requirements are “up to”, saying “cannot achieve” or “is not possible” may give the impression that it is a hard requirement. CA and BW larger than 20MHz should not be mentioned. P7 belongs in modulation restriction if that technique is included.  P12 seems not a spectral efficiency argument but more a coexistence or system impact  P13 no need to discuss for FR1 |
| Ericsson | P1, P2, P3, P6, P8, P9, P10, P11, P15  Regarding P12 and P13, we agree these performance aspects are important. But further studies are needed. |
| Sierra Wireless | P1-P7, P9, P10 |
| Spreadtrum | P1, P10, P13, P14 |
| ZTE,Sanechips | P6, P10, P11 |
| Panasonic | P1, P6, P7 |
| vivo | For FR1: P1/2/6/7/8/9/10 |
| Samsung | P2, P10, P11, P12, P13, P15 |
| OPPO | P2/P10/P11/P15 |
| Xiaomi | P3,P4,P5,P6,P7,P11,P15 |
| CMCC | P1-P7,P10,P11,P12,P13,P17 |
| Huawei, HiSilicon | P1, P2, P4, P6, P7, P8, P9, P11, P15 are critical.  P3 is unclear why 80Mbps is chosen as a target and why MIMO layers is not preferred in such observation. P5 has a similar issue.  P10 is not critically needed as BW reduction is not aimed for achieving power saving benefit. P13/P14 also seems to be looking at a non-targeted aspects but can be further studied.  P12 needs further study, as our view that 20MHz BW is the same as legacy so for initial access it does not affect the SE. |
| TIM | See previous table |
| Sequans | P1-P6, P10-P13, P15 |
| Lenovo, Motorola Mobility | P1, P2, P8, P9, P10, P11, P12, P13, P15 |
| Intel | P1, P2, P6, P9, P10. |
| Nokia, NSB | P1, P2, P9, P10, P11, P15 |
| MediaTek | P1, P2 (may be combined with P6 P7), P4, P8, P9, P11, P15  P3, P5 could be mentioned in the section where restriction on maximum modulation order is discussed. |
| Qualcomm | P1, P2, P3, P4, P5, P6, P8, P9, P10, P11, P15 |
| CATT | P1, P3, P4, P5, P6, P8, P9, P10, P11, P15 |
| DOCOMO | P1, P2, P3, P4, P5, P6, P8, P9, P10, P11, P15 |
| LG | P1, P2, P6, P10, P11, P15 |
| SONY | P1, P8, P9, P11, P13  Also, we should capture P14 or P15 (they seem to be mutually exclusive)  We would also like the capture something about power consumption, but would like to study further whether there is a power consumption benefit (P10). If the UE is “on” for longer due to reduced bandwidth, we see a mechanism for the power consumption to increase, not decrease. |
| InterDigital | P2, P10, P11, P12, P13, P15 |
|  |  |

**Q 7.3.3-3: Does the list (P1, P2, …, P25) above capture the most important performance impacts that need to be considered for bandwidth reduction in FR2? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | Y |  |
| Ericsson | Y |  |
| Sierra Wireless | Y |  |
| Spreadtrum | Yes |  |
| ZTE,Sanechips | Y |  |
| Panasonic | Y |  |
| vivo |  | FR2  For impacts common to 50 MHz and 100 MHz: P16 is fine. If UE can support 100MHz, not sure if P17/18 are still valid. P19 is conditional if the RedCap cannot be offloaded to other BWPs  For impacts identified specific to 50 MHz UE bandwidth: P20/24/25 are fine |
| Samsung |  | To align with other feature on whether to add coverage analysis  Some observations needs to be further discussed and revisited. |
| OPPO | Yes |  |
| CMCC | Y |  |
| Huawei, HiSilicon | Y |  |
| TIM |  | See previous table |
| Sequans | Yes |  |
| Lenovo, Motorola Mobility | Y |  |
| Intel | N | Propose adding a P26 (specific to 50 MHz): “Precludes FDM-based multiplexing patterns between SSB and CORESET #0.”  For FR2, we think this is a serious scheduling constraint to scheduling that heavily relies on analogue beamforming. |
| Nokia, NSB | Y |  |
| MediaTek | Y |  |
| Qualcomm | Y | Please add [29] to P20 |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| SONY | Y |  |
| InterDigital | Y |  |
|  |  |  |

**Q 7.3.3-4: Which of the identified performance impacts or aspects in the list above (P1, P2, …, P25) are the most critical ones to be captured in TR 38.875 for bandwidth reduction in FR2?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Example | P1, P2 |
| FUTUREWEI | Should capture: P16,P17 (where more impact is expected for 50MHz), P20-22, P24-25 (need to be rewritten to emphasize that there is a degradation, then the dB range (so far).  No strong feeling: P23  Should not capture:  P18 issue not clear  P19 more a coexistence issue |
| Ericsson | P1, P9, P10, P11, P15, P16, P17, P23, P24, P25  Regarding P12, P13, P19, and P21, we agree these performance aspects are important. But further studies are needed. |
| Sierra Wireless | P17 |
| ZTE,Sanechips | P20,P22,P23 |
| Panasonic | P17, P24, P25 |
| vivo | For FR2: P16/24/25 |
| Samsung | P11, P12, P13, for both FR1 and FR2  P16, P20, P21 for FR 2 |
| OPPO | P18  Since PDSCH for SIBx and other common messages are scheduled by the gNB with DCI, the PDSCH may not occupy the whole initial DL BWP. Redcap UE’s receiving bandwidth may not fully overlap with the PDSCH scheduling bandwidth, as shown in Figure 1. In this case, the PDSCH decoding performance will deteriorate. Therefore, method to avoid such mis-alignment between Redcap UE’s receiving bandwidth and PDSCH scheduling bandwidth shall be further studied.    Figure 1 Mis-alignment between Redcap UE’s receiving bandwidth and PDSCH scheduling bandwidth |
| CMCC | P20,P21,P24,P25 |
| Huawei, HiSilicon | P1, P2, P4, P6, P7, P8, P9, P11, P15, P16, P17, P20, P21, P22, P23, P24, P25 |
| TIM | See previous table |
| Sequans | P16, P17, P20, P21, P25 |
| Lenovo, Motorola Mobility | P1, P8, P9, P10, P11, P12, P13, P15, P16, P17, P20, P21 |
| Intel | P9, P10, P16, P19, P20, P22, P26 (proposed to be added in response to Q 7.3.3-1). |
| Nokia, NSB | P16, P20, P21, P24, P25 |
| MediaTek | P1, P2 (may be combined with P6 P7), P4, P8, P9, P11, P15, P16, P17  P20, P21, P23  Agree with qualitatively stating the degradation in P22. |
| Qualcomm | P1, P8, P13, P14, P16, P17, P20, P21, P24, P25 |
| CATT | P6, P13, P20, P24, P25 |
| DOCOMO | P1, P9, P10, P11, P16, P17, P20, P21, P24, P25 |
| LG | P1, P10, P11, P15, P16, P17, P21, P23, P24, P25 |
| Ericsson 2 | Regarding P20, we disagree. AL 8 and 16 can be used for 50 MHz Ues. There is however a link performance degradation. We show the loss is up to 1.7 dB for AL 16 in [1]. |
| InterDigital | P1, P9, P10, P11, P12, P13, P15, P16, P17, P23, P24, P25 |
|  |  |

Based on the responses in this section, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For UE bandwidth reduction in FR1, the following performance impacts (which have been slightly rephrased compared to above in some cases for improved clarity) should be captured in the TR according to at least half of the 23 responses to Q 7.3.3-2.   * P1: There is peak data rate reduction due to bandwidth reduction. * P2: 20 MHz bandwidth can either achieve or sufficiently close to achieve data rate requirements for all targeted use cases. * P6: A UE bandwidth of 20MHz without MIMO cannot achieve DL peak bit rate of 150Mbps. To achieve 150 Mbps in DL, either MIMO, CA, or larger bandwidth than 20 MHz is needed. * P9: Reliability should not be impacted by bandwidth reduction as it is envisaged that BLER targets can still be achieved at a reduced bandwidth. * P10: Bandwidth reduction achieves a power saving benefit. * P11: Bandwidth reduction results in minimal spectral efficiency degradation. * P15: Bandwidth reduction results in minor or no coverage loss.   Proposal 7.3.3-1:   * For UE bandwidth reduction in FR1, at least the following performance impacts can be captured in the TR.   + P1: There is peak data rate reduction due to bandwidth reduction.   + P2: 20 MHz bandwidth can either achieve or sufficiently close to achieve data rate requirements for all targeted use cases.   + P6: A UE bandwidth of 20MHz without MIMO cannot achieve DL peak bit rate of 150Mbps. To achieve 150 Mbps in DL, either MIMO, CA, or larger bandwidth than 20 MHz is needed.   + P9: Reliability should not be impacted by bandwidth reduction as it is envisaged that BLER targets can still be achieved at a reduced bandwidth.   + P10: Bandwidth reduction achieves a power saving benefit.   + P11: Bandwidth reduction results in minimal spectral efficiency degradation.   + P15: Bandwidth reduction results in minor or no coverage loss. |
| **Company** | **Comments** |
| vivo | P1/P6/P9/P10/P11/P15 are fine.  P2 is related to the previous question, whether 150Mbps is still the target for the SI. |
| Samsung | For P10, we prefer similar wording as for antenna reduction, since it will also reduce bitrate in general.  Besides, we think P12 is also need to be captured for FR 1. |
| Qualcomm | P1/P6/P9/P10/P11 |
| Huawei, HiSilicon | Except for P9/P10/P11. Reliability/SE are critical aspects that needs to be considered; but the observations need more verification.  P6 is discussed in a previous question, no need to mention it.  The discussion a bit difficult to us, since we understood the question is to ask which ‘aspects’ (i.e. which KPIs) are important, as we explained in Q 7.2.3-1. |
| SONY3 | We are OK with capturing the list in the proposal.  Agree with Huawei, that the list is basically a set of aspects (KPIs) that are important, as per Q 7.2.3-1 comment. |
| Ericsson | Fine with FL proposal. |
| Sierra Wireless | We agree with P1, P6, P9, P10, P11, P15 |
| FUTUREWEI\* | Mostly OK. If P6 is a bit touchy, ok to skip for now. If want to for P10/15 we can wait for results from next time to confirm. |
| ZTE,Sanechips\* | P2 is related to previous question. We have concern for P2. We need to capture that in order for 20Mhz to achieve data rate requirement Redcap UE needs to use 2 layer MIMO. |
| CATT | We agree with P1, P6, P9, P10, P11, P15 |
| Lenovo, Motorola Mobility | Fine with the proposal |
| Intel | Fine with the proposal. |
| LG | We are OK with the proposal. |
| FL5 | Several responses expressed concerns with P2. For the other bullets, only one or two responses expressed concerns.  Proposal 7.3.3-1-v2:   * For UE bandwidth reduction in FR1, at least the following performance impacts can be captured in the TR in the next meeting.   + P1: There is peak data rate reduction due to bandwidth reduction.   + ~~P2: 20 MHz bandwidth can either achieve or sufficiently close to achieve data rate requirements for all targeted use cases.~~   + P6: A UE bandwidth of 20MHz without MIMO cannot achieve DL peak bit rate of 150Mbps. To achieve 150 Mbps in DL, either MIMO, CA, or larger bandwidth than 20 MHz is needed.   + P9: Reliability should not be impacted by bandwidth reduction as it is envisaged that BLER targets can still be achieved at a reduced bandwidth.   + P10: Bandwidth reduction achieves a power saving benefit.   + P11: Bandwidth reduction results in minimal spectral efficiency degradation.   + P15: Bandwidth reduction results in minor or no coverage loss. |
| OPPO | Fine with current Proposal 7.3.3-1-v2 |
| FUTUREWEI | OK. If concerns and some of these start to disappear we can wait for next time and get a fuller picture. |
| vivo | Fine with proposal 7.3.3-1-v2 |
| Huawei, HiSilicon | Can live with P10/P11 but NOT prefer P6 and P9. Reliability needs to be studied together with latency requirements. |
| Samsung | We like to put P10 in bracket. |
| MediaTek | We are fine with the proposal. |
| Ericsson | We are fine with the proposal. We would also be fine with inserting ‘FFS’ in P6, P9 and P10 to address the concerns expressed by other companies in the comments above. |
| FL6 | Proposal 7.3.3-1-v3:   * For UE bandwidth reduction in FR1, at least the following performance impacts can be captured in the TR in the next meeting.   + P1: There is peak data rate reduction due to bandwidth reduction.   + ~~P2: 20 MHz bandwidth can either achieve or sufficiently close to achieve data rate requirements for all targeted use cases.~~   + P6: FFS: A UE bandwidth of 20MHz without MIMO cannot achieve DL peak bit rate of 150Mbps. To achieve 150 Mbps in DL, either MIMO, CA, or larger bandwidth than 20 MHz is needed.   + P9: FFS: Reliability should not be impacted by bandwidth reduction as it is envisaged that BLER targets can still be achieved at a reduced bandwidth.   + P10: FFS: Bandwidth reduction achieves a power saving benefit.   + P11: Bandwidth reduction results in minimal spectral efficiency degradation.   + P15: Bandwidth reduction results in minor or no coverage loss. |
|  |  |

Furthermore, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For UE bandwidth reduction in FR2, the following performance impacts (which have been slightly rephrased compared to above in some cases for improved clarity) should be captured in the TR according to at least half of the 22 responses to Q 7.3.3-4.   * P16: In FR2, both maximum UE bandwidth 50 MHz and 100 MHz can meet the peak data rate requirement. * P17: SSB/CORESET acquisition time can be impacted if the UE bandwidth is reduced.   For the 50 MHz UE bandwidth option for FR2, the following should be captured according to at least half of the 22 responses to Q 7.3.3-4.   * P20: The UE may not be able to receive AL 8 or 16 for certain CORESET#0 configurations. * P21: PDCCH blocking probability * P24: Regarding PBCH performance degradation, the findings are:   + very modest   + < 1 dB   + 0.6 dB * P25: Regarding PDCCH performance degradation when CORESET#0 is configured to 69.12 MHz, the findings are:   + 1.5-1.7 dB   + Not expected to have a significant impact to system performance   Proposal 7.3.3-3:   * For UE bandwidth reduction in FR2, at least the following performance impacts can be captured in the TR.   + P16: In FR2, both maximum UE bandwidth 50 MHz and 100 MHz can meet the peak data rate requirement.   + P17: SSB/CORESET acquisition time can be impacted if the UE bandwidth is reduced. * For the 50 MHz bandwidth option for FR2, at least the following performance impacts can be captured in the TR.   + P20: The UE may not be able to receive AL 8 or 16 for certain CORESET#0 configurations.   + P21: PDCCH blocking probability   + P24: Regarding PBCH performance degradation, the findings are:     - very modest     - < 1 dB     - 0.6 dB   + P25: Regarding PDCCH performance degradation when CORESET#0 is configured to 69.12 MHz, the findings are:     - 1.5-1.7 dB     - Not expected to have a significant impact to system performance |
| **Company** | **Comments** |
| Samsung | We think P12 is also very important for FR2 and apply for both 100MHz and 50MHz.  P12: CORESET#0 capacity before RRC connection setup and impact as such on spectral efficiency. |
| Huawei, HiSilicon | Fine with P16, P17, P20 and P21. For P24 and P25, more evaluations are needed. |
| Qualcomm | P20: fine  P21: need to be more specific about the impacts, i.e., may increase PDCCH blocking probability  P24: fine  P25: we are not fine with this:  - 1.5-1.7 dB loss is based on 1 company’s results (we cannot take as general observation)  - ”Not expected to have a significant impact to system performance”, we cannot accept this observation as this sentence is very subjective without technical justification  - ”Regarding PDCCH performance degradation when CORESET#0 is configured to 69.12 MHz”, not very clear on this. The main proposal is talking about 50 MHz BW, how can CORESET0 be > 50?  - We recommend capturing the following: “PDDCH performance degradation is expected to impact the system performance, this impact may be studied further” |
| Ericsson | We don’t agree with P20. A RedCap UE limited to 50 MHz maximum BW can be designed to receive AL 8 and 16, although there is a performance reduction. |
| FUTUREWEI\* | Mostly OK. Prefer for P17 to mention that 50 will have more impact than 100 (or wait for next time). For P25 the “Not expected to have a …” needs to be removed, too much promotion. For P24 prefer to have a dB number and not “very modest” as that is subjective.  P12 seems more a coexistence impact. If captured should indicate more impact for 50 than 100. |
| CATT | Agree with Futurewei that P17 should differentiate 100MHz and 50MHz. |
| Lenovo, Motorola Mobility | P24, P25 need more evaluations, fine with others. |
| Intel | At least P19, P20, P22 need to be added to the list. |
| FL5 | A couple of responses wanted P17 to capture that the 50 MHz option will have more impact than the 100 MHz option. A few responses suggested revisions of P24 and P25. One response regarded P20 as incorrect. For the other bullets, only one or two responses expressed concerns. Perhaps the following updated proposal can be considered.  Proposal 7.3.3-3-v2:   * For UE bandwidth reduction in FR2, at least the following performance impacts can be captured in the TR in the next meeting.   + P16: In FR2, both maximum UE bandwidth 50 MHz and 100 MHz can meet the peak data rate requirement.   + P17: SSB/CORESET acquisition time can be impacted if the UE bandwidth is reduced. The 50 MHz option will have more impact than the 100 MHz option. * For the 50 MHz bandwidth option for FR2, at least the following performance impacts can be captured in the TR in the next meeting.   + P20: The UE may or may not be able to receive AL 8 or 16 for certain CORESET#0 configurations.   + P21: PDCCH blocking probability   + P24: ~~Regarding~~ PBCH performance degradation~~, the findings are:~~     - ~~very modest~~     - ~~< 1 dB~~     - ~~0.6 dB~~   + P25: ~~Regarding~~ PDCCH performance degradation when CORESET#0 is configured to 69.12 MHz~~, the findings are:~~     - ~~1.5-1.7 dB~~     - ~~Not expected to have a significant impact to system performance~~ |
| FUTUREWEI | OK. If concerns and some of these start to disappear we can wait for next time and get a fuller picture. |
| Samsung | We think P12 also need to be captured, especially for 50MHz.  P12: CORESET#0 capacity before RRC connection setup and impact as such on spectral efficiency [17, 20]  We have a question for P17, is the long acquisition time because of retuning between SSB and CORESET 0? Why there is no loss of PDSCH but the acquisition time will be impacted? If that is the case, we like to update P17 as below:  P17: SSB/CORESET acquisition time can be impacted because retuning time from SSB to COREST 0 is needed if the UE bandwidth is reduced. |
| Ericsson | We are fine with the proposal.  We are also fine with the following modification of P17 (similar as Samsung’s proposal but without the word ‘time’ since the issue is not the retuning time in itself but the fact that the UE may not be able to receive SSB and CORESET 0 simultaneously):  P17: SSB/CORESET acquisition time can be impacted because retuning from SSB to CORESET 0 is needed if the UE bandwidth is reduced. |
| FL6 | Proposal 7.3.3-3-v3:   * For UE bandwidth reduction in FR2, at least the following performance impacts can be captured in the TR in the next meeting.   + P16: In FR2, both maximum UE bandwidth 50 MHz and 100 MHz can meet the peak data rate requirement.   + P17: SSB/CORESET acquisition time can be impacted because retuning from SSB to CORESET 0 is needed if the UE bandwidth is reduced. The 50 MHz option will have more impact than the 100 MHz option. * For the 50 MHz bandwidth option for FR2, at least the following performance impacts can be captured in the TR in the next meeting.   + P20: The UE may or may not be able to receive AL 8 or 16 for certain CORESET#0 configurations.   + P21: PDCCH blocking probability   + P24: ~~Regarding~~ PBCH performance degradation~~, the findings are:~~     - ~~very modest~~     - ~~< 1 dB~~     - ~~0.6 dB~~   + P25: ~~Regarding~~ PDCCH performance degradation when CORESET#0 is configured to 69.12 MHz~~, the findings are:~~     - ~~1.5-1.7 dB~~     - ~~Not expected to have a significant impact to system performance~~ |
|  |  |

Finally, the following can be considered.

|  |  |
| --- | --- |
| FL3 | Many responses did not explicitly indicate which ones of (P1, P2, …, P15) that also apply to FR2, but it seems reasonable to capture the performance impacts for FR1 that are relevant for FR2. Furthermore, the following additional potential performance impact was identified in the responses to Q 7.3.3-3.   * P26 (specific to 50 MHz): Precludes FDM-based multiplexing patterns between SSB and CORESET #0.   Question 7.3.3-5:   * Which ones of (P1, P2, ..., P15) and P26 should be captured in the TR as performance impacts for UE bandwidth reduction for FR2? |
| **Company** | **Comments** |
| Samsung | For P26, we think UE can retune to CORESET #0 after acquire SSB.  P11 and P12 should be captured for FR2.   * P11: Minimal spectral efficiency degradation [6, 7, 17]   P12: CORESET#0 capacity before RRC connection setup and impact as such on spectral efficiency [17, 20] |
| Qualcomm | P1, P8, P13, P14, and P26 |
| Ericsson | P1, P9, P10, P11, P15  Regarding P12 and P13, we agree these performance aspects are important. But further studies are needed.  Regarding P26, in our view, the FDM-based multiplexing patterns between SSB and CORESET #0 can be supported by a UE limited to maximum BW of 50 MHz. The UE needs frequency retuning to detect SSB and SIB1 in sequential manner. |
| ZTE,Sanechips\* | Regarding P26, without specification change, FDM-based multiplexing patterns between SSB and CORESET #0 cannot be supported by 50Mhz UE bandwidth. |
| Lenovo, Motorola Mobility | P1, P8, P10, P11, P12.  For P26, we have same view with Samsung and Ericsson. |
| Intel | P1, P9, P10, and P26.  For P26, as ZTE mentioned, this is not possible with current specifications and even if UE were to retune to another BWP to receive CORESET #0, there would be adverse impact on sync reference and time/freq tracking, potentially require dynamic retuning, etc.  To take into account observations from Samsung and Ericsson, we could rephrase P26 to say:  P26 (specific to 50 MHz): Precludes FDM-based multiplexing patterns between SSB and CORESET #0, per Rel-15 initial access design and procedure. |
| LG | We would like to note that P26 somehow overlaps with C7. |
| FL5 | There were not many responses to this question. For P26, the answers are mixed (~50/50).  The FL recommendation is to come back to this question later, e.g. once the TR has been populated according to P1-P15 for FR1 and see what impacts that also apply to FR2. |

### 7.3.4 Analysis of coexistence with legacy Ues

Contributions [1, 3, 4, 5, 7, 11, 20] analyse the coexistence issues with legacy Ues. The findings are:

* C1: Small overall impact [1, 20]
* C2: Fully reusing the legacy procedure for RedCap Ues will potentially impact the performance of legacy Ues during initial access and increase the load of the initial BWP [4, 11]
* C3: Longer processing time for PRS is needed [7]
* C4: Paging capacity may be a concern [5]
* C5: Resource fragmentation and reduced peak data rates available for non-RedCap Ues [3]
* C6: Coexistence with URLLC Ues [11]

**Q 7.3.4-1: Does the list above (C1, C2, …, C6) capture the most important coexistence impacts and findings that need to be considered for bandwidth reduction in FR1? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | Y |  |
| Ericsson | Y |  |
| Sierra Wireless | Y |  |
| Spreadtrum | Yes |  |
| ZTE,Sanechips | Y |  |
| Panasonic | Y |  |
| vivo |  | We think C2 and C4 are important aspects that should be addressed for high load scenario. If the cell load is not a concern, i.e. no massive RedCap Ues, the overall impact should be small, i.e. C1. |
| Samsung |  | C3: PRS is not a part of the study focus.  Some observations need to be further discussed, e.g, C5. |
| OPPO | Y |  |
| Xiaomi | Y |  |
| CMCC | Y |  |
| Huawei, HiSilicon | Y |  |
| TIM |  | Detailed coexistence analysis should be perfomed |
| Sequans | Yes |  |
| Lenovo, Motorola Mobility | Y |  |
| Intel | Y |  |
| Nokia, NSB | Y |  |
| MediaTek | Y |  |
| Qualcomm | Y |  |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | Y | Considering the FDMed RO issue, initial access procedures or RACH configurations of RedCap Ues should be clarified first. |
| SONY | Partially Y | C1, C2, C3, C4, C5, C6 can be captured, but C3 text should be modified to “Redcap UE unable to receive wider bandwidth PRS”  For C3, the issue is not that a longer processing time for PRS is needed, it is that only a narrower bandwidth PRS can be received, which would impact positioning accuracy. In [7], we observed that if the RF BW is greater than the baseband BW, then that wider BW (and hence more accurate) PRS could be received, but the baseband processing would need to be spread over more than one slot. We think that observing that there is an impact on positioning accuracy is within the scope of the SI (why would it not be?). |
| InterDigital | Y |  |
|  |  |  |

**Q 7.3.4-2: Which of the identified coexistence impacts in the list above (C1, C2, …, C6) are the most critical ones to be captured in TR 38.875 for bandwidth reduction in FR1?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Example | C1, C2 |
| FUTUREWEI | Should capture:  C5. We had a similar statement in 888.  No strong feeling:  Should not capture:  C1: This is not compatible with the other statements. Better to list the impacts. Also, not applicable to FR2.  C2: This seems more an issue for FR2. |
| Ericsson | C1, C3.  Regarding C2, C4, C5, and C6, further discussions are needed. |
| Sierra Wireless | C5 |
| Spreadtrum | C1 |
| ZTE,Sanechips | C1 |
| Panasonic | C1 |
| vivo | For high load scenario, C2, C4, otherwise C1. |
| Samsung | C2, C4, |
| OPPO | C1,C2,C4 |
| Xiaomi | C1,C2 |
| CMCC | C2, C4 |
| Huawei, HiSilicon | C2, C5 |
| TIM | See previous table |
| Sequans | At least C1, C2, C5 |
| Lenovo, Motorola Mobility | C2 |
| Intel | C1 |
| Nokia, NSB | C1 |
| MediaTek | C1,C2, C5 |
| Qualcomm | C1, C2 |
| CATT | C1 |
| DOCOMO | C1 |
| LG | C1, C2. Basically, we don’t think the overall impact is small. Among the listed impacts, C2 seems to be a bit more important than others considering the FDMed RO issue. The initial access procedures or RACH configurations of RedCap Ues needs to address this issue. |
| SONY | C1, C3 |
| InterDigital | C2, C4, C5 |
|  |  |

Some of the coexistence impacts identified for FR1 above might be relevant for FR2.

Concerning 50 MHz UE bandwidth in FR2, contributions [3, 5, 17, 29] highlight the following issues.

* C7: Restrictions on SSB/CORESET#0 configurations or Type0-PDCCH monitoring [3, 17, 5]
* C8: PDCCH blocking probability increases [29]
* C9: Half capacity compared to 100 MHz with a TDM scheduler [29]
* C10: Reduced SIR compared to 100 MHz [29]

**Q 7.3.4-3: Does the list above (C1, C2, …, C10) capture the most important coexistence impacts and findings that need to be considered for bandwidth reduction in FR2? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | N | As above, should have a statement like “a value of X MHz in FR2 will avoid these issues with 50MHz, but would require effort in RAN4 to define a new bandwidth.” |
| Ericsson | Y |  |
| Sierra Wireless | Y |  |
| Spreadtrum | Yes |  |
| ZTE,Sanechips | N | Seems not a complete lists. PDCCH performance …UE retuning complexity |
| Panasonic | Y |  |
| vivo |  | We think C7 is more important. |
| Samsung | Yes | Some observations need to be further discussed |
| OPPO | N | C11, Misalignment between Redcap UE’s receiving bandwidth and PDSCH scheduling bandwidth shall also be considered |
| CMCC | Y |  |
| Huawei, HiSilicon | Y |  |
| TIM |  | See previous table |
| Sequans | Yes |  |
| Lenovo, Motorola Mobility | Y |  |
| Intel | N | Propose to add a C11: “Higher system information acquisition delay due to infeasibility of frequency division multiplexing between SSB and CORESET 0 for 50 MHz”. FDM-based SSB-CORESET0 multiplexing patterns are not possible even for 120 kHz SCS (both SSB and control/data) for 50 MHz max BW. |
| Nokia, NSB | Y |  |
| MediaTek | N |  |
| Qualcomm | Y |  |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| SONY | Y |  |
| InterDigital | Y |  |
|  |  |  |

**Q 7.3.4-4: Which of the identified coexistence impacts in the list above (C1, C2, …, C10) are the most critical ones to be captured in TR 38.875 for bandwidth reduction in FR2?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Example | C1, C2 |
| FUTUREWEI | Should capture: C7  C2 should be rewritten: For 50MHz, two initial access procedures will have to coexist: one for ‘regular’ Ues, one for RedCap Ues  No strong feeling:C8,C9,C10  Should not capture:  C1 (for at least 50MHz) |
| Ericsson | C3, C7.  Regarding C7: we agree this aspect should be captured in the TR. However, our view is that all the currently defined SSB/CORESET#0 configurations can be reused. One restriction we see is that the UE needs to detect SSB and SIB1 in a sequential manner for certain SSB/CORESET#0 configurations.  All the other coexistence impacts need to be discussed further. |
| Sierra Wireless | C7 |
| ZTE,Sanechips | If 100MHz are adopted then there is no concern. For 50MHz most in the list are all critical issues need to be resolved |
| Panasonic | C7 |
| vivo | C1 |
| Samsung | C7 C8 |
| OPPO | For 50MHz case, Misalignment between Redcap UE’s receiving bandwidth and PDSCH scheduling bandwidth shall also be considered |
| CMCC | C7,C8 |
| Huawei, HiSilicon | C2, C5, C7, C8, C9, C10 |
| Sequans | At least C7 |
| Lenovo, Motorola Mobility | C2, C7, C8 |
| Intel | C2, C11 (proposed to be added as in response to **Q 7.3.4-3**) |
| Nokia, NSB | C7 |
| MediaTek | C5, C7, C8 |
| Qualcomm | C4, C7, C8, C9 |
| CATT | C1, C7, C8 |
| DOCOMO | C7, C8 |
| LG | C7.  When RedCap Ues with maximum 50 MHz bandwidth coexist with legacy NR Ues in FR2, FDMed SSB/CORESET0 (i.e. multiplexing pattern 2 and 3) cannot be configured, which means restriction on the legacy UE configurations. We need to study/discuss whether this restriction is acceptable. |
| SONY | C3, C7 |
| InterDigital | C7, C8, C9 |
| FL5 | No clear consensus in this meeting |

Furthermore, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For UE bandwidth reduction in FR1, the following coexistence impacts should be captured in the TR according to at least half of the 22 responses to Q 7.3.4-2.   * C1: Small overall impact * C2: Fully reusing the legacy procedure for RedCap Ues will potentially impact the performance of legacy Ues during initial access and increase the load of the initial BWP.   Proposal 7.3.4-1:   * For UE bandwidth reduction in FR1, at least the following coexistence impacts can be captured in the TR.   + C1: Small overall impact   + C2: Fully reusing the legacy procedure for RedCap Ues will potentially impact the performance of legacy Ues during initial access and increase the load of the initial BWP. |
| **Company** | **Comments** |
| vivo | C1 is fine.  C2 maybe true but prefer to discuss the severity of the issue and if so what are the potential solutions. Based on such discussion, C2 (with necessary updates) could be captured. |
| Samsung | OK in general. |
| OPPO | Fine with proposal |
| Qualcomm | OK for C1 and C2 |
| Huawei, HiSilicon | Prefer to check if C1 is proper later after looking into more aspects. |
| SONY3 | The list seems to be so incomplete that we think it is not worth making a proposal here at the moment. |
| Ericsson | Fine with the proposal |
| FUTUREWEI\* | Not OK with either of these as written.  C1 OK if add “, at least for 100MHz”.  C2 still needs to be clarified and rewritten. More of an issue for 50MHz again.  In general, we think there is too strong a promotion effort for 50MHz to imply that 50 and 100 will have the exact same impact when coexisting with legacy Ues. |
| ZTE,Sanechips\* | Agree that for C1 we need to add “at least for 100Mhz”. |
| CATT | Agree with C1, C2 needs further study. |
| Lenovo, Motorola Mobility | Fine with C2.  For C1, we agree with Huawei’s view that we need to check it later. |
| Intel | Fine with C1, but we do not think C2 is well-substantiated at this point. |
| FL5 | No clear consensus in this meeting |

Based on the responses in this section, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For the 50 MHz UE bandwidth option for FR2, the following coexistence impact should be captured in the TR according to at least half of the 22 responses to Q 7.3.4-4.   * C7: Restrictions on SSB/CORESET#0 configurations or Type0-PDCCH monitoring   Proposal 7.3.4-3:   * For the 50 MHz bandwidth option for FR2, at least the following coexistence impact can be captured in the TR.   + C7: Restrictions on SSB/CORESET#0 configurations or Type0-PDCCH monitoring |
| **Company** | **Comments** |
| vivo | Agree |
| Samsung | OK in general. |
| SONY3 | As stated for previous questions related to coexistence, we don’t really see a “restriction on configuration” to be a coexistence issue: it is a “restriction on configuration issue”. If a suitable configuration of SSB / CORESET#0 is chosen, then a Redcap UE can coexist with a legacy UE. |
| Qualcomm | Should also capture C8 and C9 |
| Ericsson | This problem can be addressed through UE implementation solutions. So, we can accept this statement as long as we also capture that “However, with UE implementation-based solutions, all SSB/CORESET#0 configurations and Type0-PDCCH monitoring options can be preserved.” |
| Sierra Wireless | Agree with proposal |
| FUTUREWEI\* | Disagree with Sony, this is an issue when both redcap and legacy Ues coexist in the system so should be captured. |
| CATT | Fine with the proposal. |
| Lenovo, Motorola Mobility | Fine with this proposal. |
| Intel | Following comment from Sony, we are fine to capture this as a performance issue if P19 is added in previous discussion point, else we need to add C7. |
| LG | We are OK with the proposal. |
| FL5 | Two responses do not agree with C7, and one of them proposes to add a clarification in order to accept the bullet.  Proposal 7.3.4-3-v2:   * For the 50 MHz bandwidth option for FR2, at least the following coexistence impact can be captured in the TR in the next meeting.   + C7: Restrictions on SSB/CORESET#0 configurations or Type0-PDCCH monitoring. However, with UE implementation-based solutions, all SSB/CORESET#0 configurations and Type0-PDCCH monitoring options can be preserved. |
| OPPO | Ok in general |
| FUTUREWEI | Prefer an FFS in front of the implementation-based solution sentence. |
| vivo | Agree with FUTUREWEI |
| Huawei, HiSilicon | Agree with FUTUREWEI. |
| Samsung | OK with FUTUREWEI’s suggestion |
| MediaTek | Fine with the proposal with having the FFS as FUTUREWEI suggested. |
| Ericsson | Fine with the proposal. Also fine with Futurewei’s suggestion. |
| FL6 | Proposal 7.3.4-3-v3:   * For the 50 MHz bandwidth option for FR2, at least the following coexistence impact can be captured in the TR in the next meeting.   + C7: Restrictions on SSB/CORESET#0 configurations or Type0-PDCCH monitoring. FFS: However, with UE implementation-based solutions, all SSB/CORESET#0 configurations and Type0-PDCCH monitoring options can be preserved. |
|  |  |

Finally, the following can be considered.

|  |  |
| --- | --- |
| FL3 | Many responses did not explicitly indicate which ones of (C1, C2, …, C6) that also apply to FR2, but it seems reasonable to capture the coexistence impacts for FR1 that are relevant for FR2. Furthermore, the following additional potential coexistence impact was identified in the responses to Q 7.3.4-3.   * C11: Misalignment between Redcap UE’s receiving bandwidth and PDSCH scheduling bandwidth shall also be considered. * C12: “A value of X MHz in FR2 will avoid these issues with 50MHz, but would require effort in RAN4 to define a new bandwidth.” * C13: PDCCH performance * C14: UE retuning complexity * C15: Higher system information acquisition delay due to infeasibility of frequency division multiplexing between SSB and CORESET 0 for 50 MHz   Question 7.3.4-5:   * Which ones of (C1, C2, …, C6) and (C11, C12, ..., C15) should be captured in the TR as coexistence impacts for UE bandwidth reduction for FR2? |
| **Company** | **Comments** |
| Samsung | C4 can be considered to captured, but can update C2 to include it as part of load of initial BWP increase.  We think C11, C14 is part of solution other than impact. No need to capture in TR as coexistence impacts. None of the rest of C11-C15 need to be captured. |
| OPPO | C11 shall be captured. Redap UE with 50MHz maximum bandwidth and legacy UE have different receiving bandwidth therefore the misalignment issue exists. |
| SONY3 | These do not seem to be coexistence issues, rather these seem to be a list of performance issues. |
| Qualcomm | C4, C13, C14, C15 |
| Ericsson | None |
| FUTUREWEI\* | Assuming we properly include the issues with 50MHz, C12 is appropriate and in line with the discussion in GTW last meeting. |
| ZTE,Sanechips\* | Agree that for some item it depends on the UE bandwidth for FR2. |
| Lenovo, Motorola Mobility | C2, C4, C11 |
| Intel | C13, C14, C15 are performance issues and agree that these should be captured – but they are not really coexistence issues. |
| LG | C2, C14, C15 |
| FL5 | No clear consensus in this meeting  The FL recommendation is to come back to this question later, e.g. once the TR has been populated according to C1-C6 for FR1 and see what impacts that also apply to FR2. |

## 7.4 Half-duplex FDD operation

### 7.4.3 Analysis of performance impacts

Contributions [1, 2, 3, 5, 6, 7, 8, 13, 15, 17, 20, 21, 22, 25, 27, 29, 30] analyze the performance impact if HD-FDD is introduced for RedCap UEs. The findings are listed below. Some of the items were identified to be studied further.

* P1: no coverage loss [1, 3, 6, 17, 20, 21, 22, 25, 29, 30]
* P2: lower power consumption, lower maximum power peaks, lower power state, or lower insertion loss [3, 5, 6, 7, 8, 13, 20, 21, 29]
* P3: lower noise figure [1, 6, 7, 17, 29]
* P4: lower (peak) data rates or throughput [2, 3, 5, 6, 7, 15, 27, 29]
* P5: increase PUSCH/PDSCH SINR requirements [2, 21]
* P6: larger number of HARQ processes may be required, which increases the UE buffer occupation and processing complexity [2]
* P7: no impact on spectral efficiency or capacity [3, 6, 7, 17, 20]
* P8: coverage impact for delay sensitive services [27]
* P9: negative impact on latency [2, 7, 15, 27, 29]
* P10: more complicated scheduling at the gNB, more scheduling constraints, or significant impact on network [2, 3, 21, 27]
* P11: Scheduling effectiveness is not jeopardized by supporting Type-A half-duplex UE’s in paired spectrum [8]
* P12: Contributions [1, 5] analyze latency and conclude that an HD-FDD device in RRC\_CON14TED can meet the 5-10 ms latency requirement for safety related sensors.

These performance impacts can be classified as follows:

* Peak data rate: P4
* Latency: P8, P9, P12
* Power consumption: P2, P3,
* Spectral efficiency: P3, P5, P7
* PDCCH blocking probability
* Coverage: P3, P5, P8
* UE buffer and processing complexity: P6
* Scheduling and network: P10, P11

**Q 7.4.3-1: Does the list (P1, P2, …, P12) above capture the most important performance impacts that need to be considered for HD-FDD? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | Y |  |
| Ericsson | Y |  |
| Sierra Wireless | Y |  |
| Spreadtrum | Y |  |
| ZTE,Sanechips | Y |  |
| Samsung | Y | Some observations need to be further discussed. |
| OPPO | Y |  |
| Xiaomi | Yes | We agree on FL’s summary.  A correction: P1 is missing in classified performance impact on Coverage. |
| Huawei, HiSilicon | Y |  |
| TIM |  | Simulations both SLS both LLS are considered beneficial. |
| Sequans | Yes |  |
| Lenovo, Motorola Mobility | Y |  |
| Intel | Y | With the disclaimer than many of the items in the list may not be relevant unless the switching times are significantly long compared to typical scheduling durations (e.g., slot). |
| Nokia, NSB | Y |  |
| MediaTek | Y |  |
| Qualcomm | Y |  |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| SONY | Y |  |
| InterDigital | Y |  |
|  |  |  |

**Q 7.4.3-2: Which of the identified performance impacts in the list above (P1, P2, …, P12) are the most critical ones to be captured in TR 38.875 for HD-FDD?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Example | P1, P2 |
| FUTUREWEI | Should include:P1,P2,P4, P6,P7,P8,P9,P10,P11  No strong feeling: P3, P5, P12  Should not include:  P11 |
| Ericsson | P1, P3, P7, P12 |
| Sierra Wireless | P1, P2, P3, P4, P7 |
| Spreadtrum | P2, P4 |
| ZTE,Sanechips | P1,P2,P7 |
| Samsung | P1, P2, P3, P7, P9, P11, P12 |
| Xiaomi | P2, P4, P9, P12 |
| Huawei, HiSilicon | Except for P2, P3 and P12.  HD-FDD is studied for cost reduction and associated impact on e.g. data rate, as stated in SID. Thus, P2 and P3 are not critical. P12 may need further verification as not clear about the reliability aspect. |
| Sequans | P2-P6, P7 for Type A, P8-P11, FFS for P12 |
| Lenovo, Motorola Mobility | P1, P3, P7 |
| Intel | P1, P2, P3, P4, P11 (under the assumption that switching gaps are not significantly long compared to typical scheduling time granularity) |
| Nokia, NSB | P1, P2, P3, P4, P7, P9 |
| MediaTek | P1, P2, P4, P7, P9, P11 |
| Qualcomm | P1, P2, P3, P7, P11, P12 |
| CATT | P1, P2, P4, P7, P9, P10 |
| DOCOMO | P1, P4, P7, P9, P10 |
| LG | P1, P2, P4, P5, P7, P9, P10 |
| SONY | P1, P2, P3, P4, P7, P10, P12 |
|  |  |

Based on the responses in this section, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For HD-FDD, the following performance impacts should be captured in the TR according to at least half of the 18 responses to Q 7.4.3-2.   * P1: No coverage loss * P2: Lower power consumption, lower maximum power peaks, lower power state, or lower insertion loss * P3: Lower noise figure * P4: Lower (peak) data rates or throughput * P7: No impact on spectral efficiency or capacity * P9: Negative impact on latency   Proposal 7.4.3-1:   * For HD-FDD, at least the following performance impacts can be captured in the TR.   + P1: No coverage loss   + P2: Lower power consumption, lower maximum power peaks, lower power state, or lower insertion loss   + P3: Lower noise figure   + P4: Lower (peak) data rates or throughput   + P7: No impact on spectral efficiency or capacity   + P9: Negative impact on latency |
| **Company** | **Comments** |
| vivo | We are wondering whether P7 is true? HD-FDD will have scheduling restriction to gNB which likely cause some system performance loss. |
| Samsung | We don’t agree on P4. It depends on the traffic and how to define（peak）data rates and throughput. |
| OPPO | We don’t agree on P7. HD-FDD will have impact on system efficiency. |
| Qualcomm | When Type-A HD-FDD is supported, we agree with P1/P2/P3/P7. |
| Xiaomi | We are fine with FL proposal, but hope P12 can be additionally captured to complete the analysis of impact on latency. |
| Huawei, HiSilicon | Except for P1, P2, P3, P7.  There would be coverage loss for HD-FDD compared with FD-FDD.  Seems different aspects are covered in P2/P3. There is also different view on whether there is power consumption benefits due to short/long transmission time as discussed in P6 in 7.5.3 and P10 in Q 7.5.3-2.  P7 concerning SE/capacity is important aspect that need to be captured in the TR but the observation in P7 needs more verification (similar to vivo analysis). |
| SONY3 | This seems to be reasonable set of aspects (KPIs) to capture in the TR, but there needs to more analysis of most of these points. |
| Ericsson | We are fine with the FL proposal. |
| Sierra Wireless | We agree with P1,P2,P3,P7.  P2 the “or” should be an “and”.  P4 should not be included. In bidirectional traffic use cases HD-FDD would have a lower peak data rate compared to FD-HDD but it would have similar peak rates compared to TDD.  P9 is not true for type A HD-FDD UEs since latency measurements (e.g. Ping) have no need for bi-directional traffic. |
| FUTUREWEI\* | We cannot only include perceived benefits (~5-10% cost reduction) without the drawbacks. Compared to FDD, there will some latency and peak data rate impacts (P4,P9). P1 and P7 we can see next time if people want to check. |
| Intel | Fine with the proposal, but we think P11 would be more appropriate compared to P7, under the assumption that switching gaps are not significantly long compared to typical scheduling time granularity for Type A HD-FDD UEs. |
| FL5 | Several responses express concerns with P7. For the other bullets, only one or two responses have concerns.  Proposal 7.4.3-1-v2:   * For HD-FDD, at least the following performance impacts can be captured in the TR in the next meeting.   + P1: No coverage loss   + P2: Lower power consumption, lower maximum power peaks, lower power state, or lower insertion loss   + P3: Lower noise figure   + P4: Lower (peak) data rates or throughput   + ~~P7: No impact on spectral efficiency or capacity~~   + P9: Negative impact on latency |
| OPPO | Agree |
| FUTUREWEI | OK. If concern on P1 can wait for that one for next time. |
| vivo | Fine |
| Huawei, HiSilicon | Not fine with P1/P2/P3. P1 is itself not correct or needs conditions to hold. P2 mixes several aspects that are unclear if they are targets. Similar issue with P3. |
| Samsung | Fine with the proposal.  We don’t see issue for P1/P2/P3. We drew the same conclusion in LTE TR 36.888. 6.6.2.1 Coverage analysis Half duplex operation will result in no loss of coverage. ……  The noise figure of a switch-based receiver RF chain is less than that of a duplexer-based receiver RF chain, allowing HD-FDD UE receivers to be more sensitive than FD-FDD UE receivers. In summary the downlink coverage of an HD-FDD UE is expected to be at least as good as that of an FD-FDD UE. 6.6.2.2 Power consumption Compared to the reference category 1 LTE modem, power consumption is likely to be reduced. |
| MediaTek | Support |
| Ericsson | We are fine with the proposal. |
| FL6 | Proposal 7.4.3-1-v2:   * For HD-FDD, at least the following performance impacts can be captured in the TR in the next meeting.   + P1: No coverage loss   + P2: Lower power consumption, lower maximum power peaks, lower power state, or lower insertion loss   + P3: Lower noise figure   + P4: Lower (peak) data rates or throughput   + ~~P7: No impact on spectral efficiency or capacity~~   + P9: Negative impact on latency |
|  |  |

### 7.4.4 Analysis of coexistence with legacy Ues

Contributions [1, 2, 3, 5, 7, 17, 25] analyze coexistence impacts. The identified issues are listed below.

* C1: significant impact on network [2]
* C2: make scheduler more complex [3]
* C3: need to monitor PI/CI to ensure coexistence with URLLC Ues [7]

Contributions [1, 5, 17, 25] conclude that the impact can be minimal or do not raise a concern.

**Q 7.4.4-1: Does the list above (C1, C2, C3) capture the most important coexistence impacts that need to be considered for HD-FDD? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | Y |  |
| Ericsson | Y |  |
| Spreadtrum | Y |  |
| ZTE,Sanechips | N | C4= ‘no significant impact’ |
| Samsung | N | May have co-existence issue with legacy UE due to switching time from PRACH to Msg2, depending on the configuration and gap.  C1 to C3 need to be further discussed |
| Huawei, HiSilicon | Y |  |
| TIM |  | Coexistence is of utmost importance. Simulations results may be beneficial. |
| Sequans | Yes |  |
| Lenovo, Motorola Mobility | Y |  |
| Nokia, NSB | Y |  |
| MediaTek | Y |  |
| Qualcomm | N | None is well justified. |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | N | We don’t think there are important coexistence impacts related to HD-FDD support. Scheduling issues may be further clarified after switching times of HD-FDD type A (or type B) are defined. |
| SONY | Y |  |
| InterDigital | Y |  |
|  |  |  |

**Q 7.4.4-2: Which of the identified coexistence impacts in the list above (C1, C2, C3) are the most critical ones to be captured in TR 38.875 for HD-FDD?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Example | C1, C2 |
| FUTUREWEI | C1, C2 should be included. Not sure about C3. |
| Ericsson | Possibly C2. However, if it is done properly, the impact on scheduler might be minor. |
| Sierra Wireless | C2 |
| ZTE,Sanechips | C2 |
| Xiaomi | None |
| Huawei, HiSilicon | All |
| Sequans | C1, C2, FFS for C3 |
| Lenovo, Motorola Mobility | Possibly C2. |
| Intel | None (under the assumption that switching gaps are not significantly long compared to typical scheduling time granularity) |
| Nokia, NSB | C2 |
| MediaTek | Agree with Ericsson. |
| Qualcomm | Minor impacts on scheduler |
| CATT | C2 |
| DOCOMO | C1, C2 |
| LG | C2 |
| SONY | C3. In order to be able to coexist with a URLLC UE, the Redcap UE needs to be able to cancel its ongoing UL transmission. |
| InterDigital | Minor impact on scheduler. |
|  |  |

Based on the responses in this section, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For HD-FDD, the following coexistence impact should be captured in the TR according to at least half of the 17 responses to Q 7.4.4-2.   * C2: Makes scheduler more complex   Proposal 7.4.4-1:   * For HD-FDD, at least the following coexistence impact can be captured in the TR.   + C2: Makes scheduler more complex |
| **Company** | **Comments** |
| vivo | Fine with the proposal. |
| Samsung | We don't see much negative impact for scheduler. In Rel-15 design, we think RAN 1 spec can almost support HD-FDD, as well as for LTE. |
| OPPO | ok |
| Qualcomm | OK in general |
| Xiaomi | As commented earlier, we do not think the coexistence impacts need to be captured in the TR. |
| Huawei, HiSilicon | Fine. |
| SONY3 | We don’t support this proposal. This is a coexistence section and what we are saying is that scheduler implementation will be more complex, which isn’t a coexistence issue in the first place. The proposal then ignores some issues that are actual coexistence issues, e,g, that an HD-FDD UE cannot coexist with a URLLC UE because the HD-FDD UE cannot cancel its UL transmission as it cannot receive UL CI (cancelation indicator).  Our view is that the coexistence section should prioritise description of any coexistence issues. If there is any additional text on implementation complexity / restriction on configuration, then that’s a bonus. But let’s describe coexistence issues first. |
| Ericsson | Fine |
| Sierra Wireless | Do not support the proposal for reasons Samsung mentions. |
| CATT | Agree with the proposal. |
| Intel | Fine with the proposal |
| LG | Fine with the proposal. |
| FL5 | No clear consensus in this meeting |

Furthermore, the following can be considered.

|  |  |
| --- | --- |
| FL3 | The following additional potential coexistence impact was identified in the responses to Q 7.4.4-1.   * C4: Potential coexistence issue due to switching time from PRACH to Msg2   Question 7.4.4-3:   * Should C4 be captured in the TR as a coexistence impact for HD-FDD? |
| **Company** | **Comments** |
| Samsung | Support to capture this as least for HD-FDD type B. |
| Qualcomm | NO for Type-A HD-FDD |
| Xiaomi | We prefer to first identifying the value of the switching time from RAN4. |
| Huawei, HiSilicon | Fine. |
| SONY3 | Not a priority since we think this is only an issue for Type B and we think that Type B won’t be supported anyway (FFS). |
| Ericsson | Agree with Samsung |
| Sierra Wireless | No for Type-A HD-FDD. |
| CATT | Agree with Samsung. |
| LG | NO, why should the “potential” impact be captured? We need a further study. |
| FL5 | No clear consensus in this meeting |

## 7.5 Relaxed UE processing time

### 7.5.3 Analysis of performance impacts

Contributions [1, 2, 3, 4, 5, 6, 8, 11, 13, 16, 17, 20, 27, 29, 31] analyze the performance impact if relaxed UE processing time is introduced for RedCap Ues. The findings are listed below.

**Latency:**

* P1: Contributions [1, 2, 5, 8, 11, 13, 20, 27] mentioned the impact of relaxed UE processing time capability on latency, where [1, 5] provide some numerical examples of the impact on UL and DL latency for the initial transmission and different number of retransmissions.
* P2: Contributions [1, 2, 4, 16, 20, 27, 29, 31] observe that many RedCap use cases have rather relaxed latency requirements of up to 100 ms or 500 ms and thus can afford to have more relaxed UE processing time if the trade-off between cost reduction benefits and impacts is justified.
* P3: It is mentioned in several contributions [1, 2, 3, 8, 20, 27] that for some use cases such as safety-related sensors, rather strict latency may be required, and a more relaxed UE processing may not be feasible.
* P4: Contribution [13] discusses an implication of relaxed UE processing time on latency which can lead to having different hardware variants for RedCap Ues.

**Scheduling flexibility/complexity:**

* P5: Contributions [1, 2, 8, 17] observe negative impacts of relaxed UE processing time on scheduling complexity, especially when taking into account different scheduling timing requirements related to N1/N2 and the fact that there already exist two UE processing time capabilities in NR.

**Data rate:**

* P6: Contributions [2, 3] mention that sustained data rate may be impacted due to longer HARQ RTT because of the relaxed UE processing time.

**Coverage:**

* P7: Contributions [3, 6, 17] note that no significant coverage impact is expected from a more relaxed UE processing time.

**Spectral efficiency/network capacity:**

* P8: Contributions [6, 17] note that no impact on spectral efficiency or network capacity is expected since gNB can schedule other Ues during the UE processing time.

**Power consumption:**

* P9: Contributions [2, 4, 16, 29, 31] mentioned that power saving benefit can be obtained from relaxed UE processing time, particularly from cross-slot scheduling which may lower UE’s working voltage and avoiding unnecessary data buffering.
* P10: Contributions [1, 5, 6, 20, 27] noted that the UE power saving gain may not be clear or may even be degraded as UE may need to stay active longer due to more relaxed UE processing time, and that it may also depend on specific implementation.
* P11: Contribution [1] notes that cross-slot scheduling can be supported by gNB implementation without the need to introduce a more relaxed UE processing time capability.

**Q 7.5.3-1: Does the list (P1, P2, …, P11) above capture the most important performance impacts that need to be considered for relaxed UE processing time? If not, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | N | For cross-slot scheduling, need to state there is no real impact to latency, scheduling, data rate, coverage, spectral efficiency. Plus P9,11 |
| Ericsson | Y |  |
| Sierra Wireless | Y |  |
| Spreadtrum | Y |  |
| ZTE,Sanechips | Y |  |
| vivo |  | For latency: the latency requirement is use case dependent, so both P2 and P3 can be true in different scenarios  For scheduling: we think gNB should be able to manage different scheduling timelines.  For data rate: there should be no problem if we do not consider lower than the LTE processing capability  Coverage: agree with P7  Spectrum efficiency/capacity: agree with P8  Power consumption: agree with P9  In addition to above, another possibility is that we do not lower the UE capability, i.e. UE still capable of Cap#1 timeline, but network can configure the UE with slower timeline to achieve power saving gain. |
| Samsung |  | To align whether to add coverage analysis with other features.  Some in the above list need to be further discussed. |
| OPPO | Y |  |
| CMCC | Y |  |
| Huawei, HiSilicon | Y |  |
| TIM |  | LLS and SLS may be beneficial to understand impacts on the above parameters/KPI |
| Sequans | Yes |  |
| Lenovo, Motorola Mobility | Y |  |
| Nokia, NSB | N |  |
| MediaTek | Y |  |
| Qualcomm | Y |  |
| CATT | Y |  |
| DOCOMO | Y |  |
| LG | Y |  |
| SONY | Y |  |
|  |  |  |

**Q 7.5.3-2: Which of the identified performance impacts in the list above (P1, P2, …, P11) are the most critical ones to be captured in TR 38.875 for relaxed UE processing time?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Example | P1, P2 |
| FUTUREWEI | For e.g. doubling N1/N2:  Should include: P3, P4, P5, P6, P10  No strong feeling:P1, P2, P7  Should not include:P8 (scheduling may need to be more conservative), P9 (as P10 is correct)  For cross-slot scheduling: P9, P11 |
| Ericsson | P1-P11 |
| Sierra Wireless | P1, P3, P4, P5, P6, P7, P10 |
| Spreadtrum | P1, P2, P3, P10 |
| ZTE,Sanechips | P1, P2, P3, P5, P9,P10 |
| vivo | P2/7/8/9 |
| Samsung | P1, P3, P5, P8, P10 |
| OPPO | P2/7/8/9 |
| CMCC | P1, P2, P3, P5 |
| Huawei, HiSilicon | Can be further studied. |
| Sequans | P1-P6, P10 |
| Lenovo, Motorola Mobility | P2, P6, P7, P8, P10, P11 |
| Intel | P2, P3, P6, P7, P9, P11.  On P5: The additional scheduler complexity compared to all the different minimum processing times and various conditions and margins we have is negligible.  On P10: To properly evaluate the net effect, potential updates to the power consumption model would be necessary to factor lower power consumption from reduced demands on parallelization, working voltage, and chip area. |
| Nokia, NSB | P1-P4, P6, P7, P8, P10 |
| MediaTek | P1-P6 |
| Qualcomm | P2, P3, P6, P7, P9, P10, P11 |
| CATT | P1, P7, P8 |
| DOCOMO | P1, P2, P3, P5, P6, P7, P8 |
| LG | P1, P2, P7, P8, P9 |
|  |  |

Based on the responses in this section, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For relaxed UE processing time, the following performance impacts should be captured in the TR according to at least half of the 19 responses to Q 7.5.3-2.   * P1: Impact of relaxed UE processing time capability on latency, e.g. for the initial transmission and different number of retransmissions. * P2: Many RedCap use cases have rather relaxed latency requirements of up to 100 ms or 500 ms and thus can afford to have more relaxed UE processing time if the trade-off between cost reduction benefits and impacts is justified. * P3: For some use cases such as safety-related sensors, rather strict latency may be required, and a more relaxed UE processing may not be feasible. * P6: Sustained data rate may be impacted due to longer HARQ RTT because of the relaxed UE processing time. * P7: No significant coverage impact is expected from a more relaxed UE processing time. * P9: Power saving benefit can be obtained from relaxed UE processing time, particularly from cross-slot scheduling which may lower UE’s working voltage and avoiding unnecessary data buffering. * P10: The UE power saving gain may not be clear or may even be degraded as UE may need to stay active longer due to more relaxed UE processing time, and that it may also depend on specific implementation.   Proposal 7.5.3-1:   * For relaxed UE processing time, at least the following performance impacts can be captured in the TR.   + P1: Impact of relaxed UE processing time capability on latency, e.g. for the initial transmission and different number of retransmissions.   + P2: Many RedCap use cases have rather relaxed latency requirements of up to 100 ms or 500 ms and thus can afford to have more relaxed UE processing time if the trade-off between cost reduction benefits and impacts is justified.   + P3: For some use cases such as safety-related sensors, rather strict latency may be required, and a more relaxed UE processing may not be feasible.   + P6: Sustained data rate may be impacted due to longer HARQ RTT because of the relaxed UE processing time.   + P7: No significant coverage impact is expected from a more relaxed UE processing time.   + P9: Power saving benefit can be obtained from relaxed UE processing time, particularly from cross-slot scheduling which may lower UE’s working voltage and avoiding unnecessary data buffering.   + P10: The UE power saving gain may not be clear or may even be degraded as UE may need to stay active longer due to more relaxed UE processing time, and that it may also depend on specific implementation. |
| **Company** | **Comments** |
| vivo | We doubt whether P6 is true in all the cases, some detailed analysis is necessary before capturing P6.  P9 and P10 are contradictive to each other, we need more discussion. |
| Samsung | We don’t agree with P2, we think the processing time can be relaxed after initial access by, e.g., cross slot scheduling or by configure a larger feedback time. There is no need to introduced relaxed process time capability to achieve it.  For P9, we don’t think cost reduction and UE power saving can be achieved in the same time. We think P9 can be only achieved with same process capability but relax the processing time by gNB for power saving.  In addition, we like to capture P5 in the TR,  P5: Contributions [1, 2, 8, 17] observe negative impacts of relaxed UE processing time on scheduling complexity, especially when taking into account different scheduling timing requirements related to N1/N2 and the fact that there already exist two UE processing time capabilities in NR. |
| Spreadtrum | Fine with the proposal |
| Huawei, HiSilicon | OK with P7 in general, with the understanding that observations can be updated later under the agreed assumption of doubling the timeline requirement, if needed. |
| SONY3 | The list is OK. Again, we see this as a list of aspects (KPIs) that can eventually be captured in the TR: see comment to question 7.2.3-2 |
| Ericsson | P1, P2, P3, P6, P7, and P10 are fine. Agree with Samsung on P9. |
| Sierra Wireless | Agree with P1, P6, P7, P10  P2/P3 is not a performance impact – it’s a  use case requirement.  P9 is describing the benefit from Cross slot, not the benefit of relaxed UE processing. |
| FUTUREWEI\* | P9 and 10 are contradictory.  We agree with Samsung on P5. |
| CATT | Fine with the proposal except for P9. Cross-slot scheduling can be achieved w/o relaxed UE processing time. |
| Intel | Fine with all except P9 and P10 – these, as pointed out by vivo, sound contradictory, and more fine-tuning would be needed. Also, for P10, we do not agree we need to highlight cross-slot scheduling part, there could be power savings by appropriate trade-off between processing demands (clock rate, parallelization, etc.) and processing latency (time spent in processing). So, in this regard, Samsung’s comment is not entirely accurate that complexity and power consumption reduction cannot both be realized. |
| FL5 | Most responses expressed concerns with P9. For other bullets, only one or two responses had concerns.  Proposal 7.5.3-1-v2:   * For relaxed UE processing time, at least the following performance impacts can be captured in the TR in the next meeting.   + P1: Impact of relaxed UE processing time capability on latency, e.g. for the initial transmission and different number of retransmissions.   + P2: Many RedCap use cases have rather relaxed latency requirements of up to 100 ms or 500 ms and thus can afford to have more relaxed UE processing time if the trade-off between cost reduction benefits and impacts is justified.   + P3: For some use cases such as safety-related sensors, rather strict latency may be required, and a more relaxed UE processing may not be feasible.   + P6: Sustained data rate may be impacted due to longer HARQ RTT because of the relaxed UE processing time.   + P7: No significant coverage impact is expected from a more relaxed UE processing time.   + ~~P9: Power saving benefit can be obtained from relaxed UE processing time, particularly from cross-slot scheduling which may lower UE’s working voltage and avoiding unnecessary data buffering.~~   + P10: The UE power saving gain may not be clear or may even be degraded as UE may need to stay active longer due to more relaxed UE processing time, and that it may also depend on specific implementation. |
| OPPO | P10 shall be removed, further studied is needed. |
| FUTUREWEI | OK. If concerns and some of these start to disappear we can wait for next time and get a fuller picture. P10 could be left with an FFS so it is clearly to be resolved. |
| vivo | P6 should not be captured without quantitative analysis, it depends on how long the HARQ RTT is assumed. P10 should also be studied before conclude.  Fine wither other bullets except P6/P10. |
| Huawei, HiSilicon | Can live with it assuming we may update it with the newly agreed doubled timeline requirement. |
| Samsung | Paste the same answer as before:  **We don’t agree with P2,** we think the processing time can be relaxed after initial access by, e.g., cross slot scheduling or by configure a larger feedback time. There is no need to introduced relaxed process time capability to achieve it.  In addition, we like to capture P5 in the TR,  P5: Contributions [1, 2, 8, 17] observe negative impacts of relaxed UE processing time on scheduling complexity, especially when taking into account different scheduling timing requirements related to N1/N2 and the fact that there already exist two UE processing time capabilities in NR. |
| MediaTek | We fine in general, however, we want to leave P7 for next meeting to investigate if the is any impact on the gap between the repetitions for the PDSCH corresponding to SI-RNTI, which is currently based on Cap#1:  Section 5.1 in TS38.214 “*In a given scheduled cell, for any PDSCH corresponding to SI-RNTI, the UE is not expected to decode a re-transmission of an earlier PDSCH with a starting symbol less than N symbols after the last symbol of that PDSCH, where the value of N depends on the PDSCH subcarrier spacing configuration µ, with N=13 for µ =0, N=13 for µ =1, N=20 for µ =2, and N=24 for µ =3*”  Also, we agree with P5 highlighted by Samsung. |
| Ericsson | We are fine with the proposal. We are also fine to add ‘FFS’ for the bullets pointed out in the above comments from other companies (P2, P6, P7, P10). |
| FL6 | Proposal 7.5.3-1-v3:   * For relaxed UE processing time, at least the following performance impacts can be captured in the TR in the next meeting.   + P1: Impact of relaxed UE processing time capability on latency, e.g. for the initial transmission and different number of retransmissions.   + P2: FFS: Many RedCap use cases have rather relaxed latency requirements of up to 100 ms or 500 ms and thus can afford to have more relaxed UE processing time if the trade-off between cost reduction benefits and impacts is justified.   + P3: For some use cases such as safety-related sensors, rather strict latency may be required, and a more relaxed UE processing may not be feasible.   + P6: FFS: Sustained data rate may be impacted due to longer HARQ RTT because of the relaxed UE processing time.   + P7: FFS: No significant coverage impact is expected from a more relaxed UE processing time.   + ~~P9: Power saving benefit can be obtained from relaxed UE processing time, particularly from cross-slot scheduling which may lower UE’s working voltage and avoiding unnecessary data buffering.~~   + P10: FFS: The UE power saving gain may not be clear or may even be degraded as UE may need to stay active longer due to more relaxed UE processing time, and that it may also depend on specific implementation. |
|  |  |

Furthermore, the following can be considered.

|  |  |
| --- | --- |
| FL3 | The following additional potential performance impacts were identified in the responses to Q 7.5.3-1.   * P12: The NW can configure RedCap UEs to achieve power saving gain even if no relaxed UE processing time capability is defined. * P13: There is no real impact on latency, scheduling, data rate, coverage, and spectral efficiency from cross-slot scheduling.   Question 7.5.3-2:   * Which ones, if any, of P12 and P13 should be captured in the TR as performance impacts for relaxed UE processing time? |
| **Company** | **Comments** |
| vivo | Not sure what is the intention of P12, we can have multiple ways to achieve power saving, but in most cases they are not mutually exclusive. |
| Samsung | We support P12 more than P9.  We don’t support p13 since we think there will have some impact on latency, at least for initial access. But we wonder, is P13 for relaxed UE processing capability or for cross-slot scheduling? |
| OPPO | Support P13 |
| Huawei, HiSilicon | FFS |
| SONY3 | Neither to be captured.  P12: agree with the vivo comment. Isn’t P12 a fairly obvious statement?  P13: not sure we agree that cross-slot scheduling has no real impact on latency and scheduling. If PDCCH in slot ‘n’ schedules PDSCH in slot ‘n + 1’, then hasn’t the latency increased by 1 slot compared to same-slot scheduling? |
| Ericsson | Support P12. |
| Sierra Wireless | Do not support P13 for reasons Sony mentioned. |
| FUTUREWEI\* | P13 is OK, the point was that cross-slot scheduling is also related to processing time so can analyse it. Will anyway be considered in the power saving. |
| CATT | We support P12. |
| Lenovo, Motorola Mobility | Support P12. |
| Intel | We agree with Vivo – P12 is not a clear observation; certainly there can be other PS features, that does not seem like a relevant observation at all. |
| FL5 | Only a few responses expressed support for including P12 or P13. |
| Huawei, HiSilicon | Can wait for the next meeting. |

### 7.5.4 Analysis of coexistence with legacy Ues

Some contributions [1, 5, 17, 21] observe that there can be potential coexistence issues with legacy Ues during initial access/random access if a new, more relaxed UE processing time capability is introduced. For example, there exist the timing requirement for scheduling of Msg3 which depends on N1 and N2 values of UE processing time capability #1. If gNB schedules according to legacy Ues, RedCap Ues with relaxed N1/N2, if supported, may not be able to access the cell. On the other hand, if gNB considers potential presence of Ues with relaxed processing time in a cell, it would schedule according to the worst-case timing which would degrade the performance of legacy Ues. Contribution [3] notes that multiple timelines can be very complicated to specify and handle to ensure coexistence with legacy Ues.

In order to support relaxed UE processing time capability during initial access, contributions [5, 12, 21] mention that methods for identifying RedCap Ues, e.g., before Msg3 scheduling may need to be studied.

These identified issues are listed below.

* C1: makes scheduler more complex [1, 5, 17, 21]
* C2: complicated to specify and handle to ensure coexistence with legacy Ues [3]
* C3: identification of RedCap Ues before Msg3 may be needed [5, 12, 21]

**Q 7.5.4-1: Is the list of identified coexistence issues to study for relaxed UE processing time in terms of N1/N2 correct and complete? If not, what changes to the list are needed?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| FUTUREWEI | OK |
| Ericsson | Yes |
| Sierra Wireless | Yes |
| ZTE,Sanechips | Y |
| vivo | We agree that C3 would need to be discussed if lower processing capability UE is introduced. |
| Samsung | OK. |
| OPPO | Y |
| CMCC | Yes |
| TIM | Coexistence analysis is of utmost importance and simulation results may also be beneficial. |
| Huawei, HiSilicon | Y |
| Sequans | Yes |
| Lenovo, Motorola Mobility | Yes |
| Intel | Yes to C1 and C3. Do not agree to C2 in general.  Also, this statement is misleading “On the other hand, if gNB considers potential presence of Ues with relaxed processing time in a cell, it would schedule according to the worst-case timing which would degrade the performance of legacy Ues.” By this logic, Cap #2 is a useless feature as long as there is a single Cap #1-only UE in the system. |
| Nokia, NSB | Y |
| MediaTek | Y |
| Qualcomm | Yes |
| CATT | Y |
| DOCOMO | Y |
| LG | Yes |
|  |  |

**Q 7.5.4-2: Which of the identified coexistence issues in the list above (C1, C2, C3) are the most critical ones to be captured in TR 38.875 for relaxed UE processing time in terms of N1/N2?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Example | C1 |
| FUTUREWEI | Should include C1 and C2. C3 may be ok, FFS. |
| Ericsson | C1-C3 |
| Sierra Wireless | C1, C2, C3 |
| ZTE,Sanechips | C1, C3 |
| vivo | C3 |
| Samsung | C1, C3 |
| OPPO | C3 |
| CMCC | C1,C3 |
| Huawei, HiSilicon | all |
| Sequans | C1-C3 |
| Lenovo, Motorola Mobility | C1, C3 |
| Intel | C1, C3 |
| Nokia, NSB | C1, C2, C3 |
| MediaTek | C1,C2,C3 |
| Qualcomm | C1, C3. FFS C2. |
| CATT | C1, C3 |
| DOCOMO | C1, C3 |
| LG | C3 |
|  |  |

Based on the responses in this section, the following can be considered.

|  |  |
| --- | --- |
| FL3 | For relaxed UE processing time, the following coexistence impact should be captured in the TR according to at least half of the 18 responses to Q 7.5.4-2.   * C1: Makes scheduler more complex * C3: Identification of RedCap UEs before Msg3 may be needed   Proposal 7.5.4-1:   * For relaxed UE processing time, at least the following coexistence impacts can be captured in the TR.   + C1: Makes scheduler more complex   + C3: Identification of RedCap UEs before Msg3 may be needed |
| **Company** | **Comments** |
| vivo | C1 maybe true but gNB should already be able to handle the case when both Cap#1 and Cap#2 UEs exist in an cell, this is not a new situation.  C3 is dependent on the detailed discussion on how UE processing timeline is relaxed, one possibility is that UE operates Cap#1 timeline during initial access since the amount of data to be processed during the initial access is small. Even though we allow the UE to relax processing timeline already during initial access, network can use a slower scheduling timeline for all the UEs so that no need for early identification. |
| Samsung | OK. |
| OPPO | ok |
| Qualcomm | Agree |
| Huawei, HiSilicon | Ok with C1 with adding a “May” |
| SONY3 | We don’t see C1 as a coexistence issue |
| Ericsson | Support capturing only C1 |
| Sierra Wireless | We agree with the proposal |
| FUTUREWEI\* | C1 is a coex issue, handling multiple processing makes scheduler more complex.  Not sure yet with C3, prefer to think about it more. |
| CATT | Fine with the proposal. |
| Lenovo, Motorola Mobility | Fine with the proposal. |
| LG | We are OK with the proposal. |
| FL5 | Only one or two responses expressed concerns with C1 or C3. One response proposed to add “may” in C1.  Proposal 7.5.4-1-v2:   * For relaxed UE processing time, at least the following coexistence impacts can be captured in the TR in the next meeting.   + C1: May make scheduler more complex   + C3: Identification of RedCap UEs before Msg3 may be needed |
| OPPO | Ok in general |
| FUTUREWEI | OK |
| vivo | If C3 is to be captured, the following change should be made  C3: Identification of RedCap UEs before Msg3 may be needed if relaxed UE processing time is applicable before Msg3. |
| Huawei, HiSilicon | C3 can be postponed. It relates to the discussion in other sessions including identification, UE type etc. |
| Samsung | We are fine with FL 5.  For vivo’s update, if the relaxed UE processing time is not applicable before Msg 3. We don’t think this relaxed UE processing time can be supported. In our understanding, what we discuss here is from UE capability point of view, other than relax processing time after initial access, which is basically for UE power saving given a UE capability.  To make it more clear, we suggest to further update C3 as below.  C3: Identification of RedCap UEs before Msg3 may be needed since relaxed UE processing time needs to be applicable before Msg3. |
| MediaTek | We support the proposal.  We don’t agree with the update from vivo (for similar reasons explained by Samsung). |
| Ericsson | We are fine with the proposal. We would also be fine with inserting an ‘FFS’ for C3 to address the comments above from other companies. |
| FL6 | Proposal 7.5.4-1-v3:   * For relaxed UE processing time, at least the following coexistence impacts can be captured in the TR in the next meeting.   + C1: May make scheduler more complex   + C3: FFS: Identification of RedCap UEs before Msg3 may be needed |
|  |  |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [R1-2005234](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005234.zip) | Potential UE complexity reduction features for RedCap | Ericsson |
| [2] | [R1-2005269](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005269.zip) | Potential UE complexity reduction features | Huawei, HiSilicon |
| [3] | [R1-2005277](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005277.zip) | Complexity reduction features for RedCap UEs | FUTUREWEI |
| [4] | [R1-2005383](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005383.zip) | Discussion on complexity reduction for Reduced Capability NR devices | vivo, Guangdong Genius |
| [5] | [R1-2005474](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005474.zip) | Potential UE complexity reduction features | ZTE |
| [6] | [R1-2005525](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005525.zip) | UE complexity reduction features | Nokia, Nokia Shanghai Bell |
| [7] | [R1-2005580](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005580.zip) | On potential complexity reduction techniques for NR devices | Sony |
| [8] | [R1-2005637](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005637.zip) | On complexity reduction features for NR RedCap UEs | MediaTek Inc. |
| [9] | [R1-2005714](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005714.zip) | Discussion on potential UE complexity reduction features | CATT |
| [10] | [R1-2005770](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005770.zip) | Potential UE complexity reduction features | TCL Communication Ltd. |
| [11] | [R1-2005830](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005830.zip) | On UE complexity reduction features for RedCap | Lenovo, Motorola Mobility |
| [12] | [R1-2005880](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005880.zip) | On complexity reduction for RedCap UEs | Intel Corporation |
| [13] | [R1-2005937](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005937.zip) | Reduced Capability UE Complexity Reduction Features | Sierra Wireless, S.A. |
| [14] | [R1-2005959](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005959.zip) | Rel-16 UE power saving features for RedCap | NEC |
| [15] | [R1-2005968](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005968.zip) | Discussion on the complexity reduction for reduced capability device | Beijing Xiaomi Software Tech |
| [16] | [R1-2006036](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006036.zip) | Discussion on UE complexity reduction | OPPO |
| [17] | [R1-2007031](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2007031.zip) | UE complexity reduction | Samsung |
| [18] | [R1-2006196](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006196.zip) | Discussion on potential UE complexity reduction features | Panasonic Corporation |
| [19] | [R1-2006217](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006217.zip) | Discussion on potential UE complexity reduction features | CMCC |
| [20] | [R1-2006272](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006272.zip) | Discussion on potential UE complexity reduction features | Spreadtrum Communications |
| [21] | [R1-2006306](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006306.zip) | Discussion on potential UE complexity reduction features | LG Electronics |
| [22] | [R1-2006524](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006524.zip) | UE Complexity Reduction Features for RedCap | Apple |
| [23] | [R1-2006538](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006538.zip) | Complexity reduction features for reduced capability NR devices | InterDigital, Inc. |
| [24] | [R1-2006542](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006542.zip) | On impacts of UE bandwidth reduction | Quectel |
| [25] | [R1-2006576](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006576.zip) | Discussion on Potential UE complexity reduction features | Sharp |
| [26] | [R1-2006644](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006644.zip) | Discussion on potential UE complexity reduction features | Asia Pacific Telecom co. Ltd |
| [27] | [R1-2006682](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006682.zip) | Complexity reduction features for RedCap UE | Sequans Communications |
| [28] | [R1-2006733](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006733.zip) | Discussion on potential UE complexity reduction features for RedCap | NTT DOCOMO, INC. |
| [29] | [R1-2006811](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006811.zip) | Complexity Reduction for RedCap Devices | Qualcomm Incorporated |
| [30] | [R1-2006988](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006988.zip) | UE Complexity Reduction Features for RedCap | Apple |
| [31] | [R1-2006039](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006039.zip) | Consideration on reduced UE capability | OPPO |
| [32] | [R1-2006155](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006155.zip) | Framework and Principles for Reduced Capability | Samsung |
| [33] | [R1-2006686](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006686.zip) | Framework and principles for RedCap UE | Sequans Communications |
| [34] | [R1-2005934](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005934.zip) | Aspects related to bandwidth reduction | Lenovo, Motorola Mobility |
| [35] | [R1-2005960](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005960.zip) | CBW for RedCap | NEC |