[95e-05-RAN4-R18-FR2MultiRx] - Version 0.0.7
RAN

3GPP TSG-RAN Meeting#95-e draft RP-220865

Electronic Meeting, March 17-23, 2022

Agenda item: 9.1.4

Source: Moderator(Qualcomm Incorporated)

Title: Moderator's summary for discussion [95e-05-RAN4-R18-FR2MultiRx]

1 Introduction

In this discussion thread, the detailed scope for the Rel.18 RAN4 led work item on Requirements for NR frequency range 2 (FR2) multi-Rx chain DL reception will be discussed. The aim of this discussion is to finalize this WID so that it can approved as part of the Rel.18 RAN4 package.

The discussion is based on the draft WID captured in RP-220057 which was the outcome of the Rel.18 RAN4 package discussion summarized in RP-220020.

2 Initial Round

2.1 Motivation

The motivation as captured in RP-220057 is as follows:

The existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that UE is equipped with a single antenna panel and capable to perform DL reception using a single RX beam/chain reception. Furthermore, the UE performance requirements are limited for DL MIMO rank 1 and 2. In FR2, 4-layer MIMO reception requires beam reception from at least two directions. Although this is supported by the MIMO features since Rel-15, no performance requirements have yet been specified. This is important for high-rate MIMO in FR2, as well as for FR2 HST scenarios.

During Rel-16 and Rel-17, the support of NR FR2 CA with IBM (Independent Beam Management) and CBM (Common Beam Management) with simultaneous DL reception on different component carriers from the co-located and non-col-located TRPs was defined. The IBM concept implies a UE is capable of DL simultaneous reception on different UE panels/chains using separate beams on different component carriers and requires improved UE baseband and RF capabilities (multiple baseband chains and support of multiple antenna panels).

Several enhancements to enable efficient and robust DL multi-TRP/panel operation were introduced in the Rel-16 NR eMIMO WI. For instance, DL transmission schemes with simultaneous and non-simultaneous multi-beam reception from multiple TRPs/panels were introduced. The simultaneous reception may require support of simultaneous multi-panel operation with several independent RX beams/chains at the UE side. As part of this item, a new FR2 UE capability for simultaneous multi-beam reception was introduced

(simultaneousReceptionDiffTypeD-r16). However, no RF, RRM or performance requirements were defined in Rel-16 and Rel-17 for FR2 UEs with simultaneousReceptionDiffTypeD-r16 capability.

Enhanced NR FR2 UEs with multi-beam simultaneous reception and multiple RX chains can provide a meaningful performance improvement in FR2 improving both demodulation performance (4-layer DL MIMO), RRM performance and improve RF spherical coverage. This work item aims to introduce the requirements for UEs capable of multi-beam/chain simultaneous DL reception on a single component carrier to achieve improved RF, RRM and UE demodulation performance.

Different implementation scenarios could be considered at the UE. Single-TCI reception on different beams has been supported since Rel-15 via the Type I codebook, requiring coherent reception at the UE from at least two directions, which could be achieved with either a single panel or multiple coherent panels. Alternatively, dual TCI operation can work with or without the assumption of coherence at the UE, and can be combined with the Rel-17 mTRP framework even if the base station is actually deployed as a single TRP. Dual TCI operation is therefore the most flexible assumption allowing a variety of actual implementations.

This WI therefore provides the requirements for both single and dual TCI assumptions to specify requirements for reception of 4-layer downlink MIMO with simultaneous reception at the UE from two different directions.

Is this motivation agreeable? Are there any changes needed?

Feedback Form 1:

1 – Apple (UK) Limited

We suggest removing the paragraph below to avoid any confusion.

”Different implementation scenarios could be considered at the UE. Single-TCI reception on different beams has been supported since Rel-15 via the Type I codebook, requiring coherent reception at the UE from at least two directions, which could be achieved with either a single panel or multiple coherent panels. Alternatively, dual TCI operation can work with or without the assumption of coherence at the UE, and can be combined with the Rel-17 mTRP framework even if the base station is actually deployed as a single TRP. Dual TCI operation is therefore the most flexible assumption allowing a variety of actual implementations.”

1. There is no specific specification text as to if and how a R15 UE supports single-TCI reception on different beams. It may or may not be supported by a UE depending on implementations.
2. It is not clear what ”coherent reception at the UE from at least two directions” means, in particular the definition of ”coherent reception”. Similar comments on the statement ”dual TCI operation can work with or without the assumption of coherence at the UE”.

2 – vivo Communication Technology

The paragraph “Enhanced NR FR2 UEs with multi-beam… UE demodulation performance” seems a bit problematic and not needed. This paragraph was emphasized the “improvement” of the requirements. However, it is a new testing scenario that would be defined, and “improvement” may be misleading to be improved based on current testing scenario.

2.2 Objectives for the core part

2.2.1 RF part

The proposed objective for the RF core part based on RP-220057 is as follows:

- Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on single component carrier with up to 4DL MIMO
  - Enhanced RF requirements:
    - Specify RF requirements, mainly spherical coverage requirements, for devices with simultaneous reception with different QCL TypeD RSs
    - [Note that the current requirement of 50%-ile spherical coverage is kept intact]

Please provide answers/comments to the following issues:

1. Is it necessary to mention different QCL Type D RSs for the RF requirements or can they be done in an agnostic way by just assuming reception from 2 different angles of arrival?

2. Should the Note in [] be kept or modified? if it should be modified, please provide a concrete proposal

3. Are there any other changes needed? If yes, please provide suggestions/proposals

Feedback Form 2:

1 – MediaTek Inc.

1. Suggest to keep different QCL Type D RSs. At least in our view, same Type D QCL would means UE is allowed to use the same Rx beam for data reception. This would give a wrong message to UE in the test and should be precluded.

2. The note is not very clear to us. We expect the spherical coverage requirements for UE capable of multiple-panel reception may need to be re-defined because we are now using 2 AOA at the same time. We would like to hear more explanations/justifications.

2 – Apple (UK) Limited

1. The current wording of ”different QCL Type D RSs” was picked for clarity so it is better to keep it.

2. As the requirements to be specified are targeted for UEs capable of simultaneous reception with different QCL TypeD RSs only, it needs to be made clear that the current requirement of 50%-ile spherical coverage is kept intact. Therefore, the brackets of the note should be removed to distinguish between the new requirements and the current requirements.

3 – Sony Group Corporation

A clarification question, is the WI limited to PC3? If so, we think a clarification in the WI would be needed. Otherwise, it seems the note in the bracket with ”50% spherical coverage” can only apply to PC3 while other power classes have different values for spherical coverage.

4 – Qualcomm Finland RFFE Oy

1. It is better to specify in the WID that the requirement will be derived using dual TCI assumption. It will prevent a lot of discussion on beam management as it pertains to definition of RF requirements.

2. In principle, yes, but this number will depend on power class.

3. To Sony: In principle, we think this functionality would be agnostic of power class. We however do see that devices with better spherical coverage would have a greater chance of supporting 4L DL in the field in a scattering rich environment.

5 – ZTE Corporation

currently the baseline power class is not clearly defined yet,whether this should use the FR2 PC3 as baseline, it should be clarified.

6 – ZTE Corporation

1. Similar comments MTK and Apple, different QCL Type D RSs should be kept to make the objectives more clear.

2. For Note of 50%-ile spherical coverage is kept intact, just wondering whether its spherical coverage could be improved due to multi-Rx chain reception. More clarity is needed for better understanding of the NOTE.

7 – Guangdong OPPO Mobile Telecom.

1. Ok to keep different QCL-D in the WID to simplify the discussion, but meanwhile actually it is QCL type agnostic in the field to use the multi-panel and only different AoA matters.

2. About the spherical coverage, it is not quite clear to us at this moment about the requirement definition under two panel reception scenario, for example is the two panel receive the same DL signal and the total spherical is SUM of each panel, or it is the common area of each spherical? This may need further discussion to give a clear definition of the spherical coverage. Therefore, we would like to leave it for further discussion in the WI phase.

3. In this WI only PC3 is considered, this should be clarified.

Suggested **changes**:

Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on single component carrier with up to 4DL MIMO

Enhanced RF requirements:

- Specify **necessary** RF requirements, ~~**mainly spherical coverage requirements,**~~ for **handheld UEs** ~~**devices**~~ with simultaneous reception with different QCL TypeD RSs

- ~~**[Note that the current requirement of 50%-ile spherical coverage is kept intact]**~~

8 – vivo Communication Technology

1. The current wording is preferred. Admittedly it is a bit unusual to mention QCL type D in RF requirements, but this is more precise and also aligned with other parts, and it is worthwhile to use it.

2. It can be kept. We can accept only PC3 is supported, otherwise we may have to remove the specific 50% value, and using a more general wording such as ”The current requirements spherical coverage is kept intact for the current testing scenario”.

3. Other minor changes can reference RP-220593.

9 – LG Electronics Inc.

1. Prefer to keep the different QCL type D RSs to clear work’s objective

2. We are fine with removing the [ ] for PC3, but we think that there is no need to limit the power class, i.e., all power classes can be within scope of this WI. And, as commented by OPPO, it is better to clarify whether the spherical coverage for simultaneous reception with two panels (2 AoA) is based on the same DL signals and sum of those.

10 – Samsung Electronics Co.

It is better to keep the different QCL type D for better clarifications.

The ”[ ]” can be removed. As analysied in our paper in previous WG meeting (R4-2200925), UE spherical coverage performance does not quite rely on the number of panels in a UE. With such understanding and also avoid potential extensive discussion in the WI on spherical coverage requirements, we suggest to keep this bullet, i.e., ”[ ]” can be removed

11 – China Mobile Com. Corporation

1. It is better to clarify “different QCL Type D RSs” in the objectives

2. We can keep the Note with removing exact number, it is not necessary to limit PC3

12 – LG Uplus

We also think this functionality would be agnostic of power class. It is not required to limit at this point. Hence, the ”Note” part can be clarified based on the consensus within this discussion.

13 – Intel Corporation (UK) Ltd

1. It is a good point. We agree that mentioning QCL assumptions for RF requirements may not be required. Meantime, we are ok to keep it for consistence. One option is to keep QCL assumptions in the general Core part objective and mention 2 AoA in the RF sub-objective

2. Brackets can be removed.

3. Recommend the following objectives

- Introduce necessary requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier with up to 4DL MIMO layers
    - Enhanced RF requirements:

▪ Specify RF requirements, including spherical coverage requirements, assuming UE is capable of reception from 2 different angles of arrival ▪ Note: the current requirement of 50%-ile spherical coverage is kept intact
14 – Nokia France 1. We agree with that for the RF requirements it would be enough to say "with simultaneous DL reception from two different directions", but we are also OK to keep the current text. We slightly prefer "different directions" to "different angles of arrival" because the concept of angles of arrival is more relevant for positioning rather than MIMO reception.
15 – Huawei Technologies France It would be better to make it clear what the power class considered here.
16 – Nokia France 2. Maybe a compromise could be to say "Note that the spherical coverage must at least meet the same requirement as with a single beam."

2.2.2 RRM part

The proposed objectives for RRM based on RP-220057 are as shown below. This part was captured in the performance part in the draft, however, in the moderator's understanding, at least some of these requirements would be core RRM requirements.

- Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier with up to 4DL MIMO
  - Enhanced RRM requirements
    - Specify RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier. At least following points can be candidates:
      - Delay/timing/interpretation/scheduling restriction

Please provide answers/comments to the following issues:

1. The objective above was captured in the performance part of the draft WID in RP-220057, should these be part of the core requirements?

2. Should the requirements to be discussed in RAN4 be explicitly captured in the WID or should there be just a tentative list and let RAN4 decide which requirements will be discussed/defined?

- If an explicit list should be captured, please provide a concrete list of items

3. Are there any other changes needed? If yes, please provide suggestions/proposals

Feedback Form 3:

1 – MediaTek Inc.

1. we agree with moderator that this belongs to the core part requirements

2. It is better to list some specific requirements to save some RAN4 discussion time .

   - The following requirements can be added in the WID: handover, connection mobility control (RRC re-establishment, RRC release with redirection), RLM, BFD/CBD, L1-RSRP, SCell activation, PS-Cell addition, TCI-state switch, CONNECTED mode SSB-based intra/inter-frequency measurement delay, scheduling/measurement restriction.

   - We can add a note like ”other requirements can be considered later based on the RAN4 consensus”, in case we missed some essential requirements in the discussion this week. But we may need to be careful to prioritize Rel-15 baseline requirements over Rel-16/17.

   - The current terms ”timing” and ”interpretation” are NOT very clear to us. We would like to hear some explanations or justifications.

   - We would have some concern to reduce the measurement delay with multiple activated panels in IDLE mode in which UE power consumption is a very important KPI. Therefore, it would be good to add a limitation that the enhancements are limited in CONNECTED mode.

3. We also want to make sure that there are some feasibility check before introducing new requirements. For an example, if the UE needs to receive serving cell PDSCH and neighboring cell SSB with the same panel, probably the scheduling restriction should still be allowed.

With above discussion, we suggest to revise the objective as

- Specify **CONNECTED mode** RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier. At least following ~~**points**~~ **requirements** can be candidates**, subjected to RAN4 feasibility study**:

  - ~~**Delay/timing/interpretation/scheduling restriction**~~**Handover, connection mobility control (RRC re-establishment, RRC release with redirection), RLM, BFD/CBD, L1-RSRP, SCell activation, PSCell addition, TCI-state switch, CONNECTED mode SSB-based intra/inter-frequency measurement delay, scheduling/measurement restriction.**

    - **Note: other Rel-15 requirements can be considered later based on the RAN4 consensus.**

2 – Apple (UK) Limited

1. We agree they are core requirements.

2. It is better if we can agree on a set of requirements to be worked out at this meeting to avoid lengthy discussion in RAN4. In our view, the following list can be a candidate, as shown in RP-220440.

– L3 and L1 measurement delay

– RLM and BFD/CBD

– Scheduling restriction

– TCI switching delay with dual-TCI

we also agree with MediaTek to limit the requirements to connected mode.

3 – ZTE Corporation

1. We also agree they are core requirements.

2. Regarding the impacted RRM requirement, we could use the Apple's version as starting point. From our understanding, some of MTK proposals are not related with dual TCI reception proposed here.

3. Regarding reduction of the measurement delay with multiple activated panels in IDLE mode, we still have strong interest on it since the existing measurement delay in idle and inactive mode is quite long especially considering the big Rx beam sweeping and long DRx cycle.

4 – Guangdong OPPO Mobile Telecom.

1. We also agree they are core requirements.

2. We support to explicitly capture the requirements to save the debating time in RAN4. The followings could be high priority:

– L3 and L1 measurement requirements

– RLM and BFD/CBD requirements

– Scheduling/measurement restriction

– TCI state switching delay

we also agree with MTK to only consider connected mode.

5 – vivo Communication Technology

1. This should be part of core requirements.

2. As suggested in the discussion part of RP-220593, more specific requirements can be considered□

a) Specify TCI switching delay requirements for dual-TCI case

b) Study timing difference from different directions, and if necessary, specify new Rx timing requirements (e.g. similar to MRTD)

c) Study and if necessary, specify enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors.

d) Study and if necessary, specify enhancements BFR and RLM requirements for mTRP with simultaneous dual-TCI reception.

e) Other necessary requirements are not precluded and are subject to WI stage discussion

6 – LG Electronics Inc.

1. agree they are core requirements
2. We think it is better to capture explicitly the scope, and we are fine with Apple's lists.

7 – Samsung Electronics Co.

1) They are core requirements.

2) It is benenfit to list some specific requirements which have been already identified with impact due to introducation of multiple panels. On the other hands, if other requirements are identified during the WI phase, these shall not be precluded. Considering above, vivo's proposal can be used

8 – China Mobile Com. Corporation

1. We agree with moderator that these requirements belong to core part.
2. Having a list is fine. Apple's list is more generic and can be considered as baseline. But if impacts on other requirements are identifies in the WI phase, we still need to define them.

9 – Intel Corporation (UK) Ltd

1. Yes, RRM requirements need to be moved to Core part
2. Prefer to keep requirements up to RAN4 WG discussion and list several examples (e.g. L1/L3 measurement delay reduction). We are open for additional requirements mentioned by Apple
3. The following objectives are proposed

- *Introduce necessary requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier with up to 4DL MIMO layers*
    - *Enhanced RRM requirements:*
        - *At least following enhanced requirements are considered: L1/L3 measurement delay reduction.*

10 – Huawei Technologies France

In our understanding, timing requirements do not rely on UE beam operations. Interruption requirements specify the impacts on one CC due to the actions on another CC. So, currently we don't observe the clear impacts on timing and interruption requirements due to UE supporting DL reception simultaneously with different QCL-TypeD RSs on a single CC. Whether there are other impacts, e.g., PSCell/SCell activation delay or TCI state switching, needs further study. Therefore RAN4 needs to first identify which RRM requirements in FR2 can be enhanced, then we think it is premature to list the candidates.

11 – Ericsson LM

- RRM is part of core requirements
- RRM objective should list all requirements needed to be specified.

- Terms like L1 and L3 measurement delay can be confusing? For example does it include only measurement period or also cell search.
- We support MTK's updated version of RRM objectives since it clearly lists each requirement

12 – Nokia France

1. Yes, it should be core

2 &3. For the RRM requirements, we think it is not feasible to list all but we should list some examples, and part of the RRM work would be to identify all impacted parts. The original wording is fine (except 'interpretation' should be 'interruption'). Besides, we don't think mentioning 'with up to 4DL MIMO' is needed. Core requirements seldom address MIMO layers (more in Demod) while the RRM part is not impacted by '4DL MIMO'. We suggest the following rewording:

- Introduce necessary core requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier ~~with up to 4DL MIMO~~
  - Enhanced RRM requirements
    - Specify RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier. At least following points can be candidates:
      - Delay/timing/interruption/scheduling restriction

2.3 Objectives for performance part

The proposed objectives for the performance part based on RP-220057 are as shown below. There are some changes compared to the draft intended to adapt the content as part of it was moved to core. The intention in the second subbullet is to cover the case when existing requirements are reused for this feature, however, there are no corresponding tests with simultaneous transmission from TE and simultaneous reception at the UE.

- Introduce necessary performance requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier with up to 4DL MIMO
  - RRM Performance requirements corresponding to the new core requirements
  - RRM test cases to verify the UE behavior/functionalities needed to support this feature
  - UE demodulation requirements:
    - Specify UE demodulation and CSI performance requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier

NOTE:

- For the dual-TCI case, focus on handheld UEs supporting “simultaneousReceptionDiffTypeD-r16” UE capability, and for the 2- or 4-layer downlink MIMO reception, focus on UEs supporting the basic mTRP CSI reporting capability (FG 23-7-1 of NR FeMIMO).
  - stage 1: 2 layers downlink MIMO
  - stage 2: 4 layers downlink MIMO
- FFS staged approach for 2 and 4 MIMO layers should be needed.

Please provide answers/comments to the following issues:

1. Are there any changes needed to the RRM performance part of the objectives? If yes, please provide concrete proposals on what changes should be made

2. Should the FFS part in the last bullet be moved under the “UE demodulation requirements” bullet? Are there any changes needed to this subbullet?

3. Are there any other changes needed to the UE demod part? If yes, please provide concrete proposals on what changes should be made

Feedback Form 4:

1 – Apple (UK) Limited 1. For the second sub-bullet, suggest some wording like ”RRM test cases to verify the UE behavior/functionalities needed to support this feature in case existing requirements are reused” 2. Regarding the staged approach for MIMO, we don’t see a strong need as it is part of the WI plan when the work starts in RAN4.
2 – Qualcomm Finland RFFE Oy 1. We are ok with the Apple proposed change. 2. We are ok to remove FFS and leave it to RAN4 discussion
3 – ZTE Corporation For staged work plan for 2 and 4 MIMO layers, it could be discussed in the work plan phase.
4 – MediaTek Inc. We are fine to remove the ”FFS staged approach ...” and leave it to RAN4 workplan discussion.
5 – vivo Communication Technology 1. Basically fine.

2. We think the whole Note can be removed with some key information supplemented into previous demodulation/CSI part, since there are some duplicate information. One tentative solution can be as in RP-220593 as following:

• UE demodulation requirements and CSI reporting requirements with up to 4 layers DL MIMO~~:~~

- For CSI reporting requirement: Focus on UEs supporting basic mTRP CSI reporting capability (FG 23-7-1 of NR FeMIMO)~~S~~

6 – China Mobile Com. Corporation

1. OK with the performance objectives
2. Remove FFS and leave it to RAN4 discussion

7 – Intel Corporation (UK) Ltd

1. Recommend to formulate RRM Perf objective as "*RRM performance requirements and test cases*"
2. Prefer to remove FFS part and remove stages
3. Perf part objectives can be formulated as

- Introduce necessary requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier with up to 4DL MIMO layers
  - UE demodulation and CSI performance requirements
  - RRM performance requirements and test cases

8 – Huawei Technologies France

The first bullet already clearly states the performance requirements for enhanced FR2 UE with DL reception simultaneously with different QCL TypeD RS (same meaning as focus on handheld UEs supporting "simultaneousReceptionDiffTypeD-r16" UE capability in the NOTE) for single carrier with up to 4 DL MIMO , it is not necessary to keep that NOTE that states duplicated information. How to define the requirements for 2 layers and/or 4 layers down MIMO can leave it to RAN4 discussion.

9 – Ericsson LM

Agree with Intel that for RRM performance, it is better to formulate the objective as: "*RRM performance requirements and test cases*".

Performance requirements are done within 2-3 quarters. We therefore also don't see any reason to stage the demod work into 2 phases/stages.

10 – Nokia France

1. We prefer to keep "if needed" in the RRM performance requirements bullet because RAN4 may conclude there is no performance impact during the WI after the discussion.
2. The demod bullet needs to be modified to reflect both single and dual TCI options as stated in the Justification.

3. We suggest revising the note so it is applicable for demod study only. RRM may not exclude adding additional UE capabilities regarding simultaneous reception and measurement. Also FG 23-7-1b should be added as it lists the "triplets" for number of ports/resources in case of single-TRP measurement hypothesis

We propose the following rewording:

- Introduce necessary performance requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier with up to 4DL MIMO
    - RRM Performance requirements corresponding to the new core requirements, if needed
    - RRM test cases to verify the UE behavior/functionalities needed to support this feature
    - UE demodulation requirements:
        - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI with different QCL typeD on a single component carrier.
            - Demod requirements on up to 4 DL MIMO layers
              CSI requirements to support up to 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook
        - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI
            - Demod requirements on 4 DL MIMO layers
            - CSI requirement to support 4-layer with single TCI and Rel-15 Type I codebook
        - ~~Specify UE demodulation and CSI performance requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier~~

NOTE:

- For the dual-TCI demodulation requirement case, focus on handheld UEs supporting "simultaneousReceptionDiffTyp r16" UE capability, and for the 2- or 4-layer downlink MIMO reception, focus on UEs supporting the basic mTRP CSI reporting capability (FG 23-7-1/1b of NR FeMIMO).
- stage 1: 2 layers downlink MIMO
- stage 2: 4 layers downlink MIMO
- ~~FFS staged approach for 2 and 4 MIMO layers should be needed.~~

2.4 Other Comments

Are there any other comments regarding any aspect of this WID?

Feedback Form 5:

1 – Qualcomm Finland RFFE Oy

For practical FR2 deployments, single carrier may not be general enough. We would like to ensure intra-band CA is not precluded, and prefer to include requirements for the latter. We understand that single carrier requirements will need to be determined first as a baseline.

2 – ZTE Corporation

Similar comment as Qualcomm, single carrier is not the typical deployment in FR2, at least intra-band CA should be included with single carrier as baseline requirement.

3 – Guangdong OPPO Mobile Telecom.

Suggest to focus on single carrier in Rel-18, the CA case can be further discussed in future release. CA is not a small topic...

4 – Apple (UK) Limited

We prefer to focus on single carrier first. Keep in mind that with simultaneous reception of different beams, UE not only needs to boost its RF capability, i.e. with two panels, but also baseband processing capability. The support of intra-band CA would demand too much increase of baseband processing capability.

5 – LG Electronics Inc.

For power class, need to be clarified whether only focus on PC3 or other power classes are within scope of the WI. We prefer to consider all power classes in this WI.

6 – vivo Communication Technology

Considering the complexities of CA and multi-panel, we also prefer only single carrier requirements in Rel-18 at least in current stage. CA can be considered in Rel-19, or we may come back to this if we can have quick convergence for single carrier case.

7 – Intel Corporation (UK) Ltd

1. Ok with companies proposal to focus on single carrier case. Also, agree with Qualcomm on intra-band (not precluded and can be included later)
2. Prefer not to limit to specific power class and consider all.

8 – Huawei Technologies France

We prefer to focus on single carrier first considering this is the first release for FR2 UE to support simultaneous reception from different beams. CA case can be discussed in further release.

9 – Ericsson LM

Starting with single carrier and extending to intra-band CA in later stage is fine for us.

2.5 Summary of the 1st round

2.5.1 Motivation

Two companies commented that some paragraphs from the motivation should be removed. The updated motivation with the removed paragraph will be proposed for further comments in the intermediate round.

2.5.2 Objectives for the core part

2.5.2.1 RF part

1. Most companies commented that ”different QCL Type D RSs” should be kept some companies would prefer to remove this but are also fine to keep it. Based on this discussion, moderator proposes to keep ”different QCL Type D RSs” going forward

2. Many companies commented that the legacy spherical coverage should be kept while some companies asked for clarification about the exact meaning of such a note. In the moderator’s understanding, UEs supporting simultaneous reception still have to meet the Rel.15 spherical coverage requirements with a single active panel. The note is meant to clarify that this Rel.15 requirement will be kept and also that any spatial requirements related to simultaneous reception should be applicable to directions(angles of arrival) that are within spherical coverage.

The moderator proposes to modify the note as follows:

The legacy spherical coverage requirement for reception from a single direction will be kept. Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage.

3. There were multiple comments related to the power class for which the requirements should be defined. Some companies commented that the work should be limited to PC3(handheld device) while others commented that other power classes should also be considered. In order to progress the discussions, the moderator proposes that PC3 will be considered first while requirements for other power classes can be considered after PC3 is finalized. If a requirements framework for PC3 is developed, the discussion for other power classes should be simpler.

2.5.2.2 RRM part

1. All companies agreed that these objectives for core requirements.

2. Most companies prefer to capture an explicit list of requirements that should be discussed in RAN4 in order to streamline the discussion. Some companies proposed an explicit list, this can be further refined in the next rounds of discussion. Also, several companies commented that only connected mode requirements, moderator proposes to further consider only connected mode requirements.

3. In the moderator’s understanding, the enhancements introduced until now in previous MIMO enhancement WIs are for connected mode, hence, it is proposed to only consider connected mode requirement. Idle mode enhancements are not needed for this feature to work. Some companies commented that there is no need for 4DL MIMO in the RRM part, this can be erased.

2.5.3 Objectives for the performance part

1. Some companies suggested that the first subbullet should be reworded to ”RRM performance requirements and test cases corresponding to the new core requirements”, this change will be proposed for the updated objectives in the intermediate round. Some companies suggested the the 2nd subbullet should be reworded to RRM test cases to verify the UE behavior/functionalities needed to support this feature in case existing requirements are reused”. This change will also be proposed for the updated objectives in the intermediate round.

2. Most companies prefer to remove the FFS. Some companies proposed to make some changes the objectives that will be reflected in the update proposed for the intermediate round.

3. Some companies proposed some wording changes and also the inclusion of demod requirements for single TCI. Changes will be further discussed in the intermediate round.

2.5.4 Other comments

Some companies commented that intra-band band CA should also be consider. The moderator tends to agree with these comments as high throughput in FR2 is achieved through the use of many CCs in a single band. If the feature is defined only for single carrier, it would most likely not be used in practice because CA will anyway offer a better throughput. Moderator proposed to intra-band CA after the single carrier requirements are defined.

There were also some comments regarding the power class to be considered, this was addressed in the RF core section.

3 Intermediate Round

3.1 Motivation

The updated motivation based on the initial round is as follows:

The existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that UE is equipped with a single antenna panel and capable to perform DL reception using a single RX beam/chain reception. Furthermore, the UE performance requirements are limited for DL MIMO rank 1 and 2. In FR2, 4-layer MIMO reception requires beam reception from at least two directions. Although this is supported by the MIMO features since Rel-15, no performance requirements have yet been specified. This is important for high-rate MIMO in FR2, as well as for FR2 HST scenarios.

During Rel-16 and Rel-17, the support of NR FR2 CA with IBM (Independent Beam Management) and CBM (Common Beam Management) with simultaneous DL reception on different component carriers from the co-located and non-col-located TRPs was defined. The IBM concept implies a UE is capable of DL simultaneous reception on different UE panels/chains using separate beams on different component carriers and requires improved UE baseband and RF capabilities (multiple baseband chains and support of multiple antenna panels).

Several enhancements to enable efficient and robust DL multi-TRP/panel operation were introduced in the Rel-16 NR eMIMO WI. For instance, DL transmission schemes with simultaneous and non-simultaneous multi-beam reception from multiple TRPs/panels were introduced. The simultaneous reception may require

support of simultaneous multi-panel operation with several independent RX beams/chains at the UE side. As part of this item, a new FR2 UE capability for simultaneous multi-beam reception was introduced (simultaneousReceptionDiffTypeD-r16). However, no RF, RRM or performance requirements were defined in Rel-16 and Rel-17 for FR2 UEs with simultaneousReceptionDiffTypeD-r16 capability.

This WI therefore provides the requirements for both single and dual TCI assumptions to specify requirements for reception of 4-layer downlink MIMO with simultaneous reception at the UE from two different directions.

Is this motivation agreeable? Are there any changes needed?

Feedback Form 6:

1 – Verizon UK Ltd

The motivation is clear and fine to us.

2 – Nokia France

We have just a couple of comments:

1. In the first paragraph, the statement "The existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that UE is equipped with a single antenna panel and capable to perform DL reception using a single RX beam/chain reception" is actually not quite correct. In fact, the existing requirements assume that the UE is equipped with one or more panels, of which only one panel would be active at a time.

We therefore propose the following correction: "The existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that UE is equipped with one or more ~~a single~~ antenna panels and is capable ~~to~~ of performing DL reception using a single RX beam/chain reception".

2. We actually thought the wording of the deleted text was clear, and we did not see the need to remove it. Nevertheless, we would be OK with removing some of the references to implementations. We would suggest the following wording (modified relative to the original version):

Different implementation scenarios could be considered at the UE. Single-TCI reception on different beams has been supported by the RAN1 specifications since Rel-15 via the Type I codebook, ~~requiring coherent reception at the UE from at least two directions,~~ which could be achieved at the UE with either a single panel or multiple ~~coherent~~ panels. Alternatively, dual TCI operation ~~can work with or without the assumption of coherence at the UE, and~~ can be combined with the Rel-17 mTRP framework even if the base station is actually deployed as a single TRP. ~~Dual TCI operation is therefore the most flexible assumption allowing a variety of actual implementations.~~

This WI ~~therefore~~ provides the requirements for both single TCI and dual TCI assumptions to specify requirements for reception of 4-layer downlink MIMO with simultaneous reception at the UE from two different directions.

3.2 Objectives for the core part

3.2.1 RF part

Based on the initial round of discussion, the updated objective for the RF core part is as follows:

- Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on single component carrier with up to 4DL MIMO
  - Enhanced RF requirements:
    - Specify RF requirements, mainly spherical coverage requirements, for devices with simultaneous reception with different QCL TypeD RSs
    - The legacy spherical coverage requirement for reception from a single direction will be kept. Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage
  - PC3 will be prioritized, other power classes should be considered after the PC3 requirements framework is finalized

Please provide answers/comments to the following issues:

1. Should ”mainly spherical coverage requirements” in the 1st subbullet be kept or removed/reworded? It it should be reworded, please provide an alternative proposal.

2. Is the 2nd sub-bullet with the spherical coverage clarification agreeable? if it should be modified, please provide a concrete proposal.

3. Do you agree to prioritize PC3 while maintaining the possibility to consider other power classes? Please not that the intent with the formulation ”framework” is to be able to start the discussion on other power classes after it will be agreed which/how requirements are defined for PC3 without having to wait for the actual numbers to be finalized. Also, which power class is considered will impact the RRM discussion because some of the RRM requirements are different for different power classes.

4. Any other comments or suggestions?

Feedback Form 7:

1 – Qualcomm Finland RFFE Oy

1. We think there is need for some sort of spatial requirement for simultaneous reception from multiple directions. We are open to alternative wording proposals from other companies.

2. Our understanding of ’...should be specified for directions that are within spherical coverage’ is that the directions for 4L testing refer to those that meet the sensitivity requirement of the single layer spherical coverage sensitivity requirement. This includes directions that are not limited to the top 50% for PC3, for example. (this applies to a UE that performs better than minimum requirement)

3. yes

2 – Verizon UK Ltd

1. Yes, the spherical coverage requirements are needed for simultaneous reception from different directions. Also we agree the different QCL Type D RSs" should be kept for beam performance.

2. We are ok for the 2nd sub-bullet with the spherical coverage clarification!

3. Yes, for PC3 first!

3 – Apple (UK) Limited

1. The current wording is OK. On the one hand, it identifies the common understanding, i.e., if there is a new requirement, it is mainly the spherical coverage requirement; on the other hand, it does not close the door to other possible requirement with the modifier "mainly".

2. The meaning of sentence "Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage" is unclear. Using power class 3 as an example, EIS spherical coverage requirement is defined at the 50th percentile of the CCDF of EIS measured over the full sphere around the UE. However, it does not say anything clear about the entire spherical coverage, say if there is a coverage blind spot or not. As such, the condition "be specified for directions that are within spherical coverage" may not be easily verified. A simple WF may be to do away with the sentence, and leave it to RAN4 discussion.

3. Prioritizing PC3 is OK.

4 – MediaTek Inc.

1. We are fine to keep "mainly spherical coverage requirements".

2. Is the intention of the modification that the 2 AoA to be used for simultaneous reception should be selected within the set of best [50%] AoAs according to the legacy spherical coverage requirements? If so, we are fine with the modification. In our understanding, this is very straightforward limitation.

3. Fine to start from PC3

5 – Huawei Technologies France

Some modifications and clarification points:

- Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception with **two** different QCL TypeD RSs on single component carrier with up to 4 **layer** DL MIMO

Clarification of "The legacy spherical coverage requirement for reception from a single direction will be kept", single direction means single TRP, single beam(single QCL type D) or two beams with same direction? Do we still consider single panel reception for the same direction? Our understing is single QCL type D, and single panel reception is still considered. If it's the common understanding, we propose the changes

- The legacy spherical coverage requirement for reception from a ~~single direction~~**singlebeam of same QCL type D** will be kept. Any new spatial requirements for simultaneous reception should be specified for directions **(two different QCL type D)** that are within spherical coverage

6 – Nokia France

1. "Mainly spherical coverage requirements" is OK.

2. Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage" is very unclear to us. We suggest modifying as follows:

The legacy spherical coverage requirement for reception from a single direction will be kept. The aggregated spherical coverage from multiple directions simultaneously shall be greater than the legacy spherical coverage requirement for reception from a single direction.~~Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage~~

3. Yes

4. In the first sub-bullet, while we are OK to keep "different QCL Type D RSs", we would like to include also "from different directions" for clarity:

"Specify RF requirements, mainly spherical coverage requirements, for devices with simultaneous reception from different directions with different QCL TypeD RSs".

Thank you.

7 – Samsung Electronics Co.

We have different understanding as Moderator on the note on existing spherical coverage. The note is added based on the discussion on whether the exisiting 50% requirements shall be kept for multi-panel UE. The notes in our understanding means the same 50% spherical coverage requirements shall be also specified for multi-panel UE in Rel-18. Based on this assumption, RAN4 will check if any enhancement.

With this, we suggest to keep the orginial note by removing the [ ].

8 – LG Electronics Inc.

1. We are fine with "mainly spherical coverage requirements".

2. For "… for directions that are **within spherical coverage**", does it means that the directions (2 AoA) would be within 50%-ile (i.e., PC3) of the full sphere?

3. We are fine to prioritize PC3, but other PCs should be considered after the PC3 requirements is finalized as written above objectives.

9 – Guangdong OPPO Mobile Telecom.

1. "mainly spherical coverage requirements" in the 1st subbullet is ok.

2. 2nd sub-bullet about the spherical coverage is vague, probably it tries to clarify the relation of new multi-panel requirements with legacy single panel requirement, then only the 1st half is enough, i.e. **keep**

”The legacy spherical coverage requirement for reception from a single direction will be kept”, and **remove** ”Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage”, this can be discussed in WI phase.

3. ok.

10 – vivo Communication Technology

1. It is ok to keep ”mainly spherical coverage requirements”.

2. The sentence ”Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage” is also unclear to us. It is suggested to move the discussion during the detailed discussion. In addition, we also do not think Nokia’s new proposal is clear enough either, so maybe delete it is ok.

3. Yes. Start with PC3 but not necessarily restrict to it.

4. It seems that ”up to 4DL MIMO” is not necessary for RF requirements and it is proposed to remove it, just like in RRM.

11 – ZTE Corporation

1. mainly spherical coverage requirements” , its’ okay for us.
2. we also think that more clarification on ”Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage”. As mentioned by Nokia that, the aggregate spherical coverage requirement for multiple-panel reception should be better than the requirement defined for single panel reception.
3. it’s also fine for us.

12 – Intel Corporation (UK) Ltd

1. We are ok with current wording and the main purpose of requirements would be to characterize spatial characteristics of UEs with simultaneous reception.
2. The wording ”Any new spatial requirements for simultaneous reception should be specified for directions that are within spherical coverage”. We agree with Qualcomm’s interpretation. Overall, we think that the phrase can be removed and left up to RAN4 discussion
3. Prioritizing PC3 is ok

13 – Samsung Electronics Co.

Additional comments on spherical coverage

For “...for directions that are within spherical coverage”, we shared the similar question/concerns as LG, MediaTek and Apple, i.e., ”directions (2 AoA) would be within top 50%-ile or any directions above the minimum spherical coverage? We don’t share the similar view as Moderator, and our understanding is that any enhanced RF requriements should be specified within the minimum requiremed spatial range corresponding to the specified percentile for that power class, that is within <100-percentile rank> %,

where ‘percentile rank’ is the percentile value in the specification of spherical coverage for that power class from sub-clause 6.2.1 of TS 38.101-2..

Considering <100-percentile rank> % is just minimum requirement, of course a commerical UE will do better in the conformance test, but if the requirement is applied not limited to top N%-tile directions (e.g., N=50 for PC3), it means we define a tighter requirement for 2AoA even than 1 direction, which is contradict to the first sentence ”The legacy spherical coverage requirement for reception from a single direction will be kept.” Furthermore, our understanding on the origianl Note ”[Note that the current requirement of 50%-ile spherical coverage is kept intact]” means the 2AoA coverage direction should be within the required 50%-tile region.

We proposed to revise the bullet as:

- The legacy spherical coverage requirement for reception from a single direction will be kept. **Any new spatial requirements for simultaneous reception should be specified for directions that are within top N%-tile directions**

  - **N%= 50% for PC3**

14 – Sony Group Corporation

We agree with Apple that the condition ”be specified for directions that are within spherical coverage” may not be easily verified. We think it is better to leave it to RAN4 discussion for this technical details.

3.2.2 RRM part

Based on the initial round discussion, the following updated RRM core objectives are proposed:

- Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier
  - Enhanced RRM requirements for connected mode:
    - The following requirements should be considered and specified if necessary:
      - L1-RSRP measurement delay
      - L3 measurement delay (both cell detection delay and measurement period can be considered)
      - RLM and BFD/CBD requirements
      - Scheduling/measurement restrictions
      - TCI state switching delay with dual TCI
      - [Receive timing difference between different directions]

Other requirements such as Handover, SCell activation, PSCell addition, etc were proposed, however, in the moderator’s understanding, no enhancements/changes to these procedures were made in the MIMO enhancements requirements in previous releases, hence, enhancing these requirements is not necessary for

these feature to work. The scope should be kept to a minimum necessary considering the amount of work required for this WI.

Please provide answers/comments to the following issues:

1. Should the sub-bullet in [] be kept or not? please provide arguments on why such a requirement would be needed or not

2. Should any of the other sub-bullets be removed? if yes, please provide arguments

3. Any other comments on the core RRM objectives?

Feedback Form 8:

1 – Qualcomm Finland RFFE Oy 1. Prefer to have some notion of MRTD, so we need the requirement in [ ]. 2. We think L3 measurement delay is not necessary as a feature-critical requirement. We don't see a need for faster beam tracking/ cell tracking. This feature is focused on DL throughput improvement, not RRM enhancements. This requirement could have significant impact on baseband processing.
2 – Verizon UK Ltd 1. The [] can be removed for the receiving time from different directions. And, this is based on the experience of early works.
3 – Apple (UK) Limited 1. We are OK to have the MRTD requirements.
4 – MediaTek Inc. 1. We are fine to remove [ ]. In our understanding, it would be good to have more technical discussions in RAN4, even if in the end legacy requirements will be re-used. 2. With the clarification from moderator, we are fine to limit the scope of RRM requirement within L1 (RLM, BFD, CBD, L1-RSRP, TCI state, ...). In this case, we do not see the need for the enhancement to L3 measurement. Therefore, L3 measurement can be removed. However, because L1 and L3 measurements have some relation (e.g., sharing factor in delay requirements). It may be good to clarify that whether we keep L3 requirements completely intact or some L3 requirements will be changed by the enhancement in L1 measurement. So that RAN4 knows how big the scope is. 3. We want to mention that even if 2 different QCL Type-D are configured to the UE, it does not 100% imply UE need to use 2 different panels for reception. E.g., the 2 AoA are too closed to each other from UE's viewpoint. In this case, parallel measurement or simultaneous measurement + data reception may not be possible. This should be handled by RAN4 in later discussions.

5 – Samsung Electronics Co.

Following moderator suggestions, the listed RRM requirements shall follow the previous MIMO disucssion in which MRTD is not specfied for different directions of beams. Therefore, we suggest to remove the MRTD bullet or with [ ] pending on further RAN4 discussions.

6 – LG Electronics Inc.

1. We think the sub-bullet should be considered.

3. We think there would be power consumption issue if two panels are always powered on. So, this issue needs to be discussed later.

7 – Nokia France

1. The sub-bullet in [] **must be kept** as we do not have any UE requirements related to MRTD for UE reception from non-co-located sources on the same carrier.

2. None should be removed.

3.

i) In the main bullet, insert ”from different directions” for clarity: ”simultaneous DL reception from different directions with different QCL TypeD RSs on a single component carrier”

ii) Add ‘at least’ to ‘Enhanced RRM requirements for connected mode’. Hence: ‘Enhanced RRM requirements, at least for connected mode’.

iii) Potential enhancement to other procedures such as the proposed HO, SCell activation etc should not be excluded. Enhancements to such features are particularly important when considering FR2. Moreover, the argument that ”MIMO requirements were not enhanced in previous releases, hence, enhancing these requirements is not necessary” is somewhat tangential, as this WI is not only about MIMO, but (at least for the RF and RRM parts) covers multi-Rx DL reception in general. On the other hand, we do recognise the RAN4 workload situation, and therefore propose to add the following:

- Enhancements to other RRM procedures, such as the proposed HO and SCell activation, may be considered if time permits.

8 – vivo Communication Technology

1. We support to study MRTD related issues and remove the brackets. With more than one active panel, the UE would be able to deal with larger Rx timing difference from different angles, and potential new requirements can be discussed. However, whether and how to specify these new requirements needs to be further discussed in RAN4 after the technical analysis is provided and common understandings of new baseline UE behavior assumptions can be achieved.

2. No.

3. It can be considered to add one sub-bullet as ”Other aspects are not precluded, and can be further studied in RAN4.”

9 – Intel Corporation (UK) Ltd

1. We are ok to remove []. However, in our understanding this is not a conventional MRTD requirements and applies to signal reception within one carrier

2. Prefer to keep all listed objectives and leave decision up to RAN4.

3. Agree with Nokia and vivo proposals that other aspects shall not be precluded. Sub-bullet proposed by vivo (”Other aspects are not precluded, and can be further studied in RAN4.”) is fine for us.

10 – Huawei Technologies France

1. L1 measurement delay is per-RS specified and relies on RS periodicity and the sharing strategy between L1 measurements and L3 measurements, both of them would not be impacted due to simultaneous reception with different QCL type-Ds. So L1-RSRP measurement shall be handled in RAN4.

2. Simultaneous reception with different QCL type-D RSs on single CC is considered to improve DL reception of serving cell. However, L3 measurements are performed for both serving cell and neighbor cells. L3 measurement requirements depend on searcher capability. We see no impacts on current L3 measurement requirements.

3. For the last bullet, existing MRTD requirements are specified for different CCs not for different directions/beams. We prefer the suggestion proposed by Samsung- remove the MRTD bullet or with [ ] pending on further RAN4 discussions.

11 – ZTE Corporation

1. we are fine to have MRTD requirement to specify the maximum receiver timing difference under this multi-Rx chain reception scenario.

3. not only connected mode, but also the idle mode/inactive mode should also been considered especially for the benefit of multiple-panel reception to reduce the initial access time during idle and inactive mode, we are fine with Nokia’s update to add the at least for connected mode.

12 – China Mobile Com. Corporation

1. We are OK to remove [] since the main bullet said ”The following requirements should be considered and specified if necessary”. So [] seems not needed. Keeping the bullet does not mean RAN4 will define requirements definitely.

3.3 Objectives for the performance part

Based on the initial round discussion, the following updated objectives for the performance part are proposed:

- Introduce necessary performance requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier
    - RRM Performance requirements and test cases corresponding to the new core requirements
    - RRM test cases to verify the UE behavior/functionalities needed to support this feature in case existing requirements are reused
    - UE demodulation requirements:

- Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI with different QCL typeD on a single component carrier.
    - Demod requirements on up to 4 DL MIMO layers
    - CSI requirements to support up to 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook
- [Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI
    - Demod requirements on 4 DL MIMO layers
    - CSI requirement to support 4-layer with single TCI and Rel-15 Type I codebook]

NOTE:

- For the dual-TCI demodulation requirement case, focus on UEs supporting "simultaneousReceptionDiffTypeD-r16" UE capability, and for the 2- or 4-layer downlink MIMO reception, focus on UEs supporting the basic mTRP CSI reporting capability (FG 23-7-1 of NR FeMIMO).

Please provide answers/comments to the following issues:

1. Should the part in [] be kept or not? if kept, what would be the relationship with the other objectives since single TCI is not in the RF or RRM objectives?

2. Are the performance objectives listed above agreeable? If changes are needed, please provide concrete proposals on what changes should be made.

Feedback Form 9:

1 – Qualcomm Finland RFFE Oy 1. We think requirement in [] should not be kept because it is not consistent with the assumptions for RF requirements, which is dual-TCI based. 2. support, but see #1 above.
2 – Verizon UK Ltd 1. It is ok for us to keep the requirements in [] based on the discussion in Initial Round and for for consensus purpose
3 – Apple (UK) Limited 1. The part in [] should be removed. While supporting 4DL with single TCI may be possible, it is a corner case in our understanding. Moreover, we agree with moderator comments that since RF and RRM requirements are dual-DCI based, it is better to align it with demod requirement too.

2. We don't need the NOTE in the objectives. The applicability rule based on UE capability are discussed when requirements are defined.

4 – MediaTek Inc.

1. Suggest to remove the part in [ ], which is not aligned with the RF requirements.

5 – Nokia France

1. The part in [] should definitely be kept, since single-TCI reception from different directions has been supported by the RAN1 specifications since Rel-15 via the Type I codebook. Removing it would not be aligned with the Justification section. In response to comments about alignment with the RF requirements, "different QCL Type-D" is used there as a proxy for "from different directions": in actual fact the RF requirements for reception from multiple directions should in practice be agnostic to the TCI configuration whether single TCI versus dual TCI.

2. In the NOTE, "/1b" should be added: "FG 23-7-1/1b"

6 – vivo Communication Technology

1. We prefer to remove the bullet with []. Single TCI with R15 type I codebook would be not necessarily related to multi-Rx reception, and it is slightly redundant to specify a new set of requirements for the UE in this case. We also suggested removing related description in the justification part.

7 – Intel Corporation (UK) Ltd

We are ok to keep the objective in [] and it can be potentially handled with the 2nd priority to address companies comments.

8 – China Mobile Com. Corporation

1. We are OK to keep the objective in [].

9 – Huawei Technologies France

To keep consistent with the sub-bullet "up to 4 DL MIMO layers" we suggest to add "up to" as following:

Specify performance requirements for enhanced FR2 UEs supporting **up to** 4 DL MIMO layers with dual TCI with different QCL typeD on a single component carrier.

Demod requirements on up to 4 DL MIMO layers

CSI requirements to support up to 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook

We also prefer to remove the bullet in [].

Feedback Form 10:

1 – Qualcomm Finland RFFE Oy

1. We think requirement in [] should not be kept because it is not consistent with the assumptions for RF requirements, which is dual-TCI based.
2. support, but see #1 above.

2 – Verizon UK Ltd

1. It is ok for us to keep the requirements in [] based on the discussion in Initial Round and for for consensus purpose

3 – Apple (UK) Limited

1. The part in [] should be removed. While supporting 4DL with single TCI may be possible, it is a corner case in our understanding. Moreover, we agree with moderator comments that since RF and RRM requirements are dual-DCI based, it is better to align it with demod requirement too.
2. We don't need the NOTE in the objectives. The applicability rule based on UE capability are discussed when requirements are defined.

4 – MediaTek Inc.

1. Suggest to remove the part in [ ], which is not aligned with the RF requirements.

5 – Nokia France

1. The part in [] should definitely be kept, since single-TCI reception from different directions has been supported by the RAN1 specifications since Rel-15 via the Type I codebook. Removing it would not be aligned with the Justification section. In response to comments about alignment with the RF requirements, "different QCL Type-D" is used there as a proxy for "from different directions": in actual fact the RF requirements for reception from multiple directions should in practice be agnostic to the TCI configuration whether single TCI versus dual TCI.

2. In the NOTE, "/1b" should be added: "FG 23-7-1/1b"

6 – vivo Communication Technology

1. We prefer to remove the bullet with []. Single TCI with R15 type I codebook would be not necessarily related to multi-Rx reception, and it is slightly redundant to specify a new set of requirements for the UE in this case. We also suggested removing related description in the justification part.

7 – Intel Corporation (UK) Ltd

We are ok to keep the objective in [] and it can be potentially handled with the 2nd priority to address companies comments.

8 – China Mobile Com. Corporation

1. We are OK to keep the objective in [].

9 – Huawei Technologies France

To keep consistent with the sub-bullet ”up to 4 DL MIMO layers”□we suggest to add ”up to” as following:

Specify performance requirements for enhanced FR2 UEs supporting **up to** 4 DL MIMO layers with dual TCI with different QCL typeD on a single component carrier.

Demod requirements on up to 4 DL MIMO layers

CSI requirements to support up to 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook

We also prefer to remove the bullet in [].

3.4 Other comments/objectives

Moderator proposes that the following bullet is added to the WID objectives:

- Extension of requirements to cover intra-band CA should be considered after the single carrier requirements are defined based on operator requests

Please provide answers/comments to the following issues:

1. Is the addition of this objective agreeable?

2. Do you have any other comments/suggestions for this WID?

Feedback Form 11:

1 – Qualcomm Finland RFFE Oy

Support. We see that the typical configuration in the field is for intra-band DL CA. Add intra-band to the WID makes it more relevant to field operation.

2 – Verizon UK Ltd

We support to extent the requirements to cover intra-band CA.

In addition, the achievement of intra-band CA needs to consider use of many CCs in a single band, instead of single CC, for performing the 4 layer MIMO.

3 – Apple (UK) Limited

1. We prefer not to add intra-band CA at this late stage. We already had a clear and stable scope out of the Feb. email discussion and should stick to it. In addition, as we commented in the first round, support of

intra-band CA would demand further boost to baseband processing. After the single CC case is completed in RAN4, we can discuss intra-band CA again in RAN.

4 – MediaTek Inc.

In our understanding, some RRM requirements consider intra-band CA automatically, e.g., scheduling/measurement restriction. So the clarification is only to RF and Demod?

5 – Nokia France

This document seems to be broken so we cannot read all the moderator's text above this feedback form, but we support inclusion of intra-band CA.

6 – ZTE Corporation

we support the intra-band CA configuration as we mentioned before, intra-band CA in FR2 is quite typical implementation in field.

7 – Intel Corporation (UK) Ltd

1) We support intra-band CA.

2) One suggestion is to add a check point when work on intra-band CA can be started (e.g. after RAN #99)

8 – vivo Communication Technology

We prefer to leave the disucssion to later checking point stage rather than written in WID now.

If companies really interested in this, it is prefer to use a more softened wording such as: "Extension of requirements to cover intra-band CA ~~should~~ **can** be considered **if feasible** after the single carrier requirements are defined based on operator requests", since this request comes out rather late and may be more difficult than it looks like in current stage.

3.5 Summary for the intermediate round

3.5.1 Motivation

One company commented that one of the paragraphs which was removed should be reworded and added back. In the final round, we can check whether the proposed rewording is agreeable or not.

3.5.2 Objectives for the core part

3.5.2.1 RF Part

1. Companies agree to keep "mainly" in the objective.

2. Companies agree in general with the proposed objectives, however, multiple comments suggested that the sentence regarding the relationship between the new RF requirements specific to simultaneous reception with

different QCL typeD RS and the legacy spherical coverage requirement is not clear enough. The intention of this sentence was to say that the directions over which the new requirements are defined would have to be within the top 50%-ile of the UE spherical coverage. Considering the controversy regarding this note, the moderator will propose to drop this part of the objective.

3. There were also some other editorial comments intended to further clarify the objectives which will be reflected in the final round proposal

3.5.2.2 RRM Part

1. Most companies prefer to discuss specifying some receive time difference between the signals received from different directions. To Nokia, currently there are no such requirements on the same carrier as RAN4 has not specified requirements for such a scenario. For multi-point transmissions, this is implicitly captured in the demod requirements. The main bullet says specified if necessary so nothing will be automatically specified.

2. Most companies agree to keep all the current sub-bullets, three companies commented that L3 measurements would not be needed since there are no enhancements to the measurements. Some changes based on the Mediatek comments will be proposed in the final round.

3. Some companies are proposing to include an objective that other aspects are not precluded, however, such open ended objective does not seem to be useful. This could consume a lot of discussion in RAN4 without being something clearly needed.

There were some editorial comments that will be reflected in the proposals for the final round.

It was also proposed to consider idle/inactive mode or at least do not explicitly preclude it. The moderator's understanding is that the features for which the requirements are discussed here are only configured/used in connected mode. Any idle mode/inactive mode enhancements are just enhancements and can be implemented by the UEs but are not needed for the feature to operate.

3.5.3 Objectives for the performance part

1. The views are split regarding whether the performance requirements for single TCI should be kept or not. For the next round, moderator proposes to further discussion the relationship between these requirements and the RF/RRM requirements. There was no clarification on what this relationship is in the intermediate round.

2. There were some editorial comments and also a comment that the Note should be removed. These will be further refined in the final round.

3.5.4 Other comments/objectives

Multiple companies commented that intra-band CA should be kept as an objective as it is important to make this feature really useful in the field. As Mediatek also commented, the moderator's understanding is that most RRM procedures in FR2 intra-band CA are based on a single CC from the aggregated carriers (e.g. L3 measurements, beam management related procedures), hence, the work should only have some straightforward demod impact(tests with multiple CCs) and possible small RF impact.

Considering the above, the moderator proposes to keep the objective as previously proposed. As commented by some companies, intra-band CA is important to make this feature useful in the field.

4 Final Round

4.1 Motivation

Based on the comments in the intermediate round, the proposed updated motivation is as follows:

The existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that UE is equipped with a single antenna panel and capable to perform DL reception using a single RX beam/chain reception. Furthermore, the UE performance requirements are limited for DL MIMO rank 1 and 2. In FR2, 4-layer MIMO reception requires beam reception from at least two directions. Although this is supported by the MIMO features since Rel-15, no performance requirements have yet been specified. This is important for high-rate MIMO in FR2, as well as for FR2 HST scenarios.

During Rel-16 and Rel-17, the support of NR FR2 CA with IBM (Independent Beam Management) and CBM (Common Beam Management) with simultaneous DL reception on different component carriers from the co-located and non-col-located TRPs was defined. The IBM concept implies a UE is capable of DL simultaneous reception on different UE panels/chains using separate beams on different component carriers and requires improved UE baseband and RF capabilities (multiple baseband chains and support of multiple antenna panels).

Several enhancements to enable efficient and robust DL multi-TRP/panel operation were introduced in the Rel-16 NR eMIMO WI. For instance, DL transmission schemes with simultaneous and non-simultaneous multi-beam reception from multiple TRPs/panels were introduced. The simultaneous reception may require support of simultaneous multi-panel operation with several independent RX beams/chains at the UE side. As part of this item, a new FR2 UE capability for simultaneous multi-beam reception was introduced (simultaneousReceptionDiffTypeD-r16). However, no RF, RRM or performance requirements were defined in Rel-16 and Rel-17 for FR2 UEs with simultaneousReceptionDiffTypeD-r16 capability.

Enhanced NR FR2 UEs with multi-beam simultaneous reception and multiple RX chains can provide a meaningful performance improvement in FR2 improving both demodulation performance (4-layer DL MIMO), RRM performance and improve RF spherical coverage. This work item aims to introduce the requirements for UEs capable of multi-beam/chain simultaneous DL reception on a single component carrier to achieve improved RF, RRM and UE demodulation performance.

[Different implementation scenarios could be considered at the UE. Single-TCI reception on different beams has been supported by the RAN1 specifications since Rel-15 via the Type I codebook, which could be achieved at the UE with either a single panel or multiple panels. Alternatively, dual TCI operation can be combined with the Rel-17 mTRP framework even if the base station is actually deployed as a single TRP.]

This WI provides the requirements for [both single and] dual TCI assumptions to specify requirements for reception of 4-layer downlink MIMO with simultaneous reception at the UE from two different directions.

Please provide answers/comments to the following issues:

1. Is the paragraph in [] as suggested by Nokia agreeable or not?

2. Should the part in [] in the last paragraph be kept or should the entire WI focus on dual TCI?

3. Any other comments?

Feedback Form 12:

1 – Qualcomm Finland RFFE Oy 1. The content is correct 2. Depends on outcome of discussion on dual/single TCI in 4.3 3. We are ok to continue discussion on system design details for single TCI during the WI. If feasible, we are ok to up-scope the WI in the future.
2 – Apple (UK) Limited 1. Regarding ”Alternatively, dual TCI operation can be combined with the Rel-17 mTRP framework even if the base station is actually deployed as a single TRP.” we want to understand what part of Rel-17 mTRP framework is referred to, as dual TCI operation is supported in Rel-16. The reason is to make sure everyone has the same understanding of the justification. 2. Agree it is related to discussion on perf. part in 4.3. Our preference is to not include it.
3 – ZTE Corporation 1. it’s technically reasonable for single TCI with 4 DL MIMO layers; 2. From the workload perspective, single TCI could be down-prioritized in Rel-18. In addition, single TCI with 4 DL MIMO layer might be not very typical in practice especially considering multiple-panel reception at UE side.
4 – Nokia France We support keeping both the parts in [ ]. Single TCI has been supported since Rel-15, so both scenarios are important. To Apple, the CSI reporting framework was not fully provided in Rel-16 to support dual TCI, whereas this is provided in the Rel-17 mTRP framework and would be needed to support the demod requirements for the dual TCI case for 4-layer DL MIMO. Without Rel-17 mTRP CSI reporting, it is not possible to support noncoherent transmission with layers associated to two QCL-Type D sources by configuring a single CSI report. With Rel-16 CSI framework, the network would have to configure two Type-I CSI reports, and configure NZP-IMR for measuring interference from the other QCL-Type D source.

4.2 Objectives for the core part

4.2.1 RF part

Based on the previous rounds of discussion, the updated objective for the RF core part is as follows:

- Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception with **two** different QCL TypeD RSs on single component carrier with up to 4 **layer** DL MIMO
    - Enhanced RF requirements:

    - Specify RF requirements, mainly spherical coverage requirements, for devices with simultaneous reception from different directions with different QCL TypeD RSs
    - The legacy spherical coverage requirement for reception from a single direction will be kept.

- PC3 will be prioritized, other power classes should be considered after the PC3 requirements framework is finalize

Huawei also proposed some changes related to single beam of same QCL type D/two different QCL type D, however, moderator does not thing these are necessary as the current wording should be clear enough.

Please provide answers/comments to the following issues:

1. should ”single beam of same QCL type D” be added to the 2nd subbullet: ”The legacy spherical coverage requirement for reception from a single ~~direction~~ beam of same QCL type D will be kept”.

2. Any other comments on the proposed objectives?

Feedback Form 13:

1 – Qualcomm Finland RFFE Oy We were ok to support the original version, but we are fine with the revised wording if companies have strong views supporting the latter.
2 – MediaTek Inc. We are fine with either wording, as they are technically the same.
3 – Apple (UK) Limited 1. Either wording is fine, but consistency among RF/RRM/Demod objectives should be kept. In this sense, the original wording is preferred.
4 – Huawei Technologies France Thanks moderator for the further checking of our proposal. The intention is to align the understanding among companies. We prefer to have the clarification with the revised wording in the objectives.
5 – Guangdong OPPO Mobile Telecom. 1. ok with changes.
6 – ZTE Corporation we are fine with original words to keep aligned with other RRM part.
7 – Samsung Electronics Co. In our experience of Rel-15 discussion, it may require great RAN4 effort to determine the spherical coverage percentile which is strongly related to different UE implementations.

Considering above, we think the discussion point on how to find the 50% percentile, i.e. whether to top 50%-tile shall be selected for simultaenous reception from different direction RSs. Based on our understanding, we still prefer to apply the existing N%-tile requirements for multi-panel UE to avoid extensive discussion in RAN4. Therefore, We suggest to add sub-bullet for requirements from different directions QCL typeD RSs

- Specify RF requirements, mainly spherical coverage requirements, for devices with simultaneous reception from different directions with different QCL TypeD RSs
    - **RAN4 shall specify the multi-panel spherical coverage requirements based on the directions that are within N%-tile (N% = 50% for PC3)**
    - **RAN4 will further study on how to select N%-tile for simultaneous reception fo different QCL type D RSs**
- The legacy spherical coverage requirement for reception from a single direction will be kept.

Also, ”mainly” wording is not also clear. I am not sure if ”mainly” are restricting RAN4 to further check other requirements except sphercial coverage or sphercial coverage has to be completed before RAN4 discuss other requirements. Better clarifications are needed.

8 – LG Electronics Inc.

1. We are fine for original wording, but revised version is also fine.

9 – China Mobile Com. Corporation

We are fine with either wording.

10 – vivo Communication Technology

1. Either wording is fine for us.

2. “with up to 4 layer DL MIMO” seems not needed for RF objective, it is proposed to remove this part just as RRM part.

Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception with **two** different QCL TypeD RSs on single component carrier ~~with up to 4 **layer** DL MIMO.~~

11 – Intel Corporation (UK) Ltd

1. Either wording is ok

2. The proposed objectives are acceptable for us. Proposal from Samsung on objective clarifications seems reasonable (the first bullet)

12 – Nokia France

For the suggested modification to the 2nd sub-bullet, “same QCL” doesn’t seem to make sense without saying what it is the same as.

Samsung’s proposal is OK with us.

Note that “will be kept” is missing from the draft WID.

4.2.2 RRM part

Based on the previous rounds of discussion, the updated objective for the RRM core part is as follows:

- Introduce necessary requirement(s) for enhanced FR2 UEs with simultaneous DL reception from different directions with different QCL TypeD RSs on a single component carrier
    - Enhanced RRM requirements
        - The following requirements should be considered and specified if necessary:
            - L1-RSRP measurement delay
            - L3 measurement delay (both cell detection delay and measurement period can be considered)
                - only enhancements related to L1-RSRP measurement enhancements should be considered
            - RLM and BFD/CBD requirements
            - Scheduling/measurement restrictions
            - TCI state switching delay with dual TCI
            - Receive timing difference between different directions (different QCL Type D RSs)

Please provide answers/comments to the following issues:

1. Is the change on L3 measurement delay bullet agreeable? if changes to L3 measurement delay that are not related to L1-RSRP changes are suggested, please clarify why these are needed/justified for this feature.

2. Any other comments on the objectives?

Feedback Form 14:

1 – Qualcomm Finland RFFE Oy

The revised wording is acceptable to us.

2 – MediaTek Inc.

To make it more clear, we suggest to put the L3 bullet as a sub-bullet under L1 (with L1-RSRP and RLM/BFD/CBD merged), e.g.,

- The following requirements should be considered and specified if necessary:
  - **L1-RSRP measurement delay and RLM/BFD/CBD requirements**
    - **Corresponding changes in the impacted L3 measurement delay (e.g., cell detection delay and measurement period) can be considered to accommodate the enhancement in L1-RSRP/RLM/BFD/CBD**

In this way, we are more confident that RAN4 will not directly dive into the enhancement on L3 measurement, but just consider how to change it to accommodate the L1 enhancements.

3 – Apple (UK) Limited

Either moderator's proposal or MediaTek's revision is OK.

4 – Samsung Electronics Co.

Even though we still think MRTD shall NOT be included. For sake of progress, we can live with moderator proposal considering "specified if necessary" in main bullet.

5 – LG Electronics Inc.

We are fine with moderator's updated version.

6 – China Mobile Com. Corporation

We are fine with either moderator proposal or MTK's proposal.

7 – vivo Communication Technology

We are ok with moderator's version. For MTK's revision of L3 measurement, we still prefer the original way in the summary.

8 – Intel Corporation (UK) Ltd

We are fine with moderator proposal.

9 – Huawei Technologies France

Generally MTK's proposal to remove the L3 measurement bullet is fine. However, the enhancement in L1 measurements is not clear for now and whether the enhancement in L1 measurements will impact the L3 measurement delay is uncertain. Based on MTK's proposal, we suggest to further update as:

• L1-RSRP measurement delay and RLM/BFD/CBD requirements

• **Potential** ~~Corresponding~~ changes in the impacted L3 measurement delay (e.g., cell detection delay and measurement period) can be considered to accommodate the enhancement in L1-RSRP/RLM/BFD/CBD

10 – Nokia France

Regarding L3 measurement delay:

It is already well known from the RAN4 discussion and also captured in the justification that the existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that the UE is only required to perform DL reception (including performing L3 measurements) using single Rx beam/chain reception. This assumption was used for developing the RRM requirements. Now we will be discussing the scenario where a UE can receive from multiple directions simultaneously. We see that such a UE would be able to provide improvements in L3 measurement performance under certain conditions, and RAN4 should study and specify when and how such improvement can be expected.

The current text is in general fine, but we do not fully understand the condition in the sub-bullet, "only enhancements related to L1-RSRP measurement enhancements should be considered".

Hence, we propose to modify this bullet as follows:

- L3 measurement delay (both cell detection delay and measurement period can be considered)
  - ~~only enhancements related to L1-RSRP measurement enhancements should be considered~~
  - Identify and specify L3 measurement delay enhancements when using simultaneous DL reception from different directions

The intention is to study when L3 measurement delay improvement can be defined for a UE with the capability to receive from multiple directions simultaneously. (The intention is not to define L3 measurement delay based on the that UE shall always be assumed using multiple Rx chains for performing L3 measurements, as we see that assuming that the UE would always use multiple Rx chain for L3 measurements would have too big negative impact on the UE power consumption.)

4.3 Objectives for the performance part

Based on the previous rounds of discussion, the updated objective for the performance part is as follows:

- Introduce necessary performance requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier
  - RRM Performance requirements and test cases corresponding to the new core requirements

- RRM test cases to verify the UE behavior/functionalities needed to support this feature in case existing requirements are reused
- UE demodulation requirements:
  - Specify performance requirements for enhanced FR2 UEs supporting up to 4 DL MIMO layers with dual TCI with different QCL typeD on a single component carrier.
    - Demod requirements on up to 4 DL MIMO layers
    - CSI requirements to support up to 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook
  - [Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI
    - Demod requirements on 4 DL MIMO layers
    - CSI requirements to support up to 4-layer with single TCI and Rel-15 Type I codebook]

NOTE:

- For the dual-TCI demodulation requirement case, focus on UEs supporting "simultaneousReceptionDiffTypeD-r16" UE capability, and for the 2- or 4-layer downlink MIMO reception, focus on UEs supporting the basic mTRP CSI reporting capability (FG 23-7-1/1b of NR FeMIMO).

Please provide answers/comments to the following issues:

1. To companies proposing to keep the part on single TCI performance requirements in []: what is the relationship between these requirements and RRM/RF which are explicitly considering only dual TCI?

2. if the part in [] is kept, is it agreeable to have it de-prioritized?

3. any other comments on the proposed objectives?

Feedback Form 15:

1 – Qualcomm Finland RFFE Oy 1. 2. If single TCI proponents can demonstrate that changes are limited to performance requirements, and do not impact RF or RRM, we are ok to retain the contents of [ ] as a secondary objective. If there is RF or RRM impact, this item can become large.
2 – MediaTek Inc. We kind of keep a similar view that single TCI is not well align with the RF objective. Therefore it seems

to be out of the scope.

3 – Apple (UK) Limited

We still prefer to remove the part in [].

4 – ZTE Corporation

as we comments in the motivation part, at the current phase, we still prefer to remove it since this might be not quite typical use case.

5 – Samsung Electronics Co.

In general, we share the similar view as some other companies that the performance requirement of single TCI shall be aligned with core requirements (RF/RRM). To have only demod requirements cannot enable this feature. We also agree with QC, the work socpe is pretty large if we consider the RF/RRM requirements impact for single TCI use case. Therefore, we still think removing the bullet in square bracket is the best WF.

6 – China Mobile Com. Corporation

The part in [] can be considered as second priority.

7 – vivo Communication Technology

We prefer to remove the part in [].

8 – Huawei Technologies France

We still prefer to remove the part in [].

9 – Nokia France

It is important to keep the single TCI part. This has been included in RAN1 specs since Rel-15.

The RF and RRM requirements would be the same for reception from different directions regardless of whether the actual configuration is done using single TCI or dual TCI. It is only for the demod requirements that the actual method for how the configuration is done matters. Here it is important to ensure that we have demod requirements for both configurations.

We would prefer to keep both single and dual TCI with equal priority, as in the original version of the Justification section.

10 – Nokia France

Also, the first of the CSI requirements bullets should be corrected as follows:

- CSI requirements to support up to 4-layer DL MIMO with 2 TCIs and Rel-17 mTRP CSI reporting with Type I codebook

4.4 Other comments/objectives

Moderator proposes that the following bullet is added to the WID objectives:

- Extension of requirements to cover intra-band CA should be considered after the single carrier requirements are defined based on operator requests

Please provide answers/comments to the following issues:

1. Any strong concern to keep this objective considering the comments related to usefulness of this feature if it would not be applicable to intra-band CA?

2. Any additions/clarifications needed to this objective?

3. Any other comments related to the WID overall?

Feedback Form 16:

1 – Qualcomm Finland RFFE Oy 1. We strongly support including intra-CA in Rel-18. 2. No 3. In our view intra-band CA would mainly impact demod requirements. We do not see an RF impact, or any significant RRM impact.
2 – MediaTek Inc. We are fine to put this bullet under Demod performance part to avoid confusion.
3 – Apple (UK) Limited We still prefer to not include intra-band CA at this moment. This multi-RX proposal has been discussed in Dec. 2021 and Feb. 2022, we should not enlarge the scope at this meeting.
4 – ZTE Corporation 1. We strongly support including intra-contiguous CA in Rel-18. For intra-band non-contiguous CA case, this could be postponed later.
5 – vivo Communication Technology We may consider a phased approach, to ensure the single carrier requirements would be completed before considering CA. In addition, we may also consider to use a less affirmative wording, since the CA impact is not that clear currently. An example could be: ”Extension of requirements to cover intra-band CA ~~should~~ **can** be considered after the single carrier requirements are defined based on operator request”

6 – Intel Corporation (UK) Ltd We are fine to add this objective. We have a slight preference to include it for Core part as well so that companies can check potential impacts.
7 – Huawei Technologies France We still prefer to not include CA at the later stage after several discussion. Even for FR1, demodulation performance requirements for single carrier is defined in Rel-15, and requirements for CA were later introduced in Rel-16, we prefer to adopt the same approach as FR1 CA, considering this is the first release to define the performance requirements for FR2 Multi-Rx simultaneous reception with different QCL TypeD RSs. Also based on the currently agreed work scope, there are very heavy workload for RAN4.
8 – Nokia France 1. We support inclusion of intra-band CA. 3. There are some misalignments in the bullets in the core part: - it should not be necessary to repeat the main bullet "introduce necessary requirements…" - PC3 bullet should be a sub-bullet of enhanced RF requirements

4.5 Summary for the Final Round

4.5.1 Motivation

The decision on whether the parts in the [] should be kept or not should be taken taken based on whether single TCI will be kept in the objectives or not.

4.5.2 Objectives for the core part

4.5.2.1 RF part

Most companies are fine with the wording proposed for the final round.

There was a proposal to add back the sentence regarding the spherical coverage %-ile or reformulate it. Based on the discussion so far, this seemed to create a lot of confusion so moderator recommends to keep this part out. The proposed bullets are also not clear, the intention so far was not to define any new %-ile for any spherical coverage(either Rel.15 legacy requirement) or multi-panel. This will anyway be discuss in RAN4 when the requirements are defined. Such wording might also unnecessarily limit the way the requirements are defined and this could be detrimental.

To Vivo: there could be RF impact from support of 4L because the required SINR for 4 layers compared to 2 layers is different. Moderator suggest to keep the 4L for the RF part.

4.5.2.2 RRM part

The views are split regarding the handling of L3 measurements, however, most companies agree that only impact coming from changes on L1-RSRP should be considered and some small changes were proposed

Nokia proposed to maintain the general enhancements for L3 measurements, however, the only reason given is that UEs could in theory now perform more measurements in parallel but it does not seem that this is necessary for the feature to work. Also, performing measurements simultaneously is not just an RF capability, it would also imply a baseband capability which is not related to MIMO reception. Moderator maintains the view that such enhancements should not be part of this WI.

The proposal made by Mediatek clarifies the conditions for L3 measurement changes so moderator proposes to use this version for going forward.

4.5.3 Objectives for performance part

Most companies commented that they prefer to remove the requirements for single TCI. One company wants to keep it while one company would be fine to take this as second priority.

One company claimed that for single TCI there would be no RRM or RF impact as the dual TCI requirements could simply be reused. In the moderator's understanding, the beam management procedures are different between single TCI and dual TCI so it is not clear if the same RRM requirements can be kept, at least some RRM tests would have to be added and there could also be RF impact.

Moderator's proposal is to leave single TCI requirements out for now. If the addition is very simple and only concerning demod, this could be done very easy in the future after the dual TCI discussion becomes clear.

4.5.4 Other comments/objectives

Majority of companies support including intra-band CA while one company commented that the bullet regarding support of CA should be moved under the demod requirements to clarify the impact.

Moderator's proposal is to adopt this proposal and move the bullet regarding extension to intra-band CA under the demod requirements.