**3GPP TSG RAN meeting #89e RP-20xxxx**

**Electronic Meeting, 14 – 18 Sep., 2020**

**Agenda item:** 9.1.2

**Source:** Moderator (Intel Corporation)

**Title:** Email discussion summary for Rel-17 Demodulation working area [89E][22][RAN4\_R17\_Demod]

**Document for:** Information

# Introduction

In RAN#88e meeting the work areas of RAN4 R17 non-spectrum related WI/SIs was endorsed in [1]. One of the working area is Rel-17 Demodulation. Before RAN#89E, the email discussion for this working area was triggered and the summary was provided in [2].

# Topic #0: Objectives prioritization

## Initial round

### Candidate objectives

**UE Demodulation/CSI (see detailed objectives description in Topic #1)**

* Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
* Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO
* Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
* Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios
* Objective 1-5: Requirements for Rel-15 multi-TRP DPS TX scheme
* Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas
* Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)

**BS Demodulation (see detailed objectives description in Topic #2)**

* Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
* Objective 2-2: BS interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO
* Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
* Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements

**Link adaptation requirements (see detailed objectives description in Topic #2)**

* Objective 3-1: Link adaptation throughput requirements

### Companies views’ collection

Companies are encouraged to provide views on the support and prioritization of the candidate objectives takin into account RAN4 workload and system impacts.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Whether support on proposals | **1-1** | **1-2** | **1-3** | **1-4** | **1-5** | **1-6** | **1-7** | **2-1** | **2-2** | **2-3** | **2-4** | **3-1** | **FR2 4Rx** |
| Verizon | x |  | x |  |  |  |  | x |  | x | x |  | x |
| SoftBank |  |  |  |  |  | x | x |  |  |  |  |  |  |
| Qualcomm | x |  |  |  |  | x |  |  |  |  |  |  | x |
| Samsung | x | X | x |  |  | x | x | x |  | x | x |  |  |
| MTK | x |  |  |  |  | x |  |  |  |  |  |  |  |
| Apple | x | X |  |  |  |  |  |  |  |  |  |  |  |
| China Telecom | x | X | x | x |  |  |  | x |  | x | x |  |  |
| CMCC | x | X | x |  |  |  |  | x |  |  | x |  |  |
| ZTE | x |  |  | x |  |  |  | x |  |  |  |  | x |
| Ericsson | x |  | x |  |  |  | x | x |  |  | x |  |  |
| KDDI |  |  |  |  |  |  | x |  |  |  |  |  |  |
| ORANGE | x | x | x | x |  |  |  | x | x | x |  |  |  |
| Intel | x |  | x | x | x |  |  | x |  |  | x |  |  |
| Nokia | x |  |  |  |  |  |  |  |  |  | x |  |  |
| Vodafone | x |  |  |  |  |  |  |  |  |  |  |  |  |
| Huawei | x | x | x |  |  |  | x | x |  |  | x |  |  |
| NTT DOCOMO, INC | x |  |  |  |  |  | x | x |  |  | x |  |  |
| Note: Please use “x” to indicate the support on proposals.  *Moderator: added Vodafone preference based on comments for UE demodulation work area* | | | | | | | | | | | | | |

Companies are encouraged to provide additional comments (if any) on the support and prioritization of the candidate objectives in the table below:

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| --- | --- |
| **Company** | **Comments** |
| SoftBank | 1-7 has the highest priority for us. |
| QC | In addition to the opinion collection in the above table, the technical comments/discussions should be taken into consideration when deciding prioritization/scope of R17 demod objectives. |
| MTK | We suggest to conclude on which objectives are included in Rel-17 early. So that we can still have time to fine tune to details in the agreed objective(s) |
| China Telecom | We agree with MTK’s suggestion to conclude on which objectives are included in Rel-17 early. So that we can still have time to fine tune to details in the agreed objective(s). |
| Ericsson | The x subject to objective revisions as discussed above. |
| Samsung | 1)Timeline for this WI if approved: we suggest to start the work after Rel-16 performance part be stable i.e. Q12021 or Q2 2021 pending on the progress on Rel-16 demod requirements. 2) Rel-16 demod leftover topics: if possible, we may need to reopen the discussion on Rel-16 demod leftover topics in Dec RAN-P or March RAN-P 2021. |
| KDDI | 1-7 is requested as high priority item. |
| Nokia, Nokia Shanghai Bell | 1-1: The topic description is mature enough to start work and there is near unanimous support.  2-4: We see this as a higher priority proposal.  With regards to the workload of this WI, the mature UE advanced receiver scenarios and FR1 PUSCH 256QAM should be exclusively prioritized. |
| Huawei | Except for 1-1, 1-2, 1-7 is our high priority. We support the operator request. |
|  |  |

### Summary and recommendation for further discussion

**Summary of views:**

* The following objectives got the most support (>5 supporting companies)
  + UE demodulation / CSI reporting
    - Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
    - Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO
    - Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
  + BS demodulation / CSI reporting
    - Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
    - Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
* The following objectives got medium support (4-5 supporting companies)
  + Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios
  + Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas
  + Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)
  + Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
* Other objectives got less support

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **1-1** | **1-2** | **1-3** | **1-4** | **1-5** | **1-6** | **1-7** | **2-1** | **2-2** | **2-3** | **2-4** | **3-1** | **FR2 4Rx** |
| Total | 14 | 6 | 8 | 4 | 1 | 4 | 5 | 9 | 1 | 4 | 8 |  | 3 |

* WI timelines:
  + One company suggested to discuss WI timelines.
* Rel-16 demodulation leftover topics
  + One company suggested to discuss how to handle the Rel-16 leftovers. Same topic was discussed in the pre-plenary email discussion

**Moderator’s proposal**

* From moderator perspective the WI can fit ~5 objectives (50% of the total number of objectives)
* Propose to select 2-4 candidate objectives for UE demodulation work area and 2 candidate objectives for the BS demodulation based on majority view to ensure reasonable work scope and fair split between UE and BS enhancements.
* **Proposal 1: Prioritize the following candidate UE demodulation/CSI and BS demodulation objectives and include in the WI scope**
  + UE demodulation / CSI reporting
    - Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
    - Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
    - Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO
  + BS demodulation / CSI reporting
    - Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
    - Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
* **Proposal 2: Further discuss in the next round whether any further reduction or extension of objectives is needed.**
* **Proposal 3: Further discuss WI timelines in the next round** 
  + Option 1: start in Q1’20
  + Option 2: start in Q2’20
* **Proposal 4: Further discuss Rel-16 demodulation leftover topics in Dec’20 or March’21 RAN plenary meetings**
* No further discussion on Objective 3-1 and it will be handled in a separate email thread

## Intermediate round

### Companies views’ collection

#### WI objectives prioritization

**Proposal 1: Prioritize the following candidate UE demodulation/CSI and BS demodulation objectives and include in the WI scope**

* UE demodulation / CSI reporting
  + Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
  + Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO
  + Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
* BS demodulation / CSI reporting
  + Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
  + Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements

**Proposal 2: Further discuss in the next round whether any further reduction or extension of objectives is needed.**

Companies are encouraged to provide comments on the proposals

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| --- | --- |
| **Company** | **Comments** |
| MTK | We suggest to keep one single objective in UE demod/CSI and also one single objective in BS demod. We can compromise to 2 objectives for both UE and BS, but we suggest to discuss this in GTW session to sync with chair. |
| Ericsson | Proposal 1:  The scope is still too large. Studying all types of UE receivers would be a huge test. At least objective 1-2 should be removed and 1-1 should be downscoped. |
| NTT DOCOMO, INC | We would like to ask moderator to add NTT DOCOMO, INC as supporting companies for objective 1-1, 1-7, 2-1, 2-4.  Then the number of supporting companies for objective 1-7 is 6, which is the same number of supporting companies for objective 1-2.   * + 1. We would like to include 1-7 in the prioritized candidate objectives. |
| QC | We suggest to keep only one object for UE demod/CSI, as all current candidate involves some study phase to some extent, hence one object is pretty large work load already. |
| China Telecom | We are fine with proposal 1 for the purpose of down-scoping, although some proposals (e.g., 1-4 neighboring cell CRS-IC, which is highly related to our DSS deployment) are rolled out.  Considering the realistic question of how to further down-scope, we have to say we can be fine to remove objective 1-2 SU-MIMO.  For 1-3 MU-MIMO, currently, only MMSE-IRC receiver is kept. So for 1-1 and 1-3, although different scenarios are targeted, the same reference receiver is used. As mentioned by several companies in the 1st round, the major additional work is the MU-MIMO interference modeling. So, we would suggest to keep 1-1 and 1-3 as different scenarios for MMSE-IRC receiver.  For BS side, significant down-scoping has been already done by moderator. In addition, for PUSCH 256QAM, we think it will not take much efforts compared to other proposals for advanced receivers. |
| Apple | On UE side, objective 1-1 is quite stable and agreeable. If 1-2 and 1-3 are included, it should be defined as study phase. 1-3 is more preferable compared with 1-2. |
| Samsung | Regarding the further down scoping, two objectives for UE and BS respectively is a reasonable scope. With that, we agree to keep 1-1 and 1-3 for UE, 2-1 and 2-4 for BS. |
| SoftBank | Given the input from NTT DOCOMO, the moderator’s proposal should be changed, i.e. 1-7 should be included in the prioritized candidate objectives |
| CMCC | On UE side, we support to keep 1-2 and 1-3 for further down-scoping.  On BS side, we support the existing scope of 2-1and 2-4 |
| CATT | For UE demodulation, objective 1-1 seems already agreeable. If additional objective will be include, our preference is 1-3.  For BS demodulation, to include objective 2-1 and 2-4 in scope is acceptable to us. |
| Huawei | Regarding proposal #1 and proposal #2, firstly in our view Objective 1-1 could be merged together with Objective 1-2, because they would all be based on IRC receiver. For Objective 1-2, we think it is very useful to address the performance degradation caused by imbalanced SNR between multiple layers given that one code-word is mapped to multiple layers for NR and under the scenario with 3/4-layer DL transmissions. And we also see the interest from other operators. If other companies cannot accept WI, we can have a study phase and then make decision on whether to specify the requirements or not depending on the outcome of study phase.  Secondly, we would like to include Objective 1-7 to ensure the performance for intra-band non-contiguous EN-DC/CA with non-collocated deployment, which is aligned with other operators’ requests. |
| Intel | Proposal 1 is fine for us. Same time, taking into account that some companies still have concern on work load, we are also fine to keep 1-1 and 1-3, because these scenarios do not require significant study before agreement on requirements definition. |
| ZTE | Object 1-1 should have higher priority than objective 1-2 and 1-3. |

#### WI timelines

Companies are encouraged to further discuss WI timelines in the next round

* Option 1: start in Q1’20
* Option 2: start in Q2’20

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| **Company** | **Comments** |
| MTK | Not sure if there is any TYPO in each option. We are fine to start the WI in Q4’20 or Q1’21. |
| Ericsson | Considering Rel-16 we think earliest Q1-21 |
| QC | The discussion for R17 performance should only start after R16 performance is finished |
| China Telecom | OK with either option 1 or option 2, depending on the progress of R16 performance. Do not hope to bring much high workload for demod people. |
| Apple | We support to start from Q1’21. However, the related work plan can still be discussed in Q4’20 |
| CMCC | Support to start from Q1 2021 |
| CATT | Support to start in Q1’21 given the Rel-16 work. |
| Huawei | We prefer to start the work from Q1 21. We see the availability of TU, and we would like to have more time for Rel-17 demodulation WID.  Regarding proposal #4, we are open. But we should be consistent if this time we put too much limitation on the number of objectives and re-open the door for more in the next RAN meeting. |
| Intel | Both options are fine for us. Option 1 is slightly preferred. Work plan can be discussed in Q4’20. |
| ZTE | If the WID include Rel-16 leftovers, then start from Q1 2021, otherwise, Q2 2021 after Rel-16 leftovers are completed. |

### Summary and recommendation for further discussion

**Summary of views:**

* **Prioritization**
  + UE demodulation
    - Three companies suggested further down-scoping of objectives
    - Six companies are fine to have further scope reduction
    - Five companies mentioned that in case of down-scoping objective 1-2 can be removed
    - Three companies suggested to add objective 1-7 into the scope
  + BS demodulation
    - Scope is stable and no further major suggestions were made
* **Timelines**
  + Q4’20: MTK
  + Q1’21: MTK, E///, CTC, Apple, CMCC, CATT, HW, Intel, ZTE
  + Q2’21: CTC, Intel, ZTE
  + After R16 performance part is finished: QC

**Updated moderator’s proposal after intermediate round**

* **Proposal 1: Prioritize the following candidate UE demodulation/CSI and BS demodulation objectives and include in the WI scope**
  + UE demodulation / CSI reporting
    - Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
    - Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
    - ~~Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO~~
  + BS demodulation / CSI reporting
    - Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
    - Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
* **Proposal 2: Further discuss in the GTW whether any further reduction or extension of objectives is needed.**
* **Proposal 3: RAN4 work shall start in Q1’21**
* **Proposal 4: Further discuss Rel-16 demodulation leftover topics in Dec’20 or March’21 RAN plenary meetings**

## Fine-tuning round

### Companies views’ collection

#### Question 1: UE Demodulation/CSI objectives

Moderator: Recommend to keep Objective 1-1 and further discuss Objective 1-3 till December.

* **Prioritize “Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference” and include in WID.**
* **Do not include Objective 1-3 in the WID and further discuss details till December RAN plenary meeting**

Companies are encouraged to provide comments on the moderator proposal

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| --- | --- |
| **Company** | **Comments** |
| QC | We still prefer to remove objective from R17, but can accept moderator recommendation as a compromise if it has majority support.  For starting time of this WI, we still think it should depend on R16 progress and TU allocation. Deciding Q1’21 now is not practical, we need to decide how many TUs are required for this WI, and how many are available at what time. |
| China Telecom | We still suggest to include objective 1-3 in the WID in this meeting. As mentioned by QC, it has majority support including the support of 4 operators in the initial round.  From the deployment perspective, as mentioned by Orange in the pre-meeting discussion, MU-MIMO pairing opportunity greatly depends on the number of users active at the same time and, thus, on the users’ traffic, it is not possible to always ensure low interference between MU-MIMO users.  Moreover, with more and more UEs transient from LTE to NR, it is a good time to consider MU-MIMO PDSCH requirements in Rel-17.  For the workload, as discussed in Wed’s GTW session, currently only MMSE-IRC receiver is kept for MU-MIMO. So for 1-1 and 1-3, although different scenarios are targeted, the same reference receiver is used. The major additional work due to MU-MIMO is the interference modeling. So, we would suggest to keep 1-1 and 1-3 as different scenarios for MMSE-IRC receiver. |
| Samsung | We agree with QC on the starting time of WI. The Rel-17 Demod enhancement shall be started after completion of Rel-16 performance part.  For objective 1-3 handling, we have slight different view from moderator, we prefer to keep it in the scope considering the majority supporting view. On the detailed description of objective, given the work shall start no earlier than Q1 2021 (if agreed), we agree with moderator that further discussion is definitely needed before the actual works starts. |
| Apple | We support to keep 1-3. Depending on the exact scope, a feasibility study should be conducted first to understand the performance gain and related power consumption/UE complexity impacts. Objective 1-1 represents a small step of enhancement from previous releases.  Regarding the TU plan, we agree that R16 performance part should be prioritized. |
| MTK | Starting time: We are OK to start the WI after R16 perf part completion  Objective 1-3: Moderator’s suggestion is fine to us as a compromise. |
| CMCC | We prefer to keep 1-1 and 1-3. If BS demodulation is down scoped to 1 objective, we can keep these two objectives for UE demod. |
| Ericsson | We support to keep 1-3. For 1-1, we think that there is a need for further discussion on the scenario 1 and 2; see comments in 1.3.1. We think the start should be no earlier than Q1’21; this should be reviewed in December depending on rel-16 progress. |
| CATT | Regarding the timeline, it is reasonable to start the WI after Rel-16 performance completion.  For objective 1-3, we are OK with moderator’s proposal. |
| Intel | We think that objective 1-3 can be included in the WID, because we don’t expect significant workload. One of the main parts is MU-MIMO interference modeling which already under discussion in Rel-16 eMIMO WI.  As for starting time, we are fine to take into account R16 progress and adjust it based on it. |
| ZTE | We support to prioritize Objective 1-1. For Objective 1-3, if there is strong demand from operators, we are fine with including this objective into the WID. For the starting time, it should be after completion of Rel-16 performance. |
| Huawei | We would like to keep both Objective 1-1 and Objective 1-3. I think from UE demodulation performance perspective, all of them belongs to IRC UE performance. They should be merged. |

#### Question 2: BS Demodulation objectives

Moderator: Given that the scope of 256QAM PUSCH is quite limited and also that in the first round both objectives got high support, I’d still suggest to discuss between the following options:

* **Option 1: Keep objective 2-1 only (MMSE-IRC for inter-cell)**
* **Option 2: Keep objective 2-4 only (BS FR1 PUSCH 256QAM)**
* **Option 3: Keep both objectives 2-1 and 2-4**

Companies are encouraged to provide comments on the moderator proposal

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| **Company** | **Comments** |
| Nokia | Option 2 |
| China Telecom | First priority: option 3  Second priority: either option 1 or option 2. |
| Samsung | Option 2 with condition 1-3 is in the scope to make the overall scope reasonable for this WI |
| CMCC | Our first priority is option 3. Among option 1 and option2, we prefer option 2, PUSCH 256QAM is quite straight forward. |
| Ericsson | To keep the overall scope to 3 objectives, we are OK with option 2 for the BS assuming both 1-1 and 1-3 are also adopted. |
| CATT | We are OK with Option 3. Considering BS Demod scope, option 2 is preferred if only one will be identified. |
| Intel | We prefer Option 3, because both items have rather reasonable workload and can be handled within R17 timelines. |
| ZTE | We are fine with Option 3 to include both objective 2-1 and 2-4 in the WID. |
| Huawei | Fine to keep both. Option 3. |

### Topic Summary and recommendation for further discussion

**Summary of views:**

* **Prioritization**
  + UE demodulation
    - Remove objective 1-3 (MMSE-IRC for MU-MIMO): supported by 3 companies (QC, MTK, CATT)
    - Keep objective 1-3: Supported by 8 companies (CT, Samsung, Apple, CMCC, E///, Intel, ZTE?, HW)
  + BS demodulation
    - Keep objective 2-1 only (MMSE-IRC for inter-cell): supported by 1 company as the 2nd priority (CT)
    - Keep objective 2-4 only (BS FR1 PUSCH 256QAM):
      * Supported by 1 company without any conditions (Nokia)
      * Supported by 2 companies support under condition that that objective 1-3 is kept (Samsung, E///)
      * Supported by 3 companies as the 2nd priority in case scope reduction is needed (CT, CMCC, CATT)
    - Keep both objectives 2-1 and 2-4: Supported by 5 companies (CT, CATT, Intel, ZTE, HW)
  + Moderator:
    - For UE demodulationthe majority of companies insist to keep objective 1-3 in the scope under assumptions that MMSE-IRC receiver is used and most of the work is aligned with objective 1-1.
    - For BS demodulation there is almost equal support between Option 2 and Option 3. Several companies propose to keep UE demodulation objective 1-3 and remove objective 2-1.
    - The Chair guidance was to keep maximum 3 objectives per item.
    - Given the restriction on number of objectives and strong support to keep 1-3 and 2-4, **propose to keep objectives 1-1, 1-3 and 2-4 in the WID and the objective 2-1 can be further discussed by Dec RAN plenary.**
* **Timelines**
  + Several companies suggested that WI start time shall be aligned with R16 Performance part completion
  + Moderator proposes that the RAN4 work shall start at earliest in Q1’21 and the exact time will be decided in Dec RAN plenary based on R16 performance part completion progress.

**Updated moderator’s proposal after fine-tuning round**

* **Proposal 1:** Prioritize the following candidate UE demodulation/CSI and BS demodulation objectives and include in the WID scope
  + UE demodulation / CSI reporting
    - Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
    - Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
  + BS demodulation
    - Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
* **Proposal 2:** Do not include Objective 2-1 in the WID and further discuss details till December RAN plenary meeting
* **Proposal 3:** RAN4 work shall start at earliest in Q1’21 and the exact time will be decided in Dec RAN plenary based on R16 performance part completion progress.
* **Proposal 4:** Further discuss additional demodulation topics before the Dec’20 RAN plenary meetings.
* **Proposal 5:** Further discuss Rel-16 demodulation leftover topics in Dec’20 or March’21 RAN plenary meetings

# Topic #1: UE Demodulation/CSI requirements

## Initial round

### Candidate objectives

The following candidate objectives were identified based on pre-plenary e-mail discussion:

**Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference**

* + - Type of requirements:
    - Define PDSCH demodulation requirements
    - Further decide whether to introduce the corresponding CQI reporting requirements during the WI
    - SCS and slot duration
    - Scenario 1: Slot-based transmission and aligned SCS among cells
    - [Scenario 2: Non-slot-based transmission and/or different SCSs among cells]
    - Further discuss the assumptions for requirements definition
    - Reference receiver:
    - For scenario 1: MMSE-IRC with DMRS based interference covariance estimation
      * Note: use the DRMS for target UE’s PDSCH.
    - [For scenario 2: MMSE-IRC. Interference covariance estimation method is FFS]
    - Target frequency: FR1
    - Rx antenna number: 2Rx and 4Rx
    - Interference profile
    - Reuse LTE interference profiles as a starting point
    - Other interference profiles are not precluded
    - TRS/CSI-RS/DMRS configuration
    - Further discuss and decide whether TRS/CSI-RS are collided among cells during the WI
    - Further discuss and decide whether DMRS is colliding with TRS/CSI-RS of interfering cell during the WI
    - [Further discuss and decide whether suppression or cancellation on interfering cell’s CSI-RS/TRS is needed during the WI]
    - As baseline, avoid network assistance and/or restriction.

**Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO**

* + Phase I: Study on the reference receiver structure for (iterative) soft IC and evaluate the performance benefit over R-ML, by taking into account the implementation complexity and processing delay
    - Phase II: Define the requirements if needed based on the outcome of phase I
    - Target frequency: FR1, FR2
    - Number of data layers: up to 4 for FR1; 2 for FR2
    - Rx antenna number: 2Rx and 4Rx for FR1; 2Rx for FR2
    - Modulation order and spatial correlation level: further discuss and decide during the WI

**Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO**

* + - Phase I: Evaluate the performance under practical MU-MIMO interference profile for the candidate reference receiver including MMSE-IRC receiver.
    - Further discuss and decide the interference covariance estimation method during the WI
    - Phase II: Define the requirements if needed based on the outcome of phase I
    - Target frequency: FR1
    - Rx antenna number: 2Rx and 4Rx for FR1

**Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios**

* + - Candidate reference receivers include neighboring cell CRS-IC [and LLR de-weighting]
    - Further discuss and decide if network assistance information including cell ID, number of ports, MBSFN configuration of the neighbouring cell is required

**Objective 1-5: Demodulation requirements for Rel-15 multi-TRP DPS TX**

* + - Demodulation requirements for Rel-15 multi-TRP DPS TX scheme under normal propagation conditions

**Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas**

* + - Define channel model for downlink 8Rx antennas
    - Specify the antenna configuration and MIMO channel correlation matrices for 8Rx antennas
    - Specify the static channel model
    - Define PDSCH demodulation requirements for the rank lower than or equal to 4.
    - Further discuss and decide whether to define PDSCH demodulation requirements for the rank higher than 4 in fading channel.
    - Base on combinations of rank and MCS that can achieve the maximum configured throughput.
    - Define SDR requirements for 8Rx
    - Define CSI reporting requirements for 8Rx.
    - No PDCCH demodulation requirement is expected for 8Rx.
    - Considering the test coverage of 8Rx, test applicability rule is needed to define
    - Define applicability rule of existing performance requirements for 8Rx capable UEs.
    - After finalizing the single carrier requirements, the following CA scenarios will be specified
    - Intra-band contiguous CA with 2CC and 8Rx with up to 8-layers supported per CC
    - Inter-band CA with 8Rx/8-layers supported on one or two contiguous CCs on the identified operating bands, and with 2Rx or 4Rx supported on the other CC(s).
    - Note 1: if agreeable to be included in Rel-17 package, the RF/RRM impact needs to be included in the FR1 RF/RRM work areas.

**Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)**

* + First investigate the applicable MRTD and power imbalance level, considering the network deployment scenario and UE implementation feasibility.
  + Define PDSCH demodulation performance requirement based on the applicable MRTD and power imbalance values.
  + Introduce a UE capability report that indicates the support of dual Rx chain in a band of interest
  + Note 1: if agreeable to be included in Rel-17 package, the RF/RRM impact needs to be included in the FR1 RF/RRM work areas.

### Companies views’ collection

Companies are encouraged to provide comments on the suggested refinement of the individual WI objectives in the table below:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Verizon | We should prioritize the objectives 1-1 and 1-3 in Rel-17.  As the objectives of Rel-17 UE demodulation, the FR2 4Rx should be in scope based on the available RAN1 and RAN2 (multi-TRP) specs requirements in Rel-16. |
| SoftBank | Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas  We are interested in 8Rx deployment.  Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)  As shown in our motivation paper RP-201599, this proposal is motivated by the problems observed from our practical network, and we want to address it in Rel-17.  During the offline discussion with some of the companies including operators, we received comments that the target bands should be generic. We are fine with it. |
| QC | Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  In our opinion, Scenario 2 in SCS and slot duration should be removed. As we commented before, this scenario is a corner case, we do not see the point of further upscoping this item that is already very big.  Scenario 2 in Reference receiver is not clear what it is referring to and what enhancement can possibly achieved by including this scenario. If this is not clarified, this scenario should be removed.  For TRS/CSI-RS/DMRS configurations, in our opinion this is just part of the configuration to be specified in the scenario profile, none of these colliding/non-colliding information pieces can be taken into consideration for UE interference mitigation scheme, since in absence of network assistant information, blind detection of all these different configuration is infeasible given the huge number of combinations. Therefore, the most common case should be taken into interference scenario profile but it is not needed to study all difference scenarios and receiver enhancement doesn’t take this configuration into consideration.  Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  We don’t support studying this item. Information exchange across layers in LDPC decoder with single codeword through check nodes on parity check graph effectively performs inter-layer interference mitigation already. If a strong layer bit connected to weak layer bit through check node, interference mitigation was effectively performed by check node decoding operation. Therefore, unlike LTE, additional performance gain is small, not worth the added complexity and stretching HARQ timeline.  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  For receiver architecture, we agree to keep just MMSE-IRC. Other techniques require blind detection of interference at the UE which leads to high complexity with questionable gains.  Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios  Interference mitigation requires detection of CRS existence, power/interference channel estimation, and cancellation in channel estimation. All these algorithm requires resource and computation, therefore channel estimation and demodulation timeline can be extending by adding all these operations.  The performance gain achievable by this is not obviously large enough to justify the complexity and HARQ timeline impact. LTE study shows that gain exists only when neighboring cell is lightly loaded, even in lightly loaded scenario, the amount of achievable gain is controversial. In NR, given the flexibility of configurations, different alignment of RS/data between serving and neighboring cell can degrade the achievable gain. Additionally, although the coexistence scenario may not disappear 100%, occasions will definitely decrease significantly. Moreover, R15 LTE introduce CRS-muting scheme which is a better feature to address this issue.  To summarize, system performance improvement might be small, the occasions might also be limited, and there is a better feature to address this issue, therefore, we don’t think this study is needed for R17.  Objective 1-5: Requirements for Rel-15 multi-TRP DPS TX scheme  For demod, RAN4 has already agreed to define the requirements for m-TRP schemes in Rel-16 which cover tracking of different loops and separate channel estimation for each TRP with frequency/timing offset between two TPs. We think that Rel-16 m-TRP schemes can have much better performance than LTE schemes (designed for similar purpose) since those schemes are already designed specifically for NR. Also, in DPS scheme, only one TP transmits at a time while Rel-16 m-TRP schemes also allow for receiving from both TRPs at the same time. So, we believe that Rel-15 DPS scheme may not provide much benefit for Rel-17 NR UE.  Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas  This is our proposal, we support it. Rel.15 NR already introduced 800MHz with 2 layers for FR2, the processing requirements should be at least comparable with 8Rx with 100MHz. We are also talking about Rel.17 UEs so we do not see the argument that power consumption or UE over-heat would be an issue. The antenna implementation issue should be the same for LTE and our understanding is that there are already commercial devices with 8Rx for LTE. The main target does not necessarily have to be smartphones, this can be useful for other form factors such as CPEs or laptops/tablets. We do see a need for such requirements. In low correlation channel, 8L can obviously improve throughput by a lot. It’s true that when Rx correlation gets larger, the gain with 8L decreases, but 8Rx can still outperform 4Rx by configuring <8 layers. All these adaptation/design consideration are implemented on LTE 8Rx devices, NR should be able to do the same to achieve performance gain.  Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)  We believe that such large MRTD and power imbalance will lead to performance issues. For the power imbalance issue, it would be good to see how the 25dB was derived. With such large number, one of the links should have very low SINR so the usefulness of EN-DC is questionable as this is considered for Rel.17 when we believe SA will be available. MRTD larger than CP will also introduce performance degradation for demod. |
| MTK | Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  Support this objective in general. Some detail comments below:   * [Type of requirements] Enhancement on CQI can be considered only if network can guarantee same interference is experienced by CSI-RS and PDSCH. Otherwise, there is always a mismatch no mater UE enhances its CQI reporting or not. * [SCS and slot duration] Scenario 2 is not preferred. Non-slot based transmission requires blind detection which is rather complicated in NR, if there is no network assistance information. Also, we are not clear what UE can extra do for different SCS. * [Reference receiver] Remove scenario 2 which is too open and unclear. * [TRS/CSI-RS/DMRS configuration] It will be beneficial if network can provide information about the CSI-RS/TRS configuration from neighoring cells. Then UE can do something such as cancellation or suppression to improve the performance. If assistance information is not provided, we suggest to remove this sub-objective because the blind detection complexity is too high.   Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  No  This type of UE receiver is demanding too high UE complexity and the improvement over R-ML receiver is not clear to us. Note that in LTE 2 codewords are configured with different MCS and encoded by different turbo encoder. Therefore iteration between demapper and decoders can help exchanging extrinsic information between 2 Trubo decoders. Codeword-specific CRS can also help provide additional information for iteration. But now the encoding structure is different in NR. Another critical issue is the HARQ timeline, which is shorter in NR now, making this soft IC receiver even more challenging in implementation.  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  Neutral  2 key issues to make this feature works are how network pairs the UE and whether assistance information (MCS, PRB bundling, scrambling sequence) can be provided. Both parts needs some more study. At least from our understanding, blindly detecting the scrambling sequence of the interfering UE is impossible.  Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios  Neutral  LTE CRS is consistent in both time and frequency domain. Therefore, it is easier for UE to handle it. Cancellation is not the only solution. Some existing LTE assistance information can also be re-used. The only question is whether this is an urgent issue in Rel-17.  Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas  Support  This is a CPE type UE which is customized for special purposes. Therefore we do not see complexity is a concern here.  Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)  We understanding Operator’s deployment concern. It would be better to discuss the UE architecture in RF session first. Given current architecture (single RF chain), we expect unacceptable performance degradation due to large power imbalance and large MRTD. |
| Apple | Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  We support this. Scenario 1 should be prioritized. On RS configuration, it is suggest to remove CSI-RS cancellation related objectives.  Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  The gain of the advanced receiver over R-ML should be justified. Considering only single CW is defined for NR, CWIC in LTE cannot be reused. We are OK to further investigate this issue. A SI item is more appropriate. The wording in WI looks OK to us       Scenario b): Inter-layer interference for SU-MIMO  –    Phase I: Study on the reference receiver structure for (iterative) soft IC and evaluate the performance benefit over R-ML, by taking into account the implementation complexity and processing delay  −    Phase II: Define the requirements if needed based on the outcome of phase  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  Since NW assistant information is needed, a SI is more appropriate.  Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios  Before studying this in RAN4 it would be helpful to see some results demonstrating potential gain from this scheme.  Objective 1-5: Requirements for Rel-15 multi-TRP DPS TX scheme  There is no benefit of introducing requirements with DPS transmission schemes. This mode has been introduced in Rel-15 with multiple TCI states. The test will verify UE capability of switching TCI sate which is already covered in RRM performance test and no additional demodulation capability. The Rel-16 mTRP transmission schemes already cover UE capability/ processing of receiving simultaneously with 2 TCI states from 2 TRP where as DPS scheme would cover reception from one TRP at a time which is not really enhancement to UE demod performance.  Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas  We would like to understand the market need to introduce this in Rel-17 given the limited scope of demod enhancements WI. This would also entail some RF work to specify bands that supports 8RX. Would this be allowed and feasible?  Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)  This objective also impacts RF and RRM core part. From UE architecture point of view, LNA can be shared for intra-band non-contiguous CCs. None collocated scenario can become quite challenging. Feasibility from UE RF perspectives should be investigated first. |
| China Telecom | Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  For the SCS and slot duration, we are also ok to prioritize scenario 1 in Rel-17 to reduce the workload.  It is important to avoid network assistance and restriction for the MMSE-IRC receiver, so that this receiver can be more widely used in the real network.  Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  Support to study the performance gain. From the operator’s perspective, we would like to seek for some receiver more advanced than LTE. Especially for this SU-MIMO scenario, the UE has full knowledge of the interference parameters, which means more robust performance gain and no network signalling.  There is already a study phase. Based on the outcome of study, with consideration on both performance benefit and implementation complexity, we can then decide whether to define the requirements.  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  With massive MIMO deployed, we see MU-MIMO as an important scenario for NR. Although some more advanced receivers are preferred, to reduce the spec impact, we are fine to start with MMSE-IRC. Currently we are not sure how much gain can be brought by IRC receiver, it depends on the multi-user modelling and DMRS configuration. A study phase is needed.  Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios  This is new proposal from Intel. After internal checking, we support this proposal based on our deployment of DSS in band n1.  For DSS scenario, in LTE non-MBSFN sub-frame, the LTE CRS from neighboring cell will impact the NR PDSCH performance. For LTE, CRS-IC requirement has already defined in Rel-13.  Therefore, if the neighboring cell LTE CRS cannot be handled by UE in DSS scenario, there is a potential risk that NR performance would be even worse than LTE in some cases. |
| Samsung | In general, we think objective 1-1, 1-2 and 1-3 shall be prioritized. Based on operators’ request, we are also fine to include 1-7 in the Rel-17 scope.  Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  Interference covariance estimation we would like to exclude the data-based interference covariance estimation which extremely complicated especially for PDSCH. Explict note shall be added by removing data-based estimation  For TRS/CSI-RS colliding, not favor of interference cancellation receiver for TRS/CSI-RS measurement unless NW assistance signaling exists ,as UE cannot guarantee the enough accuracy for TRS interference estimation without NW-side assistance, and the TRS measurement error will impact the overall UE performance. Therefore, we suggest to remove this bullet totally.  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  The objective is not so clear. In our understanding, RAN4 does not have definition on the interference profile for MU-MIMO yet. The study phase is to conclude such interference profile for further requirements. If above is the common understanding on the scope of study phase, it is better to revise the objective as   * + - Phase I: Study MU-MIMO interference profile considering the practical deployment scenario for the candidate reference receiver including MMSE-IRC receiver.     - Further discuss and decide the interference covariance estimation method during the WI |
| ZTE | Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  Scenario 1 should have a higher priority than scenario 2.  Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  Since end-to-end latency demands of NR is much lower than that in LTE, e.g., user plane latency 4ms, and for URLLC 1ms, and under such restriction, the allowed headroom for the iterative IC-like method may be limited.  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  For methods other than MMSE-IRC, is UE provided any network assisted information intended in this WI, or pure blind detection assumed?  Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios  We support this objective. |
| Ericsson | Objective 1-1: Support to include with MMSE-IRC interference aware. The scope is generally OK and we think that CQI can be discussed technically and decided during the WI. Scenario 2 can be removed to focus the scope.  Objective 1-2: We do not support to include this as the complexity and benefits are not clear and, together with other more important objectives there is insufficient time for a proper study at this stage.  Objective 1-3: This is OK but the scope should be limited to MMSE-IRC receiver. As Samsung point out, there will need to be work to determine the interference profile, and so we should focus the target receiver to keep the scope reasonable.  Objective 1-4: The scope should be narrowed to deciding the feasibility of this CRS mitigation without network signaling. We can also de-prioritize this though.  Objective 1-5: In our view the rel-16 eMIMO and HST provide sufficient requirement coverage.  Objective 1-6: Technically 8RX is OK, however it is not clear that this should be prioritized considering workload. Possible could be considered if there is strong prioritization in other areas.  Objective 1-7: In principle OK, but we should consider the best approach considering splitting across WI considering the need to determine maximum expected degradation. |
| KDDI | Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)  In accordance with the spectrum allocation in Japan, we have the scenario as in Objective 1-7 and request it to be treated with priority to be finalized in Rel-17. |
| ORANGE | We generally agree with China Telecom views, that is to say, objectives 1-1 (scenario 1), 1-2 (with emphasis on soft-IC study), 1-3 and 1-4 should be prioritized.    Some comments:  In Rel. 12 the comparison of R-ML and (hard) CWIC is not valid anymore for SU-MIMO in NR since in LTE two code-words (2 CQIs) are transmitted for 2 or more spatial layers while in NR only one code-word (1 CQI) is transmitted. As a result, the CSI at Tx is degraded for managing the interference between layers in SU-MIMO. Moreover, the comparison between R-ML and CWIC was performed assuming highly correlated Rx antennas. This latter point should be revisited with more realistic Rx antenna correlation models.  The argument that advanced receivers are negative towards latency should be balanced. For eMBB in FR1, the main challenge is spectral efficiency. Therefore we believe that the gains expected from advanced receivers on macro deployments exceed the slight impact on latency.  We also think that DSS by supporting the control signals of both LTE and NR has a huge control overhead which result in a significant degradation of the spectral efficiency. We cannot allow additional degradation due to NR UE badly managing the neighbor cells’ CRS interference. Therefore, we strongly support LTE CRS-IC for NR UEs (objective 1.4). |
| Vodafone | 1-1 is the priority for us. For 1-3 would be interesting to understand realistic potential gains before agreeing the work. |
| Intel | Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  We think that Scenario 2 is one of the typical scenarios in NR taking into account flexibility of NR design. Therefore, we think that it is rather important to ensure UEs, which support operation in such scenarios, can handle interference properly.  As for TRS/CSI-RS/DMRS configuration, we think that it is mainly related to detailed discussion on simulation assumptions which is usually done during WI stage. Probably it is better to remove this information from WID. Same time, we are fine to keep it if other companies have strong position to keep it.  As for network assistance, we suggest to keep it open. We can decide it during WI stage based on outcome of reference receiver discussion.  Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  We don’t have any technical concern to have study on this topic. Same time, taking into account limited time budget, this topic has less priority for us in comparison to other topics due to performance benefits of Soft IC receiver over R-ML are not obvious.  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  Taking into account that we consider only MMSE-IRC receiver, the only open question is to define MU-MIMO interference model which will be feasible for TE vendors (because we have some issues with MU-MIMO modelling in Rel-16 eMIMO WI). Therefore, study stage on MMSE-IRC performance probably is not needed and we can focus on study of feasibility of MU-MIMO interference modelling.  Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios  CRS-IC receiver is widely used in LTE because it provides performance benefits in typical scenarios. We expect similar observations can be done in case CRS-IC receiver will be used for NR in DSS scenarios. Same time, complexity of CRS-IC receiver is comparable to existing SU-MIMO advanced receiver (R-ML) which is supported from Rel-15.  @QC: As for R15 LTE CRS muting, this feature can be activated only on some dedicated carriers on which UEs, which support this feature, can only operate. Therefore, this feature will be activated everywhere.  Objective 1-5: Requirements for Rel-15 multi-TRP DPS TX scheme  As we commented before, Multi-TRP DPS transmission scheme is supported from Rel-15. Features, which are required for this scenario are 2-4 “TCI states for PDSCH” and 2-4a “Additional active TCI state for PDCCH”, which are mandatory with capability signalling. Same time, all requirements for Rel-16 Multi-TRP Tx schemes are optional.  Same time, this feature is only covered by HST scenarios. We think that it is rather to verify support of this feature under normal conditions. Taking into account, that a lot of technical discussions were done before, we don’t expect significant workload to define such requirements.  Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas  Based on our previous comments, we don’t expect significant improvement in the maximum achievable throughput. Same time we understand that 8 Rx allows to improve SNR operating point and, as result, improve coverage. Therefore, we would like to understand whether coverage is issue for CPE or laptops/tablets devices?  Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)  As we commented before, we think that this topic should be discussed in RF and RRM rooms first. If no issue will be observed than we can continue discussion in Demod room |
| Nokia, Nokia Shanghai Bell | Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  We support scenario A (inter-cell interference with MMSE-IRC) with DM-RS based interference covariance estimation.  Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  The details of the other scenarios are not clear and the advanced receiver implementation gains are highly depending on the chose interference profile and network assistance/restriction. Significant further study is needed, with corresponding time investment.  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  The details of the other scenarios are not clear and the advanced receiver implementation gains are highly depending on the chose interference profile and network assistance/restriction. Significant further study is needed, with corresponding time investment. |
| Huawei | Objective 1-1: UE interference-aware receiver for scenario (a)  We propose to define PDSCH demodulation requirement but open to CSI requirements.  We would like to focus on slot-based scenario but open to discuss how to deal with non-slot-based scenario.  Regarding receiver, we would like to consider DMRS based interference covariance estimation.  Focus on FR1. For FR2, since the beamforming will be used, there is less interference expected.  Rx antenna: 2Rx and 4Rx.  Interference model: we would like to reuse LTE DIP profile.  Regarding TRS/CSI-RS/DMRS configuration, we can further discuss the configurations in WI. There is no need to make decision now.  Regarding the baseline assumption to avoid assistance and/or restriction, we would like to keep the possible solution on table when approving WI.  Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  We are with Phase I and Phase II proposal. But about the exact objective, we would like to have more discussion.  Focus on FR1 first. But open to FR2.  UP to 4 layer for FR1 and 2 layer for FR2.  Up to 4Rx for FR1. 2Rx for FR2.  We can discuss MCS in WI phase.  Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  We are OK with phase I and Phase II.  Focus on FR1. Consider both 2Rx and 4Rx for FR1.  Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios  We are not in favor of doing CRS-IC for NR. But if most operators thought it would be a typical case, we would like to consider it on the condition that there is no assistance signaling introduced to avoid the impact on network. UE could do it based on blind detection.  Objective 1-5: Demodulation requirements for Rel-15 multi-TRP DPS TX  Not support  We thought the frequency and time tracking functionality and performance has already been verified via Rel-16 requirement including requirements for HST and requirements for multiple TRP.  Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas  Not support. Would like to postpone it to the next release.  We understood that in LTE there are such 8Rx requirements for certain TDD bands. But for NR, can we postpone specifying such requirement?  Compared to LTE, NR is mandated to support 100MHz and 256QAM for DL. Combining 8Rx with them, UE needs to support MIMO equalizer up to 8-layer in 100MHz channel bandwidth. Let alone that UE may need support RLM algorithm for up to 8-layer with 100MHz channel bandwidth. UE seems more complicated, the power consumption will be increased significantly, which is not linearly proportional to bandwidth or Rx antenna number, and UE would be over-heat.  And for smart phone, due to the limit of form factor, it seems difficult to guarantee the isolation between Rx antenna elements.  We wonder if 8Rx is such urgent in terms of meeting the DL service requirement in the real life at the current stage. Maybe 4Rx + 100MHz for downlink would be sufficient at the current stage.  Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)  Support.  We think it is based on the practical deployment and would like to address the issue in the real life. The issue is caused by shared LNA or other RF chains for intra-band non-contiguous spectrum combinations. We see some commonality between EN-DC and CA. Fortunately we have the LTE demodulation performance requirements to address the similar issue for LTE intra-band non-contiguous combinations. We may consider following the similar approach to address the issue to avoid ping-pong between RF, RRM and demod sessions. |
| NTT DOCOMO, INC | We would like to support objectives 1-1 and 1-7.  Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference  Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)  For 1-7, we would like to specify the requirement for not only EN-DC but also NR CA. NR CA will be used for LTE refarming and SA deployment. The values of MRTD and power imbalance can be discussed considering the benefits and actual implementation. Targeted band combinations should not be limited at this time. |

### Summary and recommendation for further discussion

**Summary of views:**

**Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference**

* + - SCS and slot duration
    - Seven companies propose to prioritize Scenario 1 or only consider Scenario 1
    - Several companies open to consider Scenario 2
    - TRS/CSI-RS/DMRS configuration
    - Three companies suggest to discuss this as a part of test configuration
    - One company suggest to remove bullet 3 in case assistance information is not provided
    - Several companies suggested to remove bullet 3 (CSI-RS/TRS cancellation)
    - Network assistance
    - Two companies suggest to keep open discussion on Network assistance
    - One company suggest to avoid network assistance and/or restriction
    - Interference profile
    - One company suggest to reuse LTE profiles

**Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO**

* + - Three companies have concern to have study in Rel-17
    - Four companies support to have study.
    - Two companies suggest to consider this study with lower priority.
    - One company have concern about latency impact
    - One company have concern about workload

**Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO**

* + - Eight companies support these requirements
    - One company is neutral
    - One company proposes to use SI for this topic
    - Two companies propose to consider study of MU-MIMO interference profile as Phase I
    - One company has question on network assistance and blind detection
    - One company suggests to understand realistic potential gains before agreeing the work.

**Objective 1-4: NR PDSCH demodulation requirements for handling neighboring cell CRS in LTE-NR coexistence scenarios**

* + - Four companies support definition of these requirements
    - Two companies suggest not to define requirements for this scenario
    - One company is neutral
    - One company prefers to see performance benefits for this scenario, first
    - One company is fine with this scenario only in case no assistance signaling is introduced

**Objective 1-5: Demodulation requirements for Rel-15 multi-TRP DPS TX**

* + - Four companies don’t see the benefits of these requirements
    - One company support to define requirements

**Objective 1-6: Demodulation/CSI reporting requirements for downlink 8Rx antennas**

* + - Three companies support definition of these requirements
    - Two companies would like to understand the market need to introduce this in Rel-17
    - One companies doesn’t support definition of these requiremnets
    - One company has question about priority of this topic

**Objective 1-7: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78)**

* + - Two companies have concern on performance impact
    - Three companies suggest to discuss this topic in other rooms, first (RF and/or RRM)

**Moderator proposal**

* No further discussion on details of Objectives 1-4, 1-5, 1-6 and 1-7 based on overall objectives prioritization. Discussion can resume if companies have consensus to add more objectives into the scope.
* **Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference**
  + Further discuss the objectives in the next round
  + Proposed revised objectives
    - Added prioritization of Scenario 1 and 2
    - Removed proposal on additional IRC receivers
    - Removed statement on network assistance and this can be discussed in the WI stage
    - Removed CSI-RS/TRS suppression receivers and this can be discussed in the WI stage

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| * Type of requirements:   + Define PDSCH demodulation requirements   + Further decide whether to introduce the corresponding CQI reporting requirements during the WI * SCS and slot duration   + Scenario 1: Slot-based transmission and aligned SCS among cells (first priority)   + Scenario 2: Non-slot-based transmission and/or different SCSs among cells (second priority)   + Further discuss the assumptions for requirements definition * Reference receiver:   + MMSE-IRC with DMRS based interference covariance estimation     - Note: use the DRMS for target UE’s PDSCH. * Target frequency: FR1 * Rx antenna number: 2Rx and 4Rx * Interference profile   + Reuse LTE interference profiles as a starting point   + Other interference profiles are not precluded * TRS/CSI-RS/DMRS configuration   + Further discuss and decide whether TRS/CSI-RS are collided among cells during the WI   + Further discuss and decide whether DMRS is colliding with TRS/CSI-RS of interfering cell during the WI |

* **Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO**
  + Further discuss the objectives in the next round (no changes vs initial round)

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| --- |
| * + Phase I: Study on the reference receiver structure for (iterative) soft IC and evaluate the performance benefit over R-ML, by taking into account the implementation complexity and processing delay     - Phase II: Define the requirements if needed based on the outcome of phase I     - Target frequency: FR1, FR2     - Number of data layers: up to 4 for FR1; 2 for FR2     - Rx antenna number: 2Rx and 4Rx for FR1; 2Rx for FR2     - Modulation order and spatial correlation level: further discuss and decide during the WI |

* **Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO**
  + Further discuss the objectives in the next round (no changes vs 1st round)

|  |
| --- |
| * + - Phase I: Evaluate the performance under practical MU-MIMO interference profile for the candidate reference receiver including MMSE-IRC receiver.     - Further discuss and decide the interference covariance estimation method during the WI     - Phase II: Define the requirements if needed based on the outcome of phase I     - Target frequency: FR1     - Rx antenna number: 2Rx and 4Rx for FR1 |

## Intermediate round

### Companies views’ collection

#### Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference

Candidate objectives

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| --- |
| * Type of requirements:   + Define PDSCH demodulation requirements   + Further decide whether to introduce the corresponding CQI reporting requirements during the WI * SCS and slot duration   + Scenario 1: Slot-based transmission and aligned SCS among cells (first priority)   + Scenario 2: Non-slot-based transmission and/or different SCSs among cells (second priority)   + Further discuss the assumptions for requirements definition * Reference receiver:   + MMSE-IRC with DMRS based interference covariance estimation     - Note: use the DRMS for target UE’s PDSCH. * Target frequency: FR1 * Rx antenna number: 2Rx and 4Rx * Interference profile   + Reuse LTE interference profiles as a starting point   + Other interference profiles are not precluded * TRS/CSI-RS/DMRS configuration   + Further discuss and decide whether TRS/CSI-RS are collided among cells during the WI   + Further discuss and decide whether DMRS is colliding with TRS/CSI-RS of interfering cell during the WI |

Companies are encouraged to provide comments on further objective refinement:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| MTK | We can accept the current scope, although it will be even better to reduce objectives with ‘further decide’ or ‘further discuss’ |
| Ericsson | It is too vague what is meant with “first priority” and “second priority”. Does it mean that e.g. the second priority is not commenced until the first is complete and only if there is enough time ? If so, it could be added later. To keep the scope reasonable, we propose to focus on scenario 1.  For TRS/CSI-RS etc. the goal seems not clear. Is the objective just a discussion as to whether there can be collision ? “study the need and feasibility of requirements” may be more suitable. However, we think that this can be removed from the scope to keep workload manageable. |
| QC | We suggest to remove:   * + 1. ~~Further decide whether to introduce the corresponding CQI reporting requirements during the WI~~   And:   * + 1. ~~Scenario 2: Non-slot-based transmission and/or different SCSs among cells (second priority)~~   And:  ~~TRS/CSI-RS/DMRS configuration~~   * + ~~Further discuss and decide whether TRS/CSI-RS are collided among cells during the WI~~   + ~~Further discuss and decide whether DMRS is colliding with TRS/CSI-RS of interfering cell during the WI~~   As commented by MTK in first round, CQI reporting enhancement is only useful when NW guaranteed that CSI-RS and PDSCH experience the same interference, from the first round we don’t see network vendors or operators explaining how this can be guaranteed. If no benefit is identified, we suggest to remove it.  For non-slot based transmission and different SCS scenarios, it’s a possible scenario in NR, but not the most common one. Distinguishing possible combination of configurations can significantly increase interference cancellation algorithm complexity, and UE is required to support different level of granularity of channel estimation/demodulation algorithm to handle these possible configurations. From first round comments and contributions, no significant improvement is identified for considering this scenario, therefore, we suggest to remove it.  Taking TRS/CSI-RS/DMRS configuration into consideration for interference cancellation algorithm significantly increases the implementation complexity, since there are huge number of combinations for different colliding/non-colliding cases, due to the flexibility of configurations. Blind detection is not feasible, even with network assistance signal (which many companies already expressed concern on it), UE performing different interference cancellation for all different cases may increase implementation complexity significantly. Most importantly, we don’t see large performance gain identified for taking this information into consideration. Since this can significantly increase the complexity without significant performance improvement identified, we suggest to remove it from objectives. |
| China Telecom | For SCS and slot duration, ok to keep scenario 2 as second priority or remove it.  For CQI, regarding the different interference condition for CSI-RS and PDSCH, we understand the issue may happen in some cases. But if we do not introduce CQI requirement, the gain by IRC receiver is only on reducing BLER, but not achieving a higher MCS. In other words, the throughput improvement will be limited to some extend. We hope to keep it at least for further discussion.  For TRS/CSI-RS/DMRS configuration, ok to NOT consider any suppression or cancellation, since it is important to avoid network signaling to make IRC more widely used in real network. Also ok to leave the detailed TRS/CSI-RS/DMRS configuration in the WI phase, i.e., remove this bullet from the objective. |
| Apple | The scope is OK for us. |
| Samsung | For TRS/CSI-RS/DMRS configuration, as long as the interference cancellation receiver is remove from the scope, we can further study the performance impact for colliding case. In our understanding, for colliding case, there will be no specific interference cancelation. |
| CATT | The current scope is acceptable to us. |
| Huawei | For type of requirements, we are OK with the current objectives.  For SCS and slot duration, we are OK with the current objectives with first and second priority.  For reference receiver, we are OK not to distinguish scenario 1 and 2. After all UE may have no idea and the uniform receiver is preferred. We are OK with moderator suggested DMRS based interference covariance estimation.  For target frequency and Rx antenna number, we are fine.  For interference profile, we are OK with the proposed objective. But we do not see the need to re-run system simulation. Part of NR assumption for system simulation is the same as for LTE.  For TRS/CSI-RS/DMRS, we can make decision in WI phase as usual business. Not sure if we need the detailed sub-bullet. But we are open.  We are OK with the rest part. |
| Intel | As for “SCS and slot duration” configuration, we think that considering of scenarios different from LTE, i.e. Scenario 2, is rather important to demonstrate that MMSE-IRC can operate in different NR scenarios. Probably the following wording will be acceptable for all companies:   * + Define requirements for slot-based transmission and aligned SCS among cells   + FFS whether to define requirements for non-slot-based transmission and/or different SCSs among cells   As for “TRS/CSI-RS/DMRS configuration”, as we commented in the Initial round, we can remove this from WID and discuss this during WI stage, because it is just one of test configuration for requirements definition. |
| ZTE | The revised objectives are in general ok, except the objective of TRS/CSI-RS/DMRS configuration. As other companies commented, this objective can be dropped at this stage. |

#### 1.2.1.2 Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO

Candidate objectives

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| --- |
| * + Phase I: Study on the reference receiver structure for (iterative) soft IC and evaluate the performance benefit over R-ML, by taking into account the implementation complexity and processing delay     - Phase II: Define the requirements if needed based on the outcome of phase I     - Target frequency: FR1, FR2     - Number of data layers: up to 4 for FR1; 2 for FR2     - Rx antenna number: 2Rx and 4Rx for FR1; 2Rx for FR2     - Modulation order and spatial correlation level: further discuss and decide during the WI |

Companies are encouraged to provide comments on further objective refinement:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| MTK | We suggest to remove this objective due to the too high UE complexity and unclear benefit. |
| Ericsson | We think this scope is too large, and the objective should be removed. |
| QC | Same view as MTK, suggest to remove this objective. Many companies mentioned that CWIC in LTE can not be reused in NR, but the performance gain achievable in LTE is actually from the two codeword structure, as we explained in the first round comment. Without two codeword structure to perform CWIC, adding soft-IC iteration doesn’t improve performance too much, since the inter-stream cancellation is effectively performed in check nodes inside LDPC code through decoding iterations, repeating the same operation can’t improve performance. |
| China Telecom | Although high interest in this one, can accept to de-prioritize it in Rel-17, following chairman guidance on significant down-scoping. |
| Huawei | We see the benefit, which is clarified in the previous Topic#0. If companies are not sure about the benefit, we can have a separate SI or a dedicated study phase in the WID to study the benefit. If companies thought the scope is too broad, we can focus on FR1 with 4Rx. |
| Intel | As we commented in Section 0.2.1. If companies have concern on this objective then we are fine to remove it. |
| ZTE | As we commented in the first round, we are not sure the iterative IC-like receivers may bring any gain under the constraint in 5G. We suggest to drop this objective, or a lower priority. |

#### 1.2.1.3 Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO

Candidate objective

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| --- |
| * + - Phase I: Evaluate the performance under practical MU-MIMO interference profile for the candidate reference receiver including MMSE-IRC receiver.     - Further discuss and decide the interference covariance estimation method during the WI     - Phase II: Define the requirements if needed based on the outcome of phase I     - Target frequency: FR1     - Rx antenna number: 2Rx and 4Rx for FR1 |

Companies are encouraged to provide comments on further objective refinement:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| MTK | We suggest to remove this objective. But we can compromise to keep it if a consensus in later GTW is to consider one additional objective.  Some further clarification is needed on whether UE can expect assistance information or UE has to perform blind detection for every signal parameter. |
| Ericsson | Objectives are OK, and we think the work is useful, but this area should be removed if we would go with 1 UE objective. |
| QC | We prefer one objective for UE demod, and between 1-1 and 1-3 we support to prioritize 1-1 and remove 1-3, as the achievable performance gain is larger and application scenario is more general for enhancement in 1-1. Objective 1-3 has relatively small gain with possibly higher complexity, and application scenario is narrower than 1-1. |
| China Telecom | OK with the objective to only keep MMSE-IRC receiver. According to the discussion in Rel-16, many operators are interested in DL performance in NR MU-MIMO scenario. Considering the workload issue, starting from IRC receiver is acceptable to us. |
| Apple | OK for us if one more objective can be accomondated. |
| CMCC | OK with the objective |
| CATT | We prefer to have one or two objectives for UE Demod side. If two will be introduced on demand, objective 1-3 is also OK for us. |
| Huawei | We see the interests from operators on this scenario during Rel-16 eMIMO discussion. And in our view, RAN1 design their codebook and run the system simulation in Rel-16/17 based on the assumption that advanced receiver at least IRC is used. To ensure the performance gain for the designed technique by RAN1 in the practical network, RAN4 should specify the requirements.  Regarding the proposed objective, it seems that what kind of receiver is still open part. If that is the case, we do not see the reason to preclude Soft-IC receiver or we say that Soft-IC receiver can be considered here. If so we prefer to make it clear that reference receiver is under discussion.  Regarding the covariance estimation, we prefer to reuse DMRS based estimation.  The other part in the objective is OK for us.  Proposed changes for the objective:   * + - Phase I: Evaluate the performance under practical MU-MIMO interference profile for the candidate reference receiver ~~including MMSE-IRC receiver~~.     - Use MMSE-IRC receiver as baseline, and other receiver is not precluded       * DMRS based interference covariance estimation for MMSE-IRC receiver     - ~~Further discuss and decide the interference covariance estimation method during the WI~~     - Phase II: Define the requirements if needed based on the outcome of phase I     - Target frequency: FR1   Rx antenna number: 2Rx and 4Rx for FR1 |
| Intel | As we commented in the first round, we think that one of the important topic is definition of feasible/testable MU-MIMO model. Therefore, we suggest to revise Phase I and use proposal from Initial round from Samsung:   * + - Phase I: Study MU-MIMO interference profile considering the practical deployment scenario for the candidate reference receiver including MMSE-IRC receiver.     - Further discuss and decide the interference covariance estimation method during the WI |
| ZTE | Ok with the objective, but a lower priority than Objective 1-1 if downscoping is needed. |

### Summary and recommendation for further discussion

**Summary of views:**

* Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
  + MTK, Apple, CATT, ZTE: current scope is ok
  + SCS and slot duration
    - E///, QC: Focus on scenario 1
    - CTC: ok to keep as second priority or remove Scenario 2
    - HW, Intel: current proposal is ok
  + TRS/CSI-RS
    - E///, QC, CTC, ZTE: suggest to remove
    - HW, Intel: not sure if we need detailed bullet. Can make decision in WI phase
    - Samsung: ok to consider if IC receiver is out of scope
  + CQI reporting
    - QC: suggest to remove
    - CTC: prefer to keep
* Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO
  + Six companies suggest to deprioritize
  + One company suggest to have a separate SI or reduce the scope (4RX)
* Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
  + General
    - MTK: Remove the objective. Need to clarify network assistance.
    - QC: remove the objective
    - E///, CTC, Apple, CMCC, CATT, ZTE, Intel: Objectives are ok.
    - Intel: suggest to study MU-MIMO interference profile
  + Receiver
    - CTC: MMSE-IRC receiver is fine
    - HW: suggest to consider Soft IC receiver as well

**Updated moderator’s proposal after intermediate round**

* Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
  + Moderator views
    - SCS and slot duration: recommend to keep current text and further discuss in the WI stage
    - TRP/CSI-RS: Suggest to remove the text since the scope is unclear. The details of RS configurations can be discussed in the WI stage
    - CQI reporting: the current objective does not imply that CQI reporting will be introduced and final decision can be kept up to the WI stage
  + Proposed revised objectives

|  |
| --- |
| * Type of requirements:   + Define PDSCH demodulation requirements   + Further decide whether to introduce the corresponding CQI reporting requirements during the WI * SCS and slot duration   + Scenario 1: Slot-based transmission and aligned SCS among cells (first priority)   + Scenario 2: Non-slot-based transmission and/or different SCSs among cells (second priority)   + Further discuss the assumptions for requirements definition * Reference receiver:   + MMSE-IRC with DMRS based interference covariance estimation     - Note: use the DRMS for target UE’s PDSCH. * Target frequency: FR1 * Rx antenna number: 2Rx and 4Rx * Interference profile   + Reuse LTE interference profiles as a starting point   + Other interference profiles are not precluded |

* Objective 1-2: UE interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO
  + Moderator views: Do not continue discussion on objective unless there is a decision in GTW to add this objective
* Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
  + Moderator views:
    - Propose to add a note that MU-MIMO interference profiles shall be identified
    - Reference receiver: suggest to focus on MMSE-IRC receiver taking into account the inputs in the first round

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| --- |
| * + - Phase I: Evaluate the performance under practical MU-MIMO interference profile for the candidate reference receiver.     - Identify practical MU-MIMO interference modelling methodology     - Reference receiver: MMSE-IRC receiver. Further discuss and decide the interference covariance estimation method during the WI     - Phase II: Define the requirements if needed based on the outcome of phase I     - Target frequency: FR1     - Rx antenna number: 2Rx and 4Rx for FR1 |

## Fine-tuning round

### Companies views’ collection

#### Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference

Moderator: Proposed revised objectives based on intermediate round

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| * Type of requirements:   + Define PDSCH demodulation requirements   + Further decide whether to introduce the corresponding CQI reporting requirements during the WI * SCS and slot duration   + Scenario 1: Slot-based transmission and aligned SCS among cells (first priority)   + Scenario 2: Non-slot-based transmission and/or different SCSs among cells (second priority)   + Further discuss the assumptions for requirements definition * Reference receiver:   + MMSE-IRC with DMRS based interference covariance estimation     - Note: use the DRMS for target UE’s PDSCH. * Target frequency: FR1 * Rx antenna number: 2Rx and 4Rx * Interference profile   + Reuse LTE interference profiles as a starting point   + Other interference profiles are not precluded |

Companies are encouraged to provide further comments on the objectives (if any)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | We still suggest to remove scenario 2 in SCS and slot duration. Since there are too many combinations, and the agreed MMSE-IRC reference receiver has limited flexibility to handle this huge number of combinations in non-slot based and different SCS scenario, as optimizing for each of them is impossible for UE. If optimization is done only for limited combinations, we believe that the performance gain compared to keep UE the same as scenario 1 is negligible, even can be harmful in some cases.  We understand that this scenario is new to NR, but as we explained, this should be a relatively rare cases, and we don’t expect performance gain due to complexity limitation. Since this involves large efforts but little performance improvement can be achieved and with limited use cases, we suggest to remove this scenario from objectives.  For CQI requirement, we still prefer to remove it. If supporting companies want to keep it, we suggest to revise the objective as follows, to ensure UE implementation feasibility:   * + Further decide whether to introduce the corresponding CQI reporting requirements during the WI   + UE assumes CSI-RS and PDSCH experiencing the same inter-cell interference for CQI reporting |
| China Telecom | Scenario 2 for SCS and slot duration:  Originally some new interference estimation methods were proposed for the scenario 2, and we were afraid of the additional workload. Now only DMRS based interference estimation is kept, we can be fine to keep it as second priority.  CQI reporting:  For the following new sub-bullet proposed by QC, similar to the discussion on TRS/CSI-RS/DMRS configuration, we should leave these details in the WI phase.   * + *UE assumes CSI-RS and PDSCH experiencing the same inter-cell interference for CQI reporting* |
| Samsung | Ok with the objective description. Also, given still time remains in this week, further discussion for objective 1-3 is also needed to better utilize the meeting resource. |
| Apple | OK with the proposed scope. |
| MTK | * SCS and slot duration: We can accept at least to remove different SCS as a compromise. We believe that interference with different SCS should be a rare case. * CQI reporting: We think the issues is not about how UE can assume, but whether network can guarantee. Even if UE follows the assumption of the same interference, it eventually does not work if network cannot guarantee it. If there is no guarantee from network, we suggest to remove this item. |
| Ericsson | The formulation with scenario 2 is not very clear; what does “first priority” and “second priority” mean. Does it mean (i) that both in the end get done or that (ii) work on scenario 2 starts after scenario 1 and depending on remaining time ?  We are also concerned on the complexity of scenario 2, and think it should be removed, or alternative (ii) above adopted.   * For the CQI, we propose to keep the bullet and discuss further in RAN4 the guarantee by the network and gains. It is not clear that without considering CQI reporting the gains from the receiver can be fully exploited. |
| CATT | Support the proposed scope. |
| Intel | As for SCS and slot duration, as compromise, it is fine for us to consider scenarios with same SCS among cells, like suggested by MTK.  We support Samsung suggestion to further discuss objective 1-3.  @Ericsson: It is our assumption that we focus on definition of requirements for Scenario 1. Once it will be stable, we can discuss definition of requirements for Scenario 2. We don’t quit understand the issue with complexity of Scenario 2, because requirements will be defined for MMSE-IRC receiver with DMRS-based covariance matrix estimation. So, receiver will be the same for both scenarios. |
| Ericsson | To Intel: Then we suggest to add the following to the WID so that it is clear what RAN means with priotitization:   * Requirements for scenario 1 will first be defined and stabilized before commencing scenario 2.   If there is a need for prioritization between 1-3 and scenario 2, we would prefer to include 1-3 than scenario 2. |
| ZTE | The revision suggested by Ericsson sounds reasonable and feasible. |
| Huawei | We would like to keep both scenario 1 and scenario 2 since both would happens in the network. At least we should figure out a way to handle them. We are Ok with moderator version. |

### Summary and recommendation for further discussion

**Summary of views:**

* Objective 1-1: UE interference-aware receivers for Scenario a): Inter-cell interference
  + SCS and slot duration
    - Most companies ok with current objective
    - QC: Remove scenario 2
    - MTK: remove different SCS scenario
    - E///: suggest to add more details on prioritization
    - Moderator: Propose to add a clarification on priorities and remove different SCS from the scope.
  + CQI reporting
    - Most companies ok with current objective
    - QC: suggest to adjust the objective to ensure UE implementation feasibility
    - CT: disagree with QC suggestion
    - E///: suggest discuss in WI stage
    - Moderator: No consensus on objectives update. Propose to keep the current objective as it is
  + Proposed revised objectives based on fine-tuning round.

|  |
| --- |
| * Type of requirements:   + Define PDSCH demodulation requirements   + Further decide whether to introduce the corresponding CQI reporting requirements during the WI * SCS and slot duration   + Scenario 1: Slot-based transmission and aligned SCS among cells (first priority)   + Scenario 2: Non-slot-based transmission and aligned SCS among cells (second priority)   + Further discuss the assumptions for requirements definition   + Note: Requirements for scenario 1 will first be stabilized before commencing scenario 2. * Reference receiver:   + MMSE-IRC with DMRS based interference covariance estimation     - Note: use the DRMS for target UE’s PDSCH. * Target frequency: FR1 * Rx antenna number: 2Rx and 4Rx * Interference profile   + Reuse LTE interference profiles as a starting point   + Other interference profiles are not precluded |

* Objective 1-3: UE interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
  + No discussion in this round. Suggest to discuss till Fri based on the following proposal.
  + The objective can be discussed based on WID.

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| --- |
| * + - Phase I: Evaluate the performance under practical MU-MIMO interference profile for the candidate reference receiver.     - Identify practical MU-MIMO interference modelling methodology     - Reference receiver: MMSE-IRC receiver. Further discuss and decide the interference covariance estimation method during the WI     - Phase II: Define the requirements if needed based on the outcome of phase I     - Target frequency: FR1     - Rx antenna number: 2Rx and 4Rx for FR1 |

# Topic #2: BS Demodulation requirements

## Candidate objectives

**Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference**

* + - Type of requirements: PUSCH requirement
    - Reference receiver:
    - As starting point, use MMSE-IRC with DMRS based interference covariance estimation
    - FFS Soft-IC/CW-IC for cell sectors belonging to the same site
    - Target frequency: FR1
    - Rx antenna number: further discuss and decide in the WI
    - Interference profile
    - Reuse LTE interference profiles as a starting point
    - Other interference profiles are not precluded
    - As baseline, avoid network assistance and/or restriction.

**Objective 2-2: BS interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO**

* + - Type of requirements: PUSCH requirement
    - Candidate reference receiver:
    - Soft IC
    - SL-IC
  + Evaluate the performance gain for different reference receivers, by taking into account the implementation complexity
    - Target frequency: FR1, FR2
    - Number of data layers: 2 for FR1 and FR2
    - Rx antenna number: 2Rx, 4Rx and 8Rx for FR1; 2Rx for FR2

**Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO**

* + - Type of requirements: PUSCH requirement
    - Reference receiver:
    - As starting point, use CWIC
    - FFS hybrid-IC (mixing hard-IC and soft-IC)
    - Target frequency: FR1
    - Rx antenna number: 2Rx, 4Rx and 8Rx for FR1

**Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements**

* + - Define PUSCH demodulation requirements for FR1 256QAM

## Initial round

### Companies views’ collection

Companies are encouraged to provide comments on the individual WI objectives in the table below:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Verizon | We would prioritize the objectives 2-1, 2-3 and 2-4 in Rel-17. |
| Samsung | In general, we think objective 2-1, 2-3 and 2-4.  Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference  We do not see any use cases for soft-IC/CW-IC. Such objective shall be removed (even with FFS wording)  Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  For hybrid-IC, it is premature to define the hybrid-IC at this stage. We suggest to remove this bullet from 2-3 |
| China Telecom | Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference  Rx antenna number: Suggest to include 2Rx, 4Rx and 8Rx.  Objective 2-2: BS interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  Similar to the comment to UE SU-MIMO. We understand the complexity here, but there is already a study phase. Based on the outcome of study, with consideration on both performance benefit and implementation complexity, we can then decide whether to define the requirements.  Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  CW-IC for MU-MIMO has been specfied for LTE.  Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements  In the pre-meeting discussion, all interested companies are ok to this proposal. We think this objective will not take much efforts compard to other proposals for advanced receivers. |
| ZTE | As a generic comment, we may have to keep in mind one thing that the power consumption of 5G networks might become an unexpected issue. Reports are often seen that operators can shut down BSs during nights in order to save energies. So trade-off between complexity/power consumption and performance is always the critical key in this regard.  Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference  MMSE-IRC can be the focus. As commented in topic #1, NR systems have a more stringent end-to-end latency demands than LTE, thus it might limit the use of iterative IC-like methods under certain complexity constraint. Interference profiles of NR may be different from that in LTE.  Objective 2-2: BS interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  Similar comments on iterative IC-like methods.  Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  Similar comments on iterative IC-like methods.  Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements  We support this objective. |
| Ericsson | Objective 2-1: We are OK for MMSE-IRC, but the FFS soft IC etc. should be removed to keep the scope focused.  Objective 2-2, objective 2-3: We do not support to introduce these objectives since the amount of study required is large and we should develop the MMSE-IRC requirements first.  Objective 2-4: We should introduce these requirements. |
| ORANGE | The outcome of the NOMA SI was indeed the acknowledgement that advanced receiver improves significantly the spectral efficiency of the UL. As suggested by China Telecom we should try to tighten the performance requirements in FR1 compared to LTE.  We think objective 2-1/2-2/2-3 should be prioritized. |
| Vodafone | We would prioritise UE demod enhancements unless there is protocol work to support BS demod enhancements. |
| Intel | Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference  We are fine to define requirements for MMSE-IRC receiver. Same time, definition of requirements for Soft-IC/CW-IC receiver requires more feasibility, complexity and performance benefits study. If it will be agreed to include some advanced receivers in the scope for further study, then we prefer to have the list of reference receiver candidate open and include R-ML and SL-IC receivers  Objective 2-2: BS interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  Similar to UE, we don’t have technical concern, but consider this scenario with low priority. If it will be agreed, then we suggest to have study stage in WID (i.e. similar to UE)  Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  We suggest to have study stage of complexity and performance benefits of different receiver algorithms (CW-IC and hybrid-IC) and, based on outcome of this study, decide the definition of this requirements and reference receiver. |
| Nokia, Nokia Shanghai Bell | Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference  While the scenario A (inter-cell interference with MMSE-IRC) with DM-RS based interference covariance estimation is quite mature at this point, with regards to the work load in RAN4 demod, the BS advanced receivers should be down-prioritized w.r.t. to UE advanced receivers and FR1 PUSCH 256QAM  Objective 2-2: BS interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO  The details of this scenario are not clear and the advanced receiver implementation gains are highly depending on the chose interference profile and network assistance/restriction. Significant further study is needed, with corresponding time investment. Furthermore, the reference receiver architecture should be constrained as little as possible to allow performance input in line with the practical receiver performance of the real product implementations. In other words, all reference signals should be configured, and interference profile should be chosen, but the receiver implementation should be left open.  Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO  The details of this scenario are not clear and the advanced receiver implementation gains are highly depending on the chose interference profile and network assistance/restriction. Significant further study is needed, with corresponding time investment. Furthermore, the reference receiver architecture should be constrained as little as possible to allow performance input in line with the practical receiver performance of the real product implementations.  Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements  We see this as a higher priority proposal.  However, Nokia’s concerns (minimal mobility is to be assumed; realistic phase noise modelling is left up to the contributing entities) should, at least, be captured as a note in the WID.  Objective 3-1: Link adaptation throughput requirements  The scope of introducing link adaptation throughput requirements in RAN4 is not clear and there is a risk that the effort becomes infeasibly large. Further studies are required to evaluate the potential impact and feasibility in the first place. The introduction of requirements themselves seems difficult in Rel-17, and no support is observed in the first place. |
| Huawei | Objective 2-1:  Support.  PUSCH requirement is preferred.  Prefer MMSE-IRC with DMRS based interference covariance estimation.  FR1  Further discuss how many Rx is utilized.  Prefer to reuse LTE interference profile.  We prefer not to preclude the solution of network assistance and/or restriction.  Objective 2-2:  Prefer to postpone it to the future release.  Objective 2-3:  Prefer to postpone it to the future release.  Objective 2-4:  Support |
| NTT DOCOMO, INC | We support Objective 2-1 and 2-4.  For Objective 2-1, advanced receivers are beneficial to improve the performance under inter-cell interference conditions. It is necessary to give priority to MMSE-IRC, which was assumed even in Rel-13 LTE.  For Objective 2-4, the requirement should be specified to verify the UL 256QAM performance. It is noted that RAN4 has already had RF requirements for UL 256QAM. |

### Summary and recommendation for further discussion

**Summary of views:**

* Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
  + Most companies agree to have the objectives in the WI scope
  + Four companies suggested to remove IC receiver from the scope
  + One company suggested to clarify the number of Rx antennas (include 2Rx, 4Rx and 8Rx). One company suggest to keep it open.
  + One company suggested to further look into interference profiles since they can be different from LTE. One company suggest to focus on LTE profiles.
  + One company suggest not to put restriction on NW assistance / restrictions.
* Objective 2-2: BS interference-aware receivers for Scenario b): Inter-layer interference for SU-MIMO
  + Five companies raised concerns on receiver complexity
  + One company mentioned impact on latency for iterative IC receivers
  + Four companies are against further work in Rel-17
  + Three companies suggested to have studies in Rel-17
* Objective 2-3: BS interference-aware receivers for Scenario c): Intra-cell inter-user interference for MU-MIMO
  + Several raised concerns on receiver complexity
  + One company mentioned impact on latency for iterative IC receivers
  + Four companies are against further work in Rel-17
  + One company suggested to remove hybrid-IC
  + Further studies supported by at least 4 companies
* Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
  + Supported by almost all companies
  + One company proposed to capture a note that minimal mobility is to be assumed and realistic phase noise modelling is left up to the contributing entities

**Moderator proposal**

* Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
  + Further discuss the objectives in the next round
  + Proposed revised objectives
    - Removed IC receivers
    - Left interference profiles discussion up to WI stage
    - Removed the statement on NW assistances and restrictions. This can be discussed in WI stage.

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| --- |
| Define BS demodulation requirements for Inter-cell interference scenario   * + - Type of requirements: PUSCH requirement     - Reference receiver:     - MMSE-IRC with DMRS based interference covariance estimation     - Target frequency: FR1     - Rx antenna number: further discuss and decide in the WI     - Identify the interference profiles for requirements definition |

* Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
  + Further discuss the objectives in the next round
  + Proposed revised objectives

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| Define PUSCH demodulation requirements for FR1 256QAM   * Note 1: low mobility is considered for requirements definition * Note 2: Realistic phase noise modelling is left up to the contributing entities |

* No further discussion for Objectives 2-2 and 2-3 based on overall objectives prioritization

## Intermediate round

### Companies views’ collection

#### Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference

Candidate objectives

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| Define BS demodulation requirements for Inter-cell interference scenario   * + - Type of requirements: PUSCH requirement     - Reference receiver:     - MMSE-IRC with DMRS based interference covariance estimation     - Target frequency: FR1     - Rx antenna number: further discuss and decide in the WI     - Identify the interference profiles for requirements definition |

Companies are encouraged to provide comments on further objective refinement:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | This scope is OK. This should be the objective to remove if we go with 1 BS objective. |
| China Telecom | Suggest to keep the sub-bullet of reusing LTE interference profiles as a starting point. This is very important to control the workload. Otherwise, signification system level simulation efforts is needed. |
| Samsung | OK with the scope |
| CMCC | OK with the scope |
| CATT | OK with the current scope. |
| Huawei | For type of requirement, we are OK.  For reference receiver, we are OK.  For the interference profiles, can we reuse LTE outcome? |
| Intel | Ok with this scope. Same time, we also support proposal from China Telecom on Interference profile and have something as starting point. |
| ZTE | This objective is fine with us. |

#### Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements

Candidate objective

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| Define PUSCH demodulation requirements for FR1 256QAM   * Note 1: low mobility is considered for requirements definition * Note 2: Realistic phase noise modelling is left up to the contributing entities |

Companies are encouraged to provide comments on further objective refinement:

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| --- | --- |
| **Company** | **Comments** |
| Ericsson | This scope is OK, and this should be 1st priority for BS. |
| China Telecom | Ok with note 1.  For note 2, does it mean not explicitly model the phase noise in RAN4 simulation, i.e., take it into account in the implementation margin as we did for other modulation orders? If so, we are ok with it. |
| Samsung | The scope is ok |
| CMCC | OK with the scope |
| CATT | OK with the current scope. |
| Huawei | We also wonder what Note 2 means? If it means that we do not need model phase noise, the impact is captured in the margin, we are OK.  The rest part is OK for us. |
| Intel | Ok with this scope. |
| ZTE | We are fine with this objective |

### Summary and recommendation for further discussion

**Summary of views:**

* Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
  + Most companies agree with the proposed objective
  + One company suggested to keep sub-bullet of reusing LTE interference profiles as a starting point
* Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
  + Most companies agree with the proposed objective
  + Two companies asked for clarification on Note 2

**Updated moderator’s proposal after intermediate round**

* Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
  + Moderator views:
    - Propose to re-add a note on LTE interference profiles
  + Proposed revised objectives

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| Define BS demodulation requirements for Inter-cell interference scenario   * + - Type of requirements: PUSCH requirement     - Reference receiver:     - MMSE-IRC with DMRS based interference covariance estimation     - Target frequency: FR1     - Rx antenna number: further discuss and decide in the WI     - Identify the interference profiles for requirements definition   + LTE interference profiles can be used as a starting point |

**Updated moderator’s proposal after intermediate round**

* Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
  + Moderator views:
    - Encourage Nokia to provide more details on Note 2
  + Proposed revised objectives

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| Define PUSCH demodulation requirements for FR1 256QAM   * Note 1: low mobility is considered for requirements definition * [Note 2: Realistic phase noise modelling is left up to the contributing entities ] |

## Fine-tuning round

### Companies views’ collection

#### Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference

Candidate objectives based on intermediate round

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| Define BS demodulation requirements for Inter-cell interference scenario   * + - Type of requirements: PUSCH requirement     - Reference receiver:     - MMSE-IRC with DMRS based interference covariance estimation     - Target frequency: FR1     - Rx antenna number: further discuss and decide in the WI     - Identify the interference profiles for requirements definition     - LTE interference profiles can be used as a starting point |

Companies are encouraged to provide comments on further objective refinement:

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| --- | --- |
| **Company** | **Comments** |
| China Telecom | OK with the objective. |
| Ericsson | OK |
| CATT | OK with the scope description. |
| Intel | This objective is fine for us. |
| ZTE | Fine with us. |
| Huawei | OK |

#### Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements

Moderator:

* Objectives are stable.
* Nokia is encouraged to provide responses to companies comments in the intermediate round on the “Note 2: Realistic phase noise modelling is left up to the contributing entities”

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| --- | --- |
| **Company** | **Comments** |
| Nokia | By “Realistic phase noise modelling is left up to the contributing entities” we meant not to explicitly specify the phase noise model to be used for RAN4 simulation. The delivered impaired results contain the effect of phase noise modelling. The delivered ideal results do not contain phase noise and are used for simulation alignment. |
| China Telecom | With Nokia’s clarification above, we are ok with the note 2. |
| Samsung | Ok with the objective and also notes from Nokia |
| Ericsson | OK with the objective and note |
| CATT | OK with the objective and note. |
| Intel | We are fine with objective. Phase noise modeling is usually not considered for FR1 scenarios because it has negligible impact on performance. |
| ZTE | Ok with the objective and note. |
| Huawei | OK with the wording with Nokia clarification. |

### Summary and recommendation for further discussion

**Summary of views:**

* Objective 2-1: BS interference-aware receivers for Scenario a): Inter-cell interference
  + Objective is stable.
  + Based on topic prioritization recommend to further discuss it till Dec

|  |
| --- |
| Define BS demodulation requirements for Inter-cell interference scenario   * + - Type of requirements: PUSCH requirement     - Reference receiver:     - MMSE-IRC with DMRS based interference covariance estimation     - Target frequency: FR1     - Rx antenna number: further discuss and decide in the WI     - Identify the interference profiles for requirements definition     - LTE interference profiles can be used as a starting point |

* Objective 2-4: BS FR1 PUSCH 256QAM demodulation requirements
  + Moderator: Objective is stable. No further discussion needed.
  + Proposed objective for WID

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| Define PUSCH demodulation requirements for FR1 256QAM   * Note 1: low mobility is considered for requirements definition * Note 2: Realistic phase noise modelling is left up to the contributing entities. |

# References

[1] RP-201331 “Work areas of RAN4 R17 non-spectrum related WI/SIs”, RAN4 Chair, RAN#88e.

[2] RP‑201967 “Email discussion summary for RAN4 Rel-17 demodulation scope”, China Telecom, RAN#89e