[RAN95e-RAN4-R18Prep-01] - Version 0.0.5
RAN

3GPP TSG-RAN WG Meeting # 95 -e RP-220019

Electronic Meeting, March 17-23, 2022

Source: Moderator (CMCC)

Title: Moderator's summary for discussion [RAN95e-RAN4-R18Prep-01] FR1 RF Enhancements

Document for: Report

1 Introduction

In this email thread, the moderator follows the guidance in RP-220003 to organize the RAN4 Rel-18 RAN4 email discussion for FR1 RF enhancements.

The summary for initial round is based on the outcome of Oct. email discussion (RP-212682). For any topics not part of the Oct. email discussion, the proposals are not listed in the initial round. Companies can bring up new proposals in the "Others" section for further discussion.

2 Initial round

2.1 Working areas with stabilized objectives in RP-212682

In this section, work areas with stabilized objectives in RP-212682 will be discussed. For the objectives that still in [], companies are encouraged to share your views on whether [] can be removed or any changes are needed in order to remove the []. For the stabilized objectives, further comments are also welcome.

2.1.1 4Tx

- Enable 4Tx on a single band for FWA/CPE
    - Investigate framework and architecture
    - Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)
    - Specify the UE RF requirements to support 4Tx
    - Specify the BS demodulation performance requirements to support 4Tx UE operation

Feedback Form 1:

1 – Skyworks Solutions Inc.

Regarding targeted band, we support the chosen bands but would like to clarify if the topic should be restricted to TDD bands since example bands do not cover FDD and potential REFSENS degradation due to UL is not studied

2 – Skyworks Solutions Inc.

Further clarification needed: is this 4Tx targeting 4x4 UL MIMO only (ie no 4TX TxD)

3 – Guangdong OPPO Mobile Telecom.

1. For the 4Tx on a single band, UE can support 4 layer UL MIMO, the targeted power class should be clear in the discussion, is it PC3 or PC2 or even PC1.5?
2. The targeted bands should be TDD only in our view, or at least the bands that already support UL MIMO in R17 38.101-1.
3. To simplify the discussion and also avoid the difficult experience in UL CA in R17, we suggest to simplify the potential UE architecture and only focus on most welcome ones;
4. Regarding whether TxD is allowed or not, it might depends on whether UE has to keep same power class among 4 layer UL MIMO and single antenna port (4PAs activated), if it is then TxD might be needed to keep as high Tx power as UL MIMO.

4 – Spark NZ Ltd

We spoke this initiative, but would also like to see n40 considered as an 'example' band.

5 – SoftBank Corp.

We support the current objectives and the restriction of TDD bands is fine with us.

6 – TELECOM ITALIA S.p.A.

We support the current objectives with some clarifications:

1. clarification needed on the power class, as indicated by Oppo in their point 1.
2. the focus should be to allow MIMO 4x4 in UL
3. industrial devices should not be excluded.therefore we suggest to rephrase in

- Enable 4Tx on a single band ~~for FWA/CPE~~ targeting CPE/FWA/vehicle/industrial devices (same format used in RP-213598, WI on MIMO enhancements)

7 – China Telecommunications

We support this work. With >4 layers MIMO included in RAN1 R18 scope, it is natural for RAN4 to define the RF requirements for 4Tx at least. For the detailed objective:

- We don't agree to restrict the use of this feature on TDD band. UL 2Tx has been supported for several FDD bands, and we should not preclude the possibility to extend 2Tx to 4Tx for these FDD bands.

- For the power class, with 4 PAs activated, it is much easier for UE to transmit 26dBm or 29dBm, so we prefer to consider PC2 and PC1.5 as well. In the current spec, PC2 and PC1.5 have been supported for several bands capable of UL-MIMO.

8 – Huawei Technologies France

We support the objectives for 4Tx. Also fine to consider other bands not listed in the current objectives.

9 – China Mobile Group Device Co.

We support above objectives.

About example band, our preference is to also add band n40 and n79. As discussed in last RAN meeting, we could compromise to drop n79, but it's still suggested to add n40 as example band considering n40 is the key global 5G spectrum and more and more countries have allocated it for 5G network.

10 – Nokia Japan

We support specifying 4Tx as well as 8Rx as a package for the enhancement of CPE. Regarding 4Tx objective, it needs to clarify that the requirements for single CC per single band are the target as well as what the power class is, e.g., 26 dBm x 4 = 32 dBm or 29 dBm x 4 = 35 dBm?

11 – Ericsson France S.A.S

We are OK with including 4TX. As Nokia suggest if could be good to clarify single CC is the target. Regarding power class, agree that the focus should be on CPE power classes (PC2 and or 1.5). ULFPTx framework should also be considered

12 – Intel

We support the general objective with a focus on FWA/CPE and industrial device types.

Agree with other companies that additional clarifications are needed:

- The work should prioritize 4 UL MIMO layer transmissions
- Focus on a single carrier
- Power class needs additional discussion and 4 x 23 dBm can be considered as a starting point

13 – Sony Group Corporation

we support the enhanced Tx for CPE/FWA devices

14 – Apple (UK) Limited

What power class is intended for 4Tx? Is it only for 4x4 UL MIMO or TxD would be considered as well?

15 – ZTE Corporation

Firstly, we also have interest on this 4Tx on CPE/FWA device considering the high-end market demand e.g. ToB service to boost the uplink capacity and meanwhile in Rel-18 NR-MIMO Evolution, RAN1 has already agreed to support 8Tx UL operation to support 4 and more layers in UL for CPE/FWA. Therefore from RAN4 perspective, it does make sense to define the 4Tx requirements in Rel-18 and in future release to define the RF requirements for 8Tx.

Secondly, we share similar concerns as Skyworks and OPPO on its targeted band, it should be TDD band. For FDD bands, to have more Tx chain or Tx power, then it could be foreseen that downlink performance would be impacted.

Thirdly, for power class for 4Tx, we are open for further discussion and for sure it should be clearly clarified to ensure the reasonable scope.

Finally, for TxD, based on the difficult discussion in previous Release, it's better to not touch it in Rel-18.

16 – vivo Communication Technology

Support this working area. Similar to the first bullet of 8Rx scope, the 4Tx operation of FWA/CPE can be restricted to TDD bands. The targeting should be 4x4 UL MIMO only.

17 – China Unicom

We support to enable 4Tx on a single band for FWA/CPE. But we would like to get some clarifications on the targted power class, and why FDD band(s) are not used as example band(s).

18 – Samsung Electronics Co.

In general, we support the further enhancement for CPE devices including both 4Tx and 8Rx. Limiting the number of example bands, e.g., max 3, shall be considered from RAN4 workload perspective since anyway other bands can be introduced in release independent manner later.

We also share the similar view as many other companies to further clairfy the target power class of 4Tx. In our understanding, limiting to 4x4 MIMO in this objective could be a reasonable scope.

19 – LG Electronics Deutschland

we support this 4Tx FWA/CPE and agree that this objective can be combined with 8Rx CPE/FWA as a single one.

20 – Skyworks Solutions Inc.

For power class we think the baseline should be 4x23dBm PC1.5. we need to understand the need for full UL power support to decide on TxD (could be PC2 2x23dBm w TxD or PC1.5 2x26dBm or 4x23dBm w TxD ...). Note this has also an impact on SRS antenna switching and performance of 8Rx.

21 – NTT DOCOMO INC.

We have interests on 4Tx.

We are fine with focusing 4x4 UL MIMO, and single carrier per band.

Regarding power class, we would like to consider PC3 as this is a kind of standard power class.

We prefer to add n79 as an example band, but if there are concerns about work load and no other requests on n79, we can compromise since it can be introduced by release independent manner.

22 – MediaTek Inc.

We are generally supportive of this objective, and also are ok with the Telecom Italia proposal to extend from CPE/FWA to CPE/FWA/Industrial devices (maybe clarifying ”non-handheld” is also good though?). Also agree that the Power Class should be clearly identified and focus on TDD bands seems reasonable.

23 – Spreadtrum Communications

Spreadtrum

We support the current objectives with two clarifications:

1. Industrial devices and vehicle should be included as well as mentioned by TELECOM ITALIA.
2. For 4Tx UE operation, 4x4 UL MIMO should be clarified together with power class level.

2.1.2 8Rx

- Enable 8Rx for FWA/CPE on higher frequency bands (RAN4)
    - Consider NR TDD bands higher than 1.8GHz and example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)
    - Specify the UE RF requirements to support 8Rx
    - Specify RLM test cases with 8Rx
    - Specify UE demodulation performance and CSI requirements to support 8Rx
    - Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4

Feedback Form 2:

1 – Guangdong OPPO Mobile Telecom.

1. For the target bands, it should be part of the bands that already support 4Rx today;

2 – Spark NZ Ltd

We spoke this initiative, but would also like to see n40 considered as an ’example’ band.

3 – SoftBank Corp.

We support the current objectives.

4 – TELECOM ITALIA S.p.A.

We support the current objectives with the following modification:

- Enable 8Rx for ~~FWA/CPE~~ CPE/FWA/vehicle/industrial devices (*same format used in RP-213598, WI on MIMO enhancements*) on higher frequency bands (RAN4)

5 – China Telecommunications

We support the objective, and suggest to remove the restriction on "TDD" band.

- Consider NR ~~TDD~~bands **around and** higher than 1.8GHz and example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)

Restricting the first batch of example bands as TDD is enough. Also, as we know, 4Rx requirements are already specified for several FDD bands.

6 – Huawei Technologies France

We support the objectives for 8Rx. Also fine to consider other bands not listed in the current objectives.

7 – QUALCOMM JAPAN LLC.

We support the work on introducing requirements for 8Rx to put NR on the same footing with LTE

8 – China Mobile Group Device Co.

We support above objectives.

About example band, it is still suggested to add n40 as the example band considering n40 is the key global 5G spectrum and more and more countries have allocated it for 5G network.

9 – Nokia Japan

We support specifying 4Tx as well as 8Rx as a package for the enhancement of CPE.

10 – Ericsson France S.A.S

We are OK with the first 4 objectives. Regarding the final objective, in our view, to manage the workload for demodulation, in our view if an objective on MIMO layer >4 is added here then we should not include a soft IC study in the demodulation package.

11 – Intel

We support the general objective with a focus on FWA/CPE and industrial device types.

The work should be performed jointly with 6RX discussion so there is no need to have separate objectives/studies due very overlapping scope

12 – AT&T GNS Belgium SPRL

We support the 8Tx work for CPE/FWA. We support the example bands identified but we don't agree to limit the objective to TDD only. We would also like to see that the generic requirements cover FDD for existing 4Rx bands so that the other statement of adding other bands in a release independent way can be met.

13 – ZTE Corporation

Similar as 4Tx, we also have interest on this topic to further enhance the DL performance. In addition, considering more bands supporting 8Rx might be introduced in future release similar as 4Rx. In order to avoid the introduction of 4Rx or 8Rx in per band approach, this will create lots of similar RAN4 WID which is not helpful from RAN4 WID management perspective, therefore we propose to have one generic basket WID to cover both 4Rx and 8Rx in which operator could request the demand.

14 – vivo Communication Technology

We supprot 8Rx for CPE/FWA. Similar view with Intel, 6Rx scope of CPE/FWA should also be added to avoid the separate objectives/studies.

15 – China Unicom

We support to enable 8Rx for FWA/CPE to further enhance the DL performance.

16 – Samsung Electronics Co.

We support 8Rx for CPE/FWA. Also, 8Rx objective requires heavy demodualtion and CSI work in performance part. Relative TUs shall be reserved.

It is also better to clarify whether the specifiying the requirements for CPE with 8Rx fallback to less Rx chains including 6Rx within the scope or not.

17 – LG Electronics Deutschland

Similar to the comment on 4Tx FWA/CPE, we support 8Rx FWA/CPE and 8Rx and 4Tx FWA/CPE can be combined into a single one as commented in 4Tx section.

18 – Skyworks Solutions Inc.

Should 8Rx be independant/associated with 4Tx. Also should there be a discussion on 8Rx performance versus SRS antenna switching for 8 antennas?

19 – NTT DOCOMO INC.

We support 8Rx and DL MIMO layers larger than 4 layers.

We prefer to add n79 as an example band, but if there are concerns about work load and no other requests on n79, we can compromise since it can be introduced by release independent manner.

20 – MediaTek Inc.

We are supportive of this objective for CPE/FWA (non-handheld) devices. As the work is not confined to RF (due to demod impact) we think a separate WI would be most appropriate.

21 – Spreadtrum Communications

□Spreadtrum□

Similar view as Intel and Vivo,and we think 6Rx should be considered when Investigating the feasibility.

2.1.3 6Rx

- Investigate and enable 6Rx on higher frequency bands targeting at support of smartphone (RAN4)
    - Investigate the feasibility whether 6Rx can be extended to the smartphone, and decide which UE type (smartphone and/or FWA/CPE) will be considered
    - Feasibility study includes performance gain and form factor
    - Consider NR TDD bands higher than 1.8GHz and example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)
    - Specify the requirements to support 6Rx subject to the conclusion of feasibility study
    - Specify the UE RF requirements to support 6Rx
    - Specify RLM test cases with 6Rx
    - Specify UE demodulation performance and CSI requirements to support 6Rx
    - Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4

Feedback Form 3:

1 – Guangdong OPPO Mobile Telecom.

1. It seems 6Rx is for smartphone here according to the main bullet ”targeting at support of smartphone”, then in the 1st sub-bulltet it is going to decide which UE type will be considered... Maybe some clarification is needed on the targeted UE type. Considering the different UE architectures, and restrictions between smartphone and FWA/CPE, it is better to only focus on one UE type here, i.e. smartphone, and combine 6Rx of FWA/CPE with the 8Rx topic to make a clean discussion.

2. In our view, the 6Rx for smartphone discussion includes two phases:

    - First phase is the feasibility study, including performance gain and ”form factor **restrictions**” (in the 2nd sub-bullet the restriction is missing);
    - Second phase is the requirement definition including all the following bullets
        - UE RF/RLM/Demod/CSI

3. The last bullet should be removed, currently RAN1 doesn’t support 6 port codebook and there is no chance for UE to achieve higher layers than 4.

2 – Spark NZ Ltd

We spoke this initiative, but would also like to see n40 considered as an ’example’ band.

3 – SoftBank Corp.

We support to include smartphone as a target. And we are fine with the two phase discussion commented by OPPO.

4 – China Telecommunications

- If 6Rx is only for FWA/CPE, it can be de-prioritized since it is to enough to have 8Rx requirements.
- If 6Rx is also for smartphone, we hope it can be clearly stated in the objective.
- In addition, similar to 8Rx, we suggest to remove the restriction on "TDD" band.

  Consider NR ~~TDD~~ bands **around and** higher than 1.8GHz and example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)
- To OPPO, in our understanding, RAN1 has defined the codebook for 6-layer CSI reporting in 38.214.

5 – Huawei Technologies France

From implemenation perspective, we think 6Rx for smartphone is challange. It should focus on FWA/CPE for more than 4Rx in Rel-18.

6 – QUALCOMM JAPAN LLC.

We support this work also for smartphones. We think this can be a subset of 8Rx so the amount of work needed is limited, maybe a few extra demod tests with slightly different channels.

We do not really see the point of a feasibility study because it is unlikely that we would see many contributions with real implementation data. Implementation will come anyway when it will be feasible, the requirements could already be done now since they are a subset of 8Rx.

7 – China Mobile Group Device Co.

We support above objectives.

To make the objective more clearly, it is suggested to list current 5th-8th bullets as the sub-bullets for "Specify the requirements to support 6Rx subject to the conclusion of feasibility study".

About the example band, as stated before, band n40 is also suggested as the example band.

8 – Ericsson France S.A.S

If 6RX is standardized then it should be for smartphone. It is OK for a short feasibility study. However, in general we think that this can have lower priority than 4TX, 8RX and improvements for MSD and A-MPR.

9 – Intel

We support the objective and think it is important to provide sufficient implementation flexibility and allow both 6RX and 8RX implementations. Overall, we do not see a need for any feasibility studies, which seem strange given that no studies will be performed for 8RX. We are fine to focus the work on CPE/FWA device types and combine with 8RX. If needed, the studies can be performed for 6RX for smartphone device form factors.

10 – Apple (UK) Limited

In our view, 6Rx is more suitable for FWA/CPE rather than smartphone. We are open for feasibility study including aspects such as UE RF architecture, power consumption, form factors, performance gain. If RAN4 TU is limited, it can be deprioritized as compared to the WI of "8RX for FWA/CPE".

11 – ZTE Corporation

We are neutral on this topic, it should be fine to start from CPE/FWA device since 8Rx could be supported on CPE/FWA. Regarding the implementation challenge, this could to have one study phase for its feasibility if necessary.

12 – vivo Communication Technology

According to the discussions in Oct. email discussion summary (RP-212682), >4Rx including 8Rx and 6Rx for CPE/FWA. On top of that, further extending the applicability to smartphone by feasibility study is the intension of this working area. So we suggest to finalize the 6Rx requirement of CPE/FWA first, and then further study the feasibility of smartphone based on the outcome. In our view, a check point of WID scope in the middle of Rel-18 timeline for this aspect would be helpful.

In addition, although the targets are conducted requirements, the feasibility study should consider the form factor and antenna implementation, 6Rx antenna design of smartphone would be the restriction of performance improvement.

13 – Samsung Electronics Co.

We are open to discuss 6RX for CPE devices which can be part of work in 8Rx CPE. For 6Rx for smart phone, considering the feasibility study phase and potential large overall scope in FR1 UE RF umbrella WI, we suggest to preclude 6Rx for smart phones at this release.

14 – LG Electronics Deutschland

This objective can be discussed along with 8Rx including feasibility for hand-held form factor

15 – Skyworks Solutions Inc.

If a feasibility study is done for 6Rx for smartphone, may be it should be restricted to TDD band >2.3GHz to enable the 6 antennas with a chance for limited correllation between them but also benefit from SRS antenna switching (to be extended to 6/8 antennas?)

16 – NTT DOCOMO INC.

We support 6Rx and DL MIMO layers larger than 4 layers. For introduction of 6x6 layers DL MIMO, in our understanding, while updates on UE capability to add 6 layers is needed, there are no impact on RAN1 specification since RAN1 specification already supports 6x6 DL MIMO.

We prefer to add n79 as an example band, but if there are concerns about work load and no other requests on n79, we can compromise since it can be introduced by release independent manner.

17 – MediaTek Inc.

First should be clarified whether it is smartphone or CPE/FWA that is being investigated. We doubt the feasibility of getting practical gains from 6Rx in smartphones.

Also should be clarified if this study is targeting to improve link budgets with up to 4 layers, or increased peak data rates/MIMO layers. Demodulation would likely be largely reusing the 8Rx analysis.

18 – Spreadtrum Communications

Spreadtrum

We support finalizing the 6Rx requirement of CPE/FWA first, and then further study the feasibility of smartphone based on the outcome as mentioned by vivo.

2.1.4 3Tx

- Investigate and if necessary, specify requirements to support simulatenous 3Tx considering two use cases (RAN4)
  - 3Tx simultaneous transmissions for two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band
    - Tx switching transmission enhancement (RAN2, RAN4)
      - Cover inter-band UL CA and SUL case
        - FFS example band combination(s)
      - RAN2 signaling design
      - Identify and specify the necessary RF requirements
    - Power enhancement
      - FFS example band combination(s)
      - Study the definition of power class
        - Both power class defined per band combination as total power and power class defined per band are considered
      - Identify and specify the other necessary RF requirements
  - [3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band
    - Study the power class framework, impact on MPR/A-MPR and impact on MSD
    - Example band combinations
      - Consider TDD+TDD+TDD without simultaneous Tx/Rx
      - FFS other band combinations, e.g., FDD+FDD+TDD, FDD+TDD+TDD]
  - Drop the potential objective in use case #1: 3Tx on single uplink band for MIMO enhancement
  - FFS the potential objective of 3Tx for transmission diversity on single uplink operating band for power enhancement with the understanding that there is no RAN1 impact

Feedback Form 4:

1 – Guangdong OPPO Mobile Telecom.

Generally ok with the scope, some small updates to below items (these updates can be found in the latest WID in last RAN planery and also last RAN4 meeting R4-2201281)

1. For the 1T@band A+2T@band B scenario, EN-DC can be added, currently it only mentions about inter-band CA;
2. For the Tx switching, example band combination can be CA_n3A-n78A, and CA_n3A-n78C;
3. For the power enhancement, example band combinations could be DC_3A_n78A, CA_n3A-n78A, and CA_n3A-n78C;
4. For the 1T@band A+1T@band B+1T@band C, example band combination can be DC_3A-7A_n78A, and other example band combinations are not excluded. And remove the brackets.
5. 3Tx diversity can be removed for now, and during the discussion if necessary for example to achieve certain power class, then can be further considered.

2 – Spark NZ Ltd

Spark NZ supports this objective.

3 – Guangdong OPPO Mobile Telecom.

Regarding the work organization, we see some common handling in the new advanced UE architectures like CPE 4T/8R and Smartphone 3T/6R, it might be better to combine them as a package to facilitate discussion and work organization.

The other enhancements like lower MSD, improved AMPR, new lower power class, simultaneous RxTx for intra-band CA, Tx switching with multi-TAG they are all based on current 2T4R architecture, and suggest to keep this legacy UE architecture assumption during work item phase rather than mix them with these new advanced UE architecture to avoid complexity and misunderstanding. After new advanced architectures are finished, these enhancements could be further considered for them.

4 – TELECOM ITALIA S.p.A.

We support the activity. We also support the addition of EN-DC and removal of the square brackets as suggested by Oppo. Also ok with the band combinations suggested by Oppo.

3Tx diversity can be considered as lower priority

5 – China Telecommunications

For 3Tx, we support 0us switching period for UE capable of 3Tx, and suggest to remove the following sub-bullet. The band combinations which support Tx switching is up to UE capability reporting, and it is redundant to explicitly list these BCs in RAN4 spec (similar to R16/17 Tx switching with other switching periods)

- ~~**FFS example band combination(s)**~~

6 – QUALCOMM JAPAN LLC.

3Tx is definitely challenging to implement, the only sub-topic of interest could be 1Tx in one band + UL MIMO(2Tx) in another band.

7 – China Mobile Group Device Co.

- For 1Tx@band A + 2Tx@band B scenario,

it's suggested to remove "FFS example band combinations". No extra RF requirement is required, so it seems no need to add example band combinations and this Tx switching enhancement could be applicable for all band combinations if band B support 2Tx. and in R17 Tx switching WID, no example band combination are listed.

- for 1Tx@band A + 1Tx@band B + 1Tx @band C scenario

it's suggested to remove 3 band UL scenarios because it will introduce severe coexistence and MSD issues which will require a completely new framework as discussed in last meeting. Since we still have some remaining issues for 2Tx architecture, e.g. lower MSD, A-MPR, it's better to only focus on the simplest scenario i.e. 1Tx@band A + 2Tx@band B scenario at first.

8 – Nokia Japan

With respect to "3Tx simultaneous transmissions for two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band", it must be clarified that the work for power enhancement should start after the completion of Power*Limit*CA_DC WI since it is likely that the combination of the power class would be 23 dBm(1Tx) + 26 dBm(2Tx).

Regarding [3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band], we don't need to include this since a kind of resolution of simultaneous transmission for multi bands is going to be discussed in Rel-18 RAN1 led WI.

Concerning 3Tx on single uplink band for MIMO enhancement, this also needs to be dropped since RAN4 has been still struggling from defining 2Tx Diversity and the requirements are not stable. In addition, this impacts on RAN1 to address MIMO enhancement.

9 – Ericsson France S.A.S

There are a large amount of topics and complexity. 1TX in one band and 2TX in another band could be considered but 3 TX in 3 bands should be removed as the complexity of the MSD etc. will be very large. (but our preference is to prioritize the other items in the discussion over 3TX in general).

10 – Intel

We consider this item with a lower priority comparing to 4Tx, 6RX/8RX and MSD improvements.

Overall, the work scope needs to be limited (e.g. focus on case 1: two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band).

11 – Apple (UK) Limited

1. On the "3Tx simultaneous transmissions for two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band", need clarification that 2Tx on the other hand is for UL MIMO or TxD only, but not for intra-band non-contiguous UL CA.

2. On the "3Tx simultaneous transmissions for two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band", if the intention is for simultaneous 3Tx, why Tx switching transmission is needed?

3. We are not positive on "3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band" due to the concern on the complicated IMD products and its implication to MSD.

4. We are not positive on the potential objective of "3Tx for transmission diversity on single uplink operating band for power enhancement" due to the concern of the complexity on Reverse IMD among the 3 PAs for MPR evaluations.

12 – SoftBank Corp.

We support the objectives and fine with removing the bracket from three bands inter-band UL-CA. For 3Tx transmission diversity, we are fine to wait that 2Tx diversity discussion is stable.

13 – Guangdong OPPO Mobile Telecom.

Thanks for the comments, some answers to questions up to now, more comments are welcome:

1. Regarding Tx switching:

   - To CT/CMCC comment: It is ok to remove the example band combination;
   - To Apple comment: Tx switching is needed in 3Tx is to cover the case that UE might need to switch transmission on band A and band B due to pwoer consumption reasons. 3Tx here means UE has 3Tx chain, it can be activated simultaneously or swithcing transmission, same as Rel-16/17 Tx switching transmission feature.

2. Regarding Tx power of 1T@band A + 2T@band B:

   - To Nokia comment: Yes, it is our understanding that this kind of UE can achieve higher power than current power classes, like 23+26(2T), etc. and the Rel-17 increase higher limit of CA/DC WI conclusion can be reused as much as possible. This can be added to the WID.

3. Regarding 1T+1T+1T scenario:

   - To QC comment: If concern about the impacts to UE implementation challenges, it might be ok to start with a study phase to consider the impacts and solutions.
   - For the concerns of complexity, in our view this should be market/operator demands driven, if there is interest in deployments and demands, RAN4 should consider this no matter complexity or simple. We are open to hear more views.

4. Regarding TxD:

- It is ok to remove 3Tx TxD from this WI since 3 layer UL MIMO in one band is not included. It can be considered in future.
- For the 1T+2T case, whether TxD is supported in the 2T@band B, it might need more discussions in the WI phase, since it is connected with how to handle the power fallback, i.e. whether UE shall reach same max power or not.

14 – ZTE Corporation

Basically we agree with the 3Tx can be studied in RAN4. For 3Tx, the MSD would become complexity, where triple beat IMD should be checked. In addition, for the example band combination, which power class apply?

15 – vivo Communication Technology

1. We also share similar view with China Telecommunications that 0us switching period can be enhanced, based on current outcome of Tx switching UE feature.

2. Regarding the two band CA case with 1T@bandA+2T@bandB, there are some confusions on power class enhancement (i.e. study the definition of power class), from our understanding the 2band CA power class enhancement is under discussion in Rel-17 PowerLimitCA*DC*. Many options are on the table, most of issues have not been converged, but as the generic solution of ”sum up” for inter-band CA that could be applied for 2Tx/3Tx. So we suggest to consider this enhancement work after there is clear conclusion from Rel-17 PowerLimitCADC.

3. For 3 band UL CA, we are not clear the practical deployment scenario for TDD+TDD+TDD. Self-interference issue may persist as the DL/UL configuration among different TDD bands can be different. If we consider FDD+FDD+TDD, as mentioned by some companies in Oct. email discussion summary (RP-212682), the implementation complexity and self-interference issues will be increased dramatically. In addition, 3UL (UL in 3 different bands) requires a completely new MSD and MPR/A-MPR and power class framework, we have concern on 3 bands in Rel-18 timeline which will bring a very high work load with unclear benefit. We suggest to remove this working scope.

16 – China Unicom

We support to investigate and specify requirements to support simulatenous 3Tx for UE. We are also fine with the objectives and updates proposed from OPPO.

17 – Samsung Electronics Co.

Overall, total number of objective in FR1 UE RF umbrella WI shall be limited. We prefer to focus on CPE enhancement including 8Rx and 4Tx in this FR1 UE RF rather than smart phones considering the implementation challanges especially for 3Tx @ 3bands case.

18 – Huawei Technologies France

We support the objective ”3Tx simultaneous transmissions for two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band”, and also think that sub-bullet of ”FFS example band combinations” is not necessary. Regarding Power enhancement, we think the conclusion of Rel-17 WI powerLimitCA*DC* can be extended to cover the 3T two bands case after completion of the WI.

For the 1T@band A+2T@band B scenario, we are ok for the new proposal by OPPO to extend it to EN-DC as well.

19 – LG Electronics Deutschland

We are fine with the first objective, i.e. 1Tx on one band and 2Tx on the other band.

20 – KT Corp.

Rather than prioritizing TDD+TDD+TDD we need to consider spectrum refarming case as some of LTE spectrum will be refarmed to support 5G when Rel-18 product is available. Example band combination can include B3+n3+n78 where operator decide to migrate some part of LTE spectrum to 5G.

21 – Skyworks Solutions Inc.

In release 17, we are still struggling to develop a specification fram,ework for triple beat issues of 1CC in one FDD band + 2 contiguous CC in second band (ie nXXA+nYYB.C) and may not be able to finalyze in it. Any case with 3CC with 3 separate UL clusters (3 band UL, 1 band 1CC +2 non-contiguous CC in second band) should go through a study phase at least when tehre are simulataneous TxRx. Note that even in non-simultaneous TxRx case, triple beat may be a challenge for coex (band protection). At this point we think that R18 should finalyze cases where there are no more than 2UL bands/UL clusters and allow 2Tx per band (2 UL bands, contiguous 2CC per band and/or TxD/ULMIMO per band). 3CC intra-band and 3 bands UL should be out of scope of a WI.

22 – BT plc

We support the objectives of this work. However, the 1 and 2 band cases should take priority over the 3 band case (TDD+TDD+TDD)

23 – Deutsche Telekom AG

- We support 3Tx simultaneous transmissions for two band inter-band CA as we see here clear advantages. We support as well adding EN-DC here.
- Related to 3Tx simultaneous transmissions for tree bands, we see here a lower priotity due to technical challenges.

24 – Huawei Technologies France

One more comment for 3Tx for 1T@band A+2T@band B on the objective ”Tx switching transmission enhancement (RAN2, RAN4)”. Based on the discussion, seems there is no switching period needed for simultaneous 3Tx in two bands for this case. In our understanding, the existing spec can already support 0us, no addtional UE capabilty is needed. The current capability is for non-zero switching. Not sure what should be studied for Tx switching in this scenario.

Some proposed changes for this objective:

> **Identify and specify** Tx switching transmission enhancement **if needed** (RAN2, RAN4)

- Cover inter-band UL CA and SUL case
- **Identify and specify** RAN2 signaling design **if needed**
- Identify and specify the necessary RF requirements **if needed**

25 – NTT DOCOMO INC.

We support to investigate and define simultaneous 3Tx transmission requirements and inclusion of EN-DC case.

We are OK with focusing on 1Tx in one band and 2Tx in another bands case.

26 – MediaTek Inc.

We think that 3Tx for handheld devices is going to be challenging in general, and without clear benefits due to Tx power limitations.

We do not see any motivation for "Objective 2" transmitting UL on 3 bands simultaneously from a practical perspective, and it seems mainly a peak-rate improving feature, but we wonder if operators are really seeing that performance with UL CA is limited due to peak data rates today. For handheld device one would need to consider SAR impacts (i.e. UE transmits on each of 3 bands 33% of the time). What power class is being considered per band? Higher chance of IMD impact on the receiver?

On the 3Tx same band, is it understood that there is no RAN1 impact? Is there really a useful gain even if there was no impact?

27 – Guangdong OPPO Mobile Telecom.

Regarding comments about the power class in two bands Tx or three bands Tx, it can leverage the conclusion in Rel-18 increase high limit conclusions and allow high Tx power as UE can achieve.

2.1.5 lower MSD

- Investigate and introduce lower MSD for inter-band CA/EN-DC combinations (RAN4)
    - [FFS example band combinations
    - Study how the MSD performance can be improved for example band combinations
    - Study whether the generic approach can be applied based on UE indication of capability
    - Study and if possible specify the requirements and/or capability signaling
    - Power class 2 (PC2) is considered]

NOTE: for the lower MSD, the above objectives are subject to modifications based on RAN4 progress

Feedback Form 5:

1 – Guangdong OPPO Mobile Telecom.

In current scope there are two aspects, i.e. study how to improve MSD, and study capability signaling, but it is not clear the relation between them, for example whether the capability signaling can only be introduced after the study of performance improvement is done or they can be carried out simultaneously? This should be clear in the scope and be clear to the group to avoid the misunderstanding among different parties.

Meanwhile, it should also be clear once the study of performance improvement is failed, for example no

consensus can be reached, then whether the WI can be closed or not?

In general this item will be controversial as already today, clear scope will be needed before jumping into the work.

2 – QUALCOMM JAPAN LLC.

We support to continue the work in this area as there is a lot of interest and some meaningful improvements can be done. If the work load is a concern, we believe this could be somehow controlled by limiting the number of combinations considered at the same time.

3 – China Mobile Group Device Co.

We support above objectives and the bracket is suggested to be removed.

For the example band combinations, we suggest to list at least three band combinations respectively for three issues that cause MSD in the spec, i.e. UL harmonic interference, IMD interference and cross band isolation. CA_n3-n41 is suggested as the example band for IMD interference.

4 – Nokia Japan

We support specifying lower MSD as well as smaller A-MPR as package to enhance coverage.

Regarding the objective for lower MSD, we have following comments.

For example band combinations,

An example band combination(s) shall be the band combination including multiple MSDs due to different MSD sources. For instance, CA_n1-n77 can be the one since it includes MSDs due to IMD2, IMD4, 2nd harmonics. This is related to a following bullet for study how the MSD performance can be improved. Since the amount of the improvement IMD2 may not directly reflect the same amount of improvement for the 2nd harmonics. This kind of aspects need to be studied to find out suitable signalling mechanism.

For "Study how the MSD performance can be improved for example band combinations",

This objective must need more clarification. This objective must include if there is a correlation between the amount of MSD improvement for a given MSD source like IMD2 and that of MSD improvement for another MSD source like cross band isolation, or harmonics etc.

For "Study and if possible specify the requirements and/or capability signaling", we don't think we need to include "if possible". Hence, our alternative is Study and ~~if possible~~ specify the requirements and/or capability signaling

For "Power class 2 (PC2) is considered", we really don't see the necessity of limiting applicability of lower MSD to PC2. We should remove this bullet. Note that the study is OK to refer to PC2 while the lower MSD functionality shall not be limited to PC2. There is no justification to do so.

5 – Ericsson France S.A.S

Developing a framework and improved requirements for lower MSD is an important core aspect of improving coverage and user experience and we think this should be included as high priority. We don't see the need for the limit to PC2.

6 – Intel

We support the objective, and think it is important to improve the MSD performance for inter-band NR-CA/EN-DC

- Our preference is to introduce a generic approach based on indication of UE capability. Other approaches would result in too long discussions in RAN4 and unlikely result in a generic improvement.

- MSD improvements should be considered for the existing and future CA/EN-DC band combination (i.e. shall not be limited to the new band combinations only)

- We do not see the need to limit the work to any particular UE power class, ie PC2

7 – Sony Group Corporation

In general, we support to include this item. We think it should be start with identifying the possible sources to improve the MSD first and as well as the impact on the network performances. Based on the outcome of the study, we may further proceed with if generic approach could be applied and how the how the signalling should be designed.

8 – Apple (UK) Limited

1. We can support to study how the MSD performance can be improved for example band combinations. The target is for new combinations going forward.

2. We would like to have a clarification on what the "generic approach" is meant for. If it is meant for a single "low MSD" value for all band combinations, we do not think it would be technically meaningful as MSD is highly dependent on the band combination and its associated front-end architecture.

3. We propose to include the following two objectives into the work scope:

1) Investigate dynamic configuration of simultaneous and non-simultaneous Rx/Tx operation as a means to mitigate MSD impact on network performance.

2) Study on how to introduce UE signal to self-interference ratio measurement mechanism for assisting network scheduling on band combinations subject to MSD impact.

9 – AT&T GNS Belgium SPRL

We support the low MSD study in Rel-18 with the preference of a follow-on WI in Rel-18 timeframe. We think that the study should be focused on a set of representative band combinations to minimize the effort in RAN4 of looking at every combination and developing a generic solution. We agree with Nokia, Ericsson, and Intel that the work should not be limited to PC2. There are PC3 MSD cases which would benefit from lower MSD.

10 – Beijing Xiaomi Mobile Software

Generally, we support the study of the lower MSD in R18 timeline. For the objective, we think more generaric approach is prefered and the method based on UE indication of interferece shall be also invertigated. therefore, we suggest the third bullet of the objective can be changed as "Study whether the generic approach can be applied based on UE indication of capability/interference"

11 – ZTE Corporation

We are supportive on this to further improve UE performance which could be beneficial for both network planning for band combination and practical scheduling flexibility.

For targeted power class, it's understandable that inter-band CA/ED-DC PC2 might have more serious MSD performance, however it should be also noted that even for PC3, there are also some bands with bad MSD performance, therefore we think it should be reasonable to start with both PC2 and PC3.

Currently NR-DC is also missing, we propose to add it back since NR-DC requirement is reusing the requirement of inter-band CA.

In addition, as proposed in RP-212408, since MSD requirement is based on the UE at the maximum output power at the UE antenna connector, however in the practical network, most of UE is not transmitting at its maximum output power and also not located at the cell edge, from that perspective, the indicated MSD value based on the maximum output power would only provide the limited information to the network scheduling. If UE is enable to provide the real time MSD values to the network similar as PHR, then network could have more flexibility on scheduling and also handle the potential MSD problem by the implementation.

12 – vivo Communication Technology

We are supportive on the study for solutions of potential MSD improvement. If this work applies to all the combinations, then a generic solution would be preferred to reduce the workload instead of discussing the band combinations one by one. Otherwise, focus on limited number of example combinations is also acceptable for us.

13 – Samsung Electronics Co.

We support the study for potential MSD improvements. Such study shall be based on example band combinations in case by case manner. Whether RAN4 can conclude a generic solutions or generic UE capability of lower MSD for all band combinations shall be the outcome of study. It is too early to conclude such generic solution or generic UE capability. With above, we suggest to remove the 3rd bullet. The number of example band combiantions shall be certainly limited.

14 – Huawei Technologies France

We are supportive to have the study to investigate the potential ways to reduce MSD on a case by case basis. Not sure if general solution can be derived based without further study at this moment. Also we think it's too early to consier the capability signaling aspect. Example band combiantions can be further discussed. CMCC's approach to select the band combinations is ok for us.

15 – TELECOM ITALIA S.p.A.

We support, and have the same view as AT&T (study followed by Rel 18 WI; identify band combinations)

16 – LG Electronics Deutschland

We support this to be studied in Rel-18 as agreed in Rel-17 timeframe.

17 – KT Corp.

We share the same view with AT&T on how to progress with this SI and following WI.

18 – Skyworks Solutions Inc.

The low MSD term should be clarified from both a study and signaling point of view. For a given band combination and its higer orders there can be multiple MSD issues so is the goal to improve the worst ones? (with some threshold?) all MSDs at once? all power classes? and so on...for example we now have MSD related to 2UL CC in one band, is this part of the scope? Also in real life or test MSD can be quite different (antenna coupling, radiated vs conducted performance). UEs with lower MSD are anyhow performing better without any spec or signaling change so it does not mean that cell range will increase.

19 – Deutsche Telekom AG

We support the introduction of lower MSD for inter-band CA/EN-DC combination, as improvement of coverage and network performance has highest priority.

20 – BT plc

We have similar views to those expressed by AT&T

21 – MediaTek Inc.

It is still quite unclear to us what is targeted exactly. From the RAN4 discussion, identifying the levels of MSD in different parts of the band would lead to quite some effort, even before we consider how to characterize and signal any potential capability for improvement.

The fact that all of the objectives start with "study…" and the note saying that "objectives may be modified once work progresses" suggests that what is targeted or feasible should be identified first and therefore a Study Item limited to a few specific combinations would be more appropriate.

Following the result of any Study Item, RAN could then identify whether to progress to specification work for those combinations in a structured manner.

22 – NTT DOCOMO INC.

We generally support to introduce lower MSD.

Regarding power class, we think we don't need to exclude PC3, and thus we suggest to remove "Power class 2 (PC2) is considered".

For studying correlation of MSD improvement between different MSD sources, we agree that such study may be needed since improving UE RF architecture to reduce the impact of one MSD source like harmonic does not necessary means the same improvement apples to other MSD sources like IMD.

2.1.6 smaller A-MPR

- Investigate and define UE requirements with smaller A-MPR (RAN4)
  - The example band is [n1]
  - Study how to define smaller A-MPR considering the following solutions
    - Generic approach meaning that a certain improvement is always applicable to A-MPR for any conditions, and/or
      - e.g., If 1dB improvement is possible, the 1dB is applied to all the specified A-MPR values regardless of position, length of RBs, modulation, waveform and/or CBW etc
    - A specific approach meaning that a certain improvement is applicable to A-MPR only for specific condition, and/or
      - e.g., the conditions are tied with the position of the LO location
    - Other ways are not precluded

Feedback Form 6:

1 – Guangdong OPPO Mobile Telecom.

Generally understand the intention of reducing AMPR, but it is not clear how this smaller AMPR can be achieved, is there something missed when RAN4 define these AMPR requirements? Clarification is needed here, at least we need to understand how this can be improved in the end and how much people expect this can be improved. If in the end there is only 0.5dB for example, then the necessity of this work needs to be think about a little bit.

Regarding the ”generic approach” not understand the meaning of ”if 1dB improvement is possible then 1dB apply to all AMPR values”, how could this happen in the requirement definition and clarification is needed about the scenario.

2 – QUALCOMM JAPAN LLC.

It is not clear how this smaller A-MPR can be obtained or whether any meaningful gains can be achieved. Also, we think too much time would be used to get some minimal gains of at most 1-2dBs.

3 – Nokia Japan

We support specifying lower MSD as well as smaller A-MPR as package to enhance coverage.

The concept itself is similar to lower MSD meaning that if there are UEs with smaller A-MPR, the information needs to be shared with network in advance. We have introduced wider channel bandwidths and higher power classes, but they have accompanied larger A-MPR. It is very unfortunate if we cannot make maximum use of UE’s achievable performance as much as possible.

4 – Ericsson France S.A.S

We think it is useful to study a framework for smaller A-MPR. The benefits are likely not as large as MSD, but nonetheless improvements directly lead to improved coverage and user experience

5 – Intel

We consider A-MPR improvements with a lower priority.

Limited overall system performance benefits are expected comparing to the other proposed enhancements (4Tx, 6/8Rx, MSD improvements). If considered as a package with lower MSD signalling for capable UEs, then some value exists.

6 – Apple (UK) Limited

We have concern on this topic as the related A-MPR evaluations would require a new simulation campaign, and it is not clear whether the outcome would be any different than the currently defined A-MPR requirements. It is also not clear whether the smaller A-MPR is meant for a UE capability or a tightening to the existing A-MPR requirements.

7 – AT&T GNS Belgium SPRL

We support the study of smaller A-MPR. UL coverage has direct impact to user experience. We agree with the Nokia comment that trying to make use of achievable UE performance in the UL would be beneficial. We see this as similar to the low MSD study on the DL which is also trying to make use of achievable UE performance.

8 – Beijing Xiaomi Mobile Software

We also have same comments with other companies that how to achieved smaller A-MPR and the gain is not clear. A-MPR is band specific requirements, each band has different situation, which will bring about lots of work.

9 – ZTE Corporation

Similar comments as OPPO, We could understand its motivation and target, not sure 1dB improvement for A-MPR could further improved, or can be only limited within 1dB. We expect that larger A-MPR improvement could be achieved, otherwise its practical benefit should be also limited.

In addition, generic approach to improve A-MPR should be further clarified, otherwise its objective is a bit too open with only motivation and potential targe

10 – Samsung Electronics Co.

In general, RAN4 is supposed to specify the minimum requirements. With that, UE can certainly achieve better performance than minimum requirements. The question is whether it is necessary to introduce capability to differential different UE performance. In our understanding, if the intension is just to introduce UE capability for UE which can achieve better performance than minimum requirements specified in RAN4, we do not think it is necessary and also it is very risky to expand such capability to other metrics beyond A-MPR.

11 – Huawei Technologies France

Usually A-MPR is related to regulatory requirements. It is not clear how this smaller A-MPR can be obtained for this objective. For NR, A-MPR is not addtional power backoff similar to LTE. Max(MPR, A-MPR) is considered in the specification. Smaller A-MPR may not result in the smaller power backoff. The spec does not exclude that UE with better implemenation could use less power backoff.

12 – TELECOM ITALIA S.p.A.

Same view as AT&T: we support the study of smaller A-MPR. UL coverage has direct impact to user experience.

Note that improving UL coverage has a highly beneficial impact on overall network energy efficiency and to target sustainable networks. Sustainability should be a key driver of 3GPP Rel 18

13 – Nokia Japan

There are misunderstandings. We shared a possible improvement in R4-2201650 in RAN4#101-bis-e, though we are open to discuss any other ways to improve A-MPR.

Re-evaluation of the existing A-MPR

At least we don't have motivation to request re-evaluation of the existing A-MPR. The current A-MPR is derived based on the most conservative condition that DC is always placed at the center of the UE channel bandwidth. This condition maximises distance that IMD(s) reaches. However, it may not be always the case as RAN4 has discussed in UL DC location discussion. In this case, the required A-MPR changes significantly compared to the specified one. For instance, 10 MHz BWP is configured at the lower edge within UE channel bandwidth and if the DC is the center of the BWP, 10 MHz A-MPR must be referred to.

A text on "if 1 dB improvement etc

This just says that if the improved A-MPR is 1 dB, this kind of information is not helpful, we agree. But some UEs may use a special filter or due to DC location condition, the value may be significantly different, then, that information is valuable. This is the same concept as lower MSD.

14 – Skyworks Solutions Inc.

A-MPR like MPR is an allowance and UE can still transmit higher power. for low MPR/AMPR values there is little to gain in our view and for high MPR/A-MPR values there is a dependency on the PA and power control architecture. If adopted this study should focus on areas with significant gain and rather than the back-off value itself try to identify allocation types, position, and where the RF filter helps to reduce A-MPR.

15 – Deutsche Telekom AG

We support the investigation of lower A-MPR to make use of achievable UE performance in the UL and to further increase coverage.

16 – BT plc

We support the objectives of this work, and believe 3GPP RAN4 should investigate how to support UEs that can operate with a smaller A-MPR

17 – NTT DOCOMO INC.

We have interests in this topics.

For generic approach, given that A-MPR values for certain NS is not so large currently such as additional 1dB or 2dB back off compared to MPR, if the A-MPR values are improved, as a result, no A-MPR may be needed under some condition. It may be helpful to reduce testing burden as A-MPR test cases for some NS is very large.

For specific approach, if improved A-MPR values are significant, it may be utilized for NW operation.

18 – MediaTek Inc.

We don't support this. There will already be studies in the Coverage Enhancements work item to identify improvements to MPR. In general it is difficult to see how we can make generic improvements to MPR or A-MPR. However, we think we should focus efforts on the existing objectives of the Coverage Enhancements study in Rel-18. A-MPR is a more complex requirement that seems more difficult to generalize for.

2.2 Working areas which need more discussions in RP-212682

In this section, working areas which need more discussions in RP-212682 will be discussed. Companies are encouraged to share your views on these working areas.

2.2.1 New low power class for Uu and/or sidelink

- New low power class for Uu and/or sidelink (14dBm)

Feedback Form 7:

1 – Guangdong OPPO Mobile Telecom.

In our view, low power class is not good when UE is connecting the gNB, but probably there is chance in SL when UE is always connecting to devices nearby and be used for example as a replacement of WIFI/Bluetooth.

Therefore, suggest to remove uu, and only keep SL. And the Tx power suggest to be 20dBm as high as the WIFI and Bluetooth used today.

2 – China Telecommunications

Suggest to remove "Uu".

3 – QUALCOMM JAPAN LLC.

It is not clear what is the commercial use case for such device.

4 – China Mobile Group Device Co.

We suggest to remove lower power class (14dBm) in R18.

During the discussion of *New WID on enhanced support of reduced capability NR devices* in RAN1, low power red cap UE is listed as candidate objectives although this WID is not approved now(will be discussed and approved in Sep). so our suggestion is to focus this discussion in redcap WID to avoid overlapping work.

5 – Nokia Japan

A 14 dBm power class would be discussed in Rel-18 Redcap WI. Hence, if this new power class for Uu and/or sidelink is introduced or not should be discussed after the completion of Rel-18 Redcap WI to avoid duplicated discussion and minimize RAN4 workload.

6 – Intel

Do not support. Several proposals to support lower power class were made in order to allow NR-U LPI operation, however as decided in RAN4 #101-bis, existing power classes can be applied for LPI modes (with corresponding power reduction). So, we do not see a valid use case at this time. As commented by other companies it can be discussed in the scope of Rel-18 RedCap objectives in the future.

7 – ZTE Corporation

We are neutral on this topic, however to introduce the lower power class e.g. 14dBm similar as NB-IoT PC6, this would have lot of MPR and A-MPR related work.

8 – vivo Communication Technology

Given new low power class has been considered in Rel-18 RedCap WID, we are OK to discuss it in RedCap WI.

9 – TELECOM ITALIA S.p.A.

Do not support

10 – LG Electronics Deutschland We support this objective. If Rel-18 Redcap is to discuss 14dBm power class, we can compromise this to be discussed there.
11 – Deutsche Telekom AG Similar to other operators and some vendors, Deutsche Telekom does not support this objective (neither for Uu nor for SL)
12 – Skyworks Solutions Inc. It is not clear to us what the gain is to define a lower power class than what we already have since most of the targeted use cases could be supporter with PC5.
13 – MediaTek Inc. At least for Sidelink-unlicensed operation, we see that this could be interesting due to naturally applicable use cases. Would be supportive for that and it seems possible with limited effort.
14 – Spreadtrum Communications □Spreadtrum□ For lower power class, we share the similar view with some companies. We prefer to remove this topic in RAN4 at this stage until we have a clear picture on Rel-18 RedCap.

2.2.2 Simultaneous Rx/Tx for intra-band NC CA

- Simultaneous Rx/Tx for intra-band NC CA (REF: RP-211776)Example scenario: two non-contiguous carriers in n79
    - Study and if needed specify requirements to enable simultaneous Rx/Tx for Intra-band non-contiguous CA/DC in TDD band
        - Study the feasibility on self-interference and deployment scenario
            - Self-interference study to see the required MSD levels with MPR/A-MPR, UL RB restriction and frequency separation
            - Deployment scenario including BS co-channel/non-collocation with single/multiple NR operator
            - NOTE: in multiple NR operator deployment, consider restricted scenarios such as inter-operator deployment with Macro-to-Indoor and Indoor-to-indoor
            - Define the related RF requirements depending on the result of the feasibility study.

Feedback Form 8:

1 – Guangdong OPPO Mobile Telecom. For the simultaneous RxTx in intra-band CA case, it is expected there will be severe interference between them and MSD might be high. Usually for the CCs in the same band either same UL/DL configuration is

used or some freq separation is applied, they are simpler than the simultaneous RxTx in intra-band CA. Therefore, we may need to understand better on the deployment scenario.

2 – TELECOM ITALIA S.p.A.

Agree with OPPO. This seems to be a corner case, with very limited applications, unless a solution to deploy dynamic TDD is achieved. For example in Europe the Regulators are mandating inter-operator frame synchronization in the same band

3 – QUALCOMM JAPAN LLC.

Implementation of such simultaneous Rx/Tx is extremely challenging if not impossible. Even if possible, the MSD would likely make it unusable in practice.

4 – China Mobile Group Device Co.

We suggest to remove such objectives because this is overlapping with SBFD(sub band full duplex). Though some proponents propose Simultaneous Rx/Tx is for NC CA scenario while SBFD is only for signal carrier, the main works are both the feasibility of self-interference. so it's suggested to focus on SBFD to avoid overlapping workload.

5 – Nokia Japan

We see many significant challenges for the proposed scenario as summarized in RP-213244. Hence, we believe we should await outcome of RAN1 duplex evolution study. And it would be better for the proponent to propose that RAN1 duplex evolution study should consider UE full duplex in the study.

6 – Ericsson France S.A.S

There is likely to be high self-interference and the technical study is likely to be large and complex. We prefer not to study UE "Full Duplex" in this WI.

7 – Intel

We do not support. Proposed scenarios have substantial implementation challenges

8 – Apple (UK) Limited

We are not positive on this proposal as substantial REFSENS impact is expected (30+ dB MSD) since there is virtually no isolation between Rx and Tx.

9 – Beijing Xiaomi Mobile Software

we are also not positive on this proposal as it can be expected there would be serve desense for DL.

10 – ZTE Corporation

Firstly, for 2nd sub-bullet, why BS of multiple NR operator is co-channel deployed? It should be non co-channel, right?

Secondly, as mentioned by other companies, self interference should be one big problem from UE side.

Thirdly for NOTE with inter-operator deployment with Macro to Indoor and indoor to Indoor, this seems like the Rel-18 full duplex discussion where there are some cross link interference between different sites, maybe more clarifications or diagram could be helpful for further understanding.

11 – LG Uplus

In Korea, there is going to be some operators that have two carriers.

There are self/cross-interference to be considered, but there seems to be potential to accommodate various 5G applications in the same area.

12 – LG Electronics Deutschland

We support this item, however, it seems most companies are not convinced to start studying this at this stage. We are fine to discuss this along with Sub-Band Full Duplex(SBFD) discussion even though this is intra-band CA scenario which is not exactly the same as the one discussed in SBFD. We are also fine to defer this after SBFD.

13 – Skyworks Solutions Inc.

in our understanding simultaneous Tx/Rx is already a R18 topic on the BS side which has all means to do interference cancellation but we do not see how this can apply to the UE side. the BS side should be enough to provide flexibility at the network level without simultaneous Tx/Rx on the UE side. Any PA, even at large frequency offsets has around -130dBm/Hz noise floor at max power and thus in the same band, best case (at least 6xCBW away) the MSD is >35dB for 10MHz BW.

14 – MediaTek Inc.

From the first line of objectives, this initially seems to be a very specific/niche scenario that is very dependent on the exact separation considered between carriers so, even if MSD impacts would not be significant (which we doubt), the usage scenario seems limited.

However, the later description then suggests that this is actually something much more than just NCCA, as it talks about co-channel, non-collocated, multi-operator scenarios and DC? So further clarification is needed on what is exactly being proposed in this topic. It seems to have quite some overlap with the agreed Full Duplex study.

2.2.3 UL Tx switching for UL CA with multiple TAG

- UL Tx switching for UL CA with multiple TAG
  - Enhance UL CA RF requirements
    - Enable multiple TAG for TX switching (if not addressed already in Rel-17)

Feedback Form 9:

1 – Guangdong OPPO Mobile Telecom.

It seems this topic has already been covered by RAN1 lead multi-carrier enhancement WI RP-213577 as below? If it is then no more discussion is needed here.

- UL Tx switching schemes across up to 3 or 4 bands with restriction of up to 2 Tx simultaneous transmission for FR1 UEs, including mechanisms to enable more configured UL bands than its simultaneous transmission capability and to support dynamic Tx carrier switching across the configured bands

for **both single TAG and multiple TAGs** configurations (RAN1, RAN4)

2 – China Telecommunications

As mentioned by OPPO, UL CA Tx switching with multiple TAG is included in RAN1-led Multi-carrier enhancements WI, with a study phase.

However, in our understanding, the RAN1 objective is targeting Tx switching for scenarios with up to **3 or 4 bands configured**, and up to 2Tx activated.

RAN4 still needs to discuss the support of CA Tx switching with multiple TAG for 2-band scenario.

3 – China Mobile Group Device Co.

This objective is already covered by multi-carrier enhancement WID lead by RAN1. To avoid any overlapping, it's suggested to remove such objectives and focus on existing WID (RP-213577)

4 – Nokia Japan

In our understanding, this objective is accommodated by Rel-18 CA enhancement WI led by RAN1 so that we don't need to discuss this in RAN4 package WI.

5 – Ericsson France S.A.S

The RAN1 CA enhancement WI covers 3 and 4 bands configured, but not 2 band. It would be illogical not to consider also 2 band multiple TAG scenarios. We suggest to either add to this WID, or clarify the RAN1 WID to include multiple TAG for 2 bands, or solve 2 bands in Rel-17 in February (we will bring a CR).

6 – AT&T GNS Belgium SPRL

We agree with China Telecom and Ericsson that multiple TAG for 2 bands needs to be addressed. If it is not solved in Rel-17, it has to be included as part of the Rel-18 WI.

7 – ZTE Corporation

We are supportive on this topic to broaden the use case of Tx switching from co-located scenario to non located CA. Regarding the overlapping with multi-carrier enhancement in RP-212577, from our understanding, RAN4 could focus on 2 bands UL Tx switching with multiple TAG in REL-17 and RAN1 led multi-carrier enhancement could focus on 3 bands or 4 bands Tx switching in REL-18. No strong opinions on where to handle this topics.

8 – Huawei Technologies France

We think the objective is already covered by the RAN1 multi-carrier enhancement WID. Operating bands can also be discussed under the RAN1 WI. No need to consider addtional work in RAN4.

9 – NTT DOCOMO INC.

We have interests in this topic.

We need to have common understanding, and if 2 bands case is not considered anywhere, it should be included. If 2bands case is finished in Rel-17, it must be OK.

10 – MediaTek Inc.

We share the view of Oppo/Huawei, this seems fully covered by the existing UL multi-carrier item agreed at RAN#94-e. See no need for this.

11 – Nokia Japan

To Ericsson,

First of all, we support the introduction of the requirements for this feature. Multi-carrier enhancements for NR WI says that ”UL Tx switching schemes across **up to** 3 or 4 bands with restriction of up to 2 Tx simultaneous transmission for FR1 UEs....” and ”to support dynamic Tx carrier switching **across the configured bands** for both single TAG and **multiple TAGs** configurations: So, wouldn’t it be natural to interpret that RAN1 led WI need to cover this topic?

2.3 Others

Feedback Form 10:

1 – Skyworks Solutions Inc.

NR-U contiguous ULCA is seing very slow progress in Release 17, if not finalyzed, should it be moved to R18 instead?

2.4 Summary for initial round

2.4.1 4Tx

For the main bullet, 3 companies support to further clarify the 4Tx is for “single CC” instead of “single band”. 3 companies support to change the CPE/FWA device type to CPE/FWA/vehicle/industrial devices (same format used in RP-213598, WI on MIMO enhancements).

So moderator proposes the following changes:

- Enable 4Tx on a single carrier ~~band~~ for ~~FWA/CPE~~ CPE/FWA/vehicle/industrial devices

For targeting bands, 5 companies support to not consider FDD bands while 2 operators support to consider FDD bands. There are some additional request on example band n40 and n79, while one company comment that the example bands should be restricted to 3 considering RAN4 workload. From moderator perspective, the example bands had already been discussed extensively in previous discussion and the existing 3 bands are listed considering the reasonable RAN4 workload, anyway other bands can be introduced in a release independent manner. There is also no need to restrict TDD band only since any new bands request will be discussed individually in the future.

So moderator proposes to keep the following bullet as it is.

- Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)

Multiple companies support to clarify the TXD issue. 5 companies support to only consider 4x4 UL MIMO, while 2 companies support to also consider TXD. Moderator suggests to agree on 4x4 UL MIMO first and continue to discuss whether TXD is needed in Rel-18 in the intermediate round:

- Specify the UE RF requirements to support 4Tx
    - Target for 4x4 UL MIMO
    - FFS on TXD

Multiple companies support to clarify the target power class and PA configurations. 2 companies support PC2 and PC1.5, while 1 company support consider only PC 1.5 with 23dBm x4. Moderator suggests to agree on PC 1.5 with 23dBm x 4 first and continue to discuss whether other PC and/or PA configurations should be considered in Rel-18

- Target for PC1.5 with 23dBm x 4
- FFS on other PC and PA configurations

To summarize, the following objective are considered as consensus and to be confirmed in intermediate round:

- **Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices**
    - **Investigate framework and architecture**
    - **Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)**
    - **Specify the UE RF requirements to support 4Tx**
        - **Target for 4x4 UL MIMO**
        - **Target for PC1.5 with 23dBm x 4**
    - **Specify the BS demodulation performance requirements to support 4Tx UE operation**

The following open issues are to be discussed in intermediate round:

1. **FFS on TXD**
2. **FFS on other PC and PA configurations**

2.4.2 8Rx

Similar comments are received for device type and the same changes for 4Tx can be adopted for 8Rx.

For targeting bands, 2 operators propose to not restrict to TDD bands only. From moderator perspective, the bullet related to target bands can be aligned with 4Tx considering both objectives targeting for the same device types. No need to restrict TDD or FDD or frequency since anyway other bands requested later will be discussed individually.

Hence, the following objectives are considered as consensus and to be confirmed in the intermediate round:

- **Enable 8Rx for CPE/FWA/vehicle/industrial devices**
    - **Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)**
    - **Specify the UE RF requirements to support 8Rx**
    - **Specify RLM test cases with 8Rx**
    - **Specify UE demodulation performance and CSI requirements to support 8Rx**
    - **Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4**

3 companies would like to also add 6Rx for FWA/CPE, and 1 company would like to get clarification on whether 8Rx fallback to 6Rx is within the scope or not.

Open issues to be discussed in the intermediate round:

Whether 6Rx or other fallback mode should be considered together with 8Rx for CPE/FWA/vehicle/industrial devices in Rel-18.

2.4.3 6Rx

Multiple companies comment that the device type should be clarified and no study is needed for FWA/CPE. **So moderator suggests this objective only focus on smartphone, and FWA/CPE will be discussed in previous objective.**

For 6Rx support of smartphone, 2 companies do not support this objective, 2 companies consider this as a low priority and feasibility study is needed. 9 companies support this objective.

For the target bands, similar comments received as previous 8Rx/4Tx, while 1 company propose to restrict to TDD band>2.3GHz even higher considering the target for smarthpone.

Moderator suggests to continue discuss the following objectives in the intermediate round:

- **Investigate and enable 6Rx on higher frequency bands targeting at support of smartphone (RAN4)**

- **Investigate the feasibility whether 6Rx can be supported by smartphone**
    - **Feasibility study includes performance gain and form factor**
- **Example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)**
    - **FFS on the frequency upper bound.**
- **Specify the requirements to support 6Rx subject to the conclusion of feasibility study**
    - **Specify the UE RF requirements to support 6Rx**
    - **Specify RLM test cases with 6Rx**
    - **Specify UE demodulation performance and CSI requirements to support 6Rx**
    - **Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4**

2.4.4 3Tx

There are three cases in this objective,

- Tx switching: All companies support this case. According to the comments, and example band combinations is not necessary, EN-DC can be introduced.One clarification is needed that for the 2Tx on the other band does not include intra-band non-contiguous UL CA.
- Power enhancement: multiple companies comment that this should start after the completion of Rel-17 PowerLimitCA_DC WI. Example band combinataions are added based on company input.
- 3Tx on 3 bands: 3 companies support, while 10 companies against. More discussion is needed.
- 3Tx diversity: all companies agree to drop this one.

According to the discussion, the following objectives are considered as consensus and to be confirmed in the intermediate round:

- **Investigate and if necessary, specify requirements to support 3Tx considering two use cases (RAN4)**
    - **3Tx simultaneous transmissions for two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band [(intra-band non-contiguous UL CA is precluded)]**
        - **Identify and specify Tx switching transmission enhancement if needed (RAN2, RAN4)**
            - **Cover inter-band UL CA , ENDC and SUL case**
            - **Identify and specify RAN2 signaling design is needed**

- □ **Identify and specify the necessary RF requirements if needed**

- ■ **Power enhancement**
  - □ **DC_3A_78A, CA_n3A-n78A and CA n3A-n78C**
  - □ **Study the definition of power class**
    - **Both power class defined per band combination as total power and power class defined per band are considered**
  - □ **Identify and specify the other necessary RF requirements**

    Note: this objective should start after the completion of Rel-17 PowerLimitCA_DC WI.

The following objectives need further discussion:

- ○ **[3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band**
  - ■ **Study the power class framework, impact on MPR/A-MPR and impact on MSD**
  - ■ **Example band combinations**
    - □ **Consider TDD+TDD+TDD without simultaneous Tx/Rx**
    - □ **FFS other band combinations, e.g., FDD+FDD+TDD, FDD+TDD+TDD]**

2.4.5 lower MSD

In general, all companies agree to study low MSD in Rel-18. Regarding the detailed objectives, there are still different views.

1 company comment to also include DC. DC is added in [], companies are welcome to comment in 2nd round.

5 companies comment that this study should start with limited band combinations, based on initial round feedback, CA_n1-n77 and CA_n3-n41 are listed as example band combination.

2 companies comment that only new band combinations should apply this low MSD. Since we are listing existing band combination as the example for the study, further clarification on how to only apply this to new band combiantions is needed.

6 companies support to not restrict to PC2. So the last bullet is removed.

For the 2nd sub-bullet, 2 companies support to clarify the study of correlation of MSD improvement between different MSD resources.

To summarize, we will continue to discuss the following objectives in intermediate round:

- **Investigate and introduce lower MSD for inter-band CA/EN-DC/[DC] combinations (RAN4)**

- **Example band combinations: CA_n1-n77, CA_n3-n41**
- **[Study how the MSD performance can be improved for example band combinations**
  - **Study correlation of MSD improvement between different MSD resources]**
- **[Study whether the generic approach can be applied based on UE indication of capability/interference]**
- **Study and specify the requirements and/or capability signaling**

In addition, 1 company proposed two more detailed bullets, more discussion on the following bullets in the intermediate round is needed:

- [Investigate dynamic configuration of simultaneous and non-simultaneous Rx/Tx operation as a means to mitigate MSD impact on network performance.]
- [Study on how to introduce UE signal to self-interference ratio measurement mechanism for assisting network scheduling on band combinations subject to MSD impact.]

2.4.6 smaller A-MPR

8 companies do not support this objective, 1 company consider this objective as low priority, while 7 companies support this objective (including 5 operators).

It is difficult to reach consensus based on current situation. The benefits of smaller A-MPR still require more justification.

Continue to discuss the following objectives by adding "study the feasibility..."

- **[Investigate and define UE requirements with smaller A-MPR (RAN4)**
  - **The example band is [n1]**
  - **Study the feasibility and how to define smaller A-MPR considering the following solutions**
    - **Generic approach meaning that a certain improvement is always applicable to A-MPR for any conditions, and/or**
      - **e.g., If 1dB improvement is possible, the 1dB is applied to all the specified A-MPR values regardless of position, length of RBs, modulation, waveform and/or CBW etc**
    - **A specific approach meaning that a certain improvement is applicable to A-MPR only for specific condition, and/or**
      - **e.g., the conditions are tied with the position of the LO location**
    - **Other ways are not precluded]**

2.4.7 New low power class for Uu and/or sidelink

9 companies do not support this objective, 6 of them comment that Rel-18 RedCap is to discuss 14dBm power class, and this objective can be discussed there.

So moderator proposes:

Do not consider "new low power clss for Uu and/or sidelink (14dBm)" in Rel-18 RAN4 package. No more discussion in the intermediate round.

2.4.8 Simultaneous Rx/Tx for intra-band NC CA

12 companies do not support this objective, and 5 companies believe this has overlap with RAN1 full duplex study.

2 companies support this objective, while 1 of them is also OK to go with RAN1 full duplex study first.

So moderator proposes:

Do not consider "Simultaneous Rx/Tx for intra-band NC CA" in Rel-18 RAN4 package. No more discussion in the intermediate round.

2.4.9 UL Tx switching for UL CA with multiple TAG

All companies support this work. 5 companies believe that this objective is already covered by RAN1 lead multi-carrier enhancement WI, while 3 companies think RAN1 WI only cover 3 and 4 bands.

So moderator proposes:

Specify UL Tx switching for UL CA with multiple TAG (2 bands scenario) in Rel-18 RAN1 Multi-carrier enhancement WI.

Further check whether any modification or clarification is needed in RAN1 Multi-carrier enhancement WI (RP-213577) in intermediate round.

2.4.10 Others

Continue to discuss following objective in intermediate round:

NR-U contiguous UL CA is not finalized in Rel-17

3 Intermediate round

3.1 Working areas

3.1.1 4Tx

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices
  - Investigate framework and architecture
  - Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)
  - Specify the UE RF requirements to support 4Tx
    - Target for 4x4 UL MIMO
    - Target for PC1.5 with 23dBm x 4
  - Specify the BS demodulation performance requirements to support 4Tx UE operation

Feedback Form 11: Confirm the above objectives

1 – Verizon UK Ltd The working area should be further clarified to support 4Tx and 8Rx as a package for the enhancement of FWA/CPE.
2 – TELECOM ITALIA S.p.A. We support the moderator proposal. As indicated by the moderator in the summary of the initial round, we believe it would be good to consider also other power classes (maybe as lower priority or to be introduced in a Release independent way)
3 – AT&T GNS Belgium SPRL We are not sure why are first round comments for 4Tx did not appear in NWM given that we posted them prior to the 8Rx comments (in fact, we copy and pasted the text to use as the starting point for 8Rx and removed the power class aspects). Very strange. We will check with NWM support to see if they can find anything. We are OK with the moderator proposal with the following clarifications (some of these comments were part of our first round comments that went missing): - We think that the power class targets should be flexible to also allow PC2 for UL MIMO cases such as 4x2 UL MIMO and also consider the outcome of the Rel-17 WI on increased power limit. - We are OK with the example bands provided as long as the generic work completed allows for FDD bands to be introduced in a release independent way later.

4 – Spark NZ Ltd

We support the way forward for this item.

5 – SoftBank Corp.

We support the moderator's proposals and it would be good to consider the power classes other than PC1.5.

6 – China Telecommunications

Support the moderator proposal.

7 – Intel

We support the objectives from the initial round

8 – Huawei Technologies France

We support the moderator's proposal.

9 – CHTTL

ok with the proposal

10 – ZTE Corporation

We are fine with moderator proposed objectives.

11 – Samsung Electronics Co.

we support moderator proposal

12 – Skyworks Solutions Inc.

We do not agree that this covers FDD bands for the future band introduction. the example bands are all TDD and in R17 we are still discussing the REFSENS framework for 2Tx PC2 for FDD bands that are subject to desense due to UL interference (like band 3). Furthermore PC1.5 is not agreed for FDD bands. Unless there is an FDD example band with 4Tx UL self desense we do not see that this WI can cover FDD bands in the future. the WI should be restricted to TDD in that way:

example bands: n41, n77 and n78 (other **TDD** bands to be introduced in the release independent way later).

Separately, the Full UL power aspects should be in the objectives: **Study if and how Full UL power can be supported.**

13 – Orange

We support the proposal and agree with TIM that other power classes may also be considered

14 – vivo Communication Technology

We support moderator proposal. We are also OK if this work is limited to TDDbands in Rel-18 as suggested by Skyworks.

15 – LG Electronics Deutschland We also support moderator's proposal.
16 – China Unicom We support moderator's proposal.
17 – Nokia Japan We are OK with the proposal. We just would like to restate that we need to focus on one power class with one specific PA configuration to avoid the current RAN4 situation where many PA configurations were considered and this increased RAN4 work significantly. Regarding the BS demodulation, BS demod for 4Tx UE operation looks odd so that it may be "Specify the BS demodulation performance requirements to support 4x4 UL MIMO~~Tx~~ UE operation
18 – Ericsson France S.A.S We are OK with the proposal
19 – NTT DOCOMO INC. Thank you for the proposal. We still would like to include other PCs such as PC3. Other parts are OK.
20 – Spreadtrum Communications We are ok with the moderator's proposals.
21 – MediaTek Inc. It is unclear that FDD bands can be introduced release independently... if we assume 29dBM Tx power especially. This should be highlighted as a note at least.

Open issues to be discussed:

1. FFS on TXD
2. FFS on other PC and PA configurations

Feedback Form 12:

1 – TELECOM ITALIA S.p.A. See Answer to form 11: we believe it would be good to consider also other power classes (maybe as lower priority or to be introduced in a Release independent way)
2 – Guangdong OPPO Mobile Telecom. Regarding whether TxD is allowed or not, it might depends on whether UE has to keep same power class

among 4 layer UL MIMO and single antenna port (4PAs activated), if it is then TxD might be needed to keep as high Tx power as UL MIMO.

Therefore, it should be added in the WI scope, at least saying ”investigate and if necessary specify TxD requirement to support the same power class in UL MIMO and single antenna port”.

3 – SoftBank Corp.

We think it would be good to consider the power classes other than PC1.5.

4 – QUALCOMM JAPAN LLC.

TxD should be included.

As commented above, other power classes should also be considered.

5 – Intel

We support treating TxD as second priority. Also, for PC we are open to 26dBm x 4 case as a secondary priority. For PA configurations it is best for RAN4 not to specify specific architectures but just to focus on PC.

6 – Huawei Technologies France

We think that TxD is needed as single port antenna mode should be supported for a 4Tx FWA/CPE, otherwise the UE may fail the RAN5 test.

Other power class should be considered as well.

7 – Apple (UK) Limited

We share the similar view with OPPO. Current RAN4 requirement puts the constraint that the UE power class shall be the same for UL MIMO and single layer transmission. RAN4 may consider allowing power class fallback from UL MIMO to single layer transmission as the same power class may not be guaranteed with transparent TxD. However, this issue is not specific to 4Tx.

8 – ZTE Corporation

For other power class, we are open to further discuss it if there are strong market demand.

For TxD, the considering the workload for 4Tx, it should be treated with low priority.

9 – Skyworks Solutions Inc.

Regarding TxD support, one of the question is whether 4Tx TxD is needed as 2Tx is already supported. 4Tx TxD is only needed if Full UL power is supported.

regarding other power class we believe PC1.5 should be the driving example and then PC2 can be supported with 4x20dBm PAs but that is only defined for NR-U.

We believe the FDD band support is still an open issue: no PC1.5 not framework for 4Tx self desense.

10 – LG Electronics Deutschland

We are fine to include TxD and open for other PC. We can consider PA configuration as reference architecture purpose for the discussion.

11 – vivo Communication Technology

For other PCs we are open to discuss.

Regarding TxD, considering the conclusions in the study of 2Tx transparent TxD, the MPR analysis for 4Tx transparent TxD could be the same to the 4Tx UL-MIMO multi-layer case with no duplicate work. However, it should be still noted that there are still unsettled testing related issues for 2Tx transparent TxD, e.g. power imbalance issues etc, that would also impact 4Tx transparent TxD, that need to be completed before implementation and verification.

12 – Nokia Japan

If 4 TxD is considered, we should not consider multiple PA configuration assumptions if we consider 4Tx TxD. Hence, if PC1.5 4 TxD is introduced, PA configuration assumption of of 23 dBm x 4 only should be considered.

13 – Ericsson France S.A.S

Support TxD via the ULFPTx framework

14 – Samsung Electronics Co.

If TxD is included, it shall be discussed only after 4x4 MIMO work is completed. Similar comments for other power classes

15 – China Mobile Group Device Co.

We support above proposals.

About TxD, the baseline constrain is that UE power class shall be the same for UL MIMO and single antenna port transmission (4PA activated) . so the proposal as proposed by OPPO is also OK for us that ”investigate and if necessary specify TxD requirement to support the same power class in UL MIMO and single antenna port”.

About other PC configuration, they should be low priority even if they are approved to be included finally.

16 – NTT DOCOMO INC.

We still would like to include other PCs such as PC3.

17 – Spreadtrum Communications

We support TxD on condition that the PA configuration is limited to PC1.5 23dBm*4

3.1.2 8Rx

- Enable 8Rx for CPE/FWA/vehicle/industrial devices

- Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)
- Specify the UE RF requirements to support 8Rx
- Specify RLM test cases with 8Rx
- Specify UE demodulation performance and CSI requirements to support 8Rx
- Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4

Feedback Form 13: Confirm the above objectives

1 – Verizon UK Ltd The working area should be further clarified to support 4Tx and 8Rx as a package for the enhancement of FWA/CPE.
2 – Verizon UK Ltd The scope of this work should cover the FDD high band too. The band n66 can be an example band.
3 – TELECOM ITALIA S.p.A. We support the moderator's proposal
4 – AT&T GNS Belgium SPRL We are OK with the moderator proposal with the following clarification: - We are OK with the example bands provided as long as the generic work completed allows for FDD bands to be introduced in a release independent way later.
5 – Spark NZ Ltd We support the way forward for this item.
6 – SoftBank Corp. We support moderator's proposals.
7 – China Telecommunications We support the moderator proposal.
8 – QUALCOMM JAPAN LLC. with 8Rx the baseline should be to have 8 layers also defined. LTE already has tests with 8layers, the same should be done for NR>

9 – SoftBank Corp.

Thanks QC for the comment. We support QC's comment.

10 – Intel

We support the objectives from the first round. To keep the workload reasonable, we recommend to keep the three TDD example bands while not restricting to add further bands, including FDD bands in a release independent way.

11 – CHTTL

ok with the proposal

12 – ZTE Corporation

We support the moderator's proposed objectives. Regarding the new bands, it's better to add in future release to ensure reasonable workload in RAN4.

13 – China Mobile Group Device Co.

We support the moderator's proposals.

14 – Skyworks Solutions Inc.

should there be associated work to define SRS antenna switching for 8 antennas?

15 – Orange

we support the proposal

16 – LG Electronics Deutschland

We also support the moderator's proposal.

17 – vivo Communication Technology

We support the proposals.

18 – China Unicom

We support moderator's proposals.

19 – Ericsson France S.A.S

We are OK with the proposal

20 – Huawei Technologies France

We support the moderator proposal. Also think that the comment from QC should be considered.

21 – China Mobile Group Device Co.

we support moderator's suggestion.

22 – NTT DOCOMO INC.

Thank you for the proposal. We support.

23 – Spreadtrum Communications

We are ok with the moderator's proposals

Open issues to be discussed:

Whether 6Rx or other fallback mode should be considered together with 8Rx for CPE/FWA in Rel-18. If 6Rx is considered, please propose the modified objectives.

Feedback Form 14:

1 – Guangdong OPPO Mobile Telecom.

In our view, 6Rx means UE with 6Rx antennas rather than fallback mode of 8Rx UE. For example UE with 4Rx antenans can support 3 DL layer in RAN1 but no requirements in RAN4 for 3 DL layer.

Suggest to focus on only 8Rx antennas for CPE/FWA in Rel-18, and after that if necessary can further consider 6Rx UE in future releases.

2 – China Telecommunications

6Rx, if only considered as the feedback mode of 8Rx devices, may not worth the work efforts needed in RAN4. For 6Rx, we can first discuss it for smart phone.

3 – QUALCOMM JAPAN LLC.

6Rx should be considered by itself, not as a fallback. If UEs implement fallback, it will likely be to 2Rx or at most 4Rx to save power.

4 – Intel

We support allowing the flexibility to use 6Rx or 8Rx implementations for CPE/FWA type of devices. Not all CPE/FWA devices may have a sufficient flexibility to allow 8RX antenna placement and it is helpful for 3GPP technology to allow implementations with a smaller number of antennas. The objectives should support both and can be adjusted as follows:

○ Enable 6Rx and 8Rx for CPE/FWA/vehicle/industrial devices

■ Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)

■ Specify the UE RF requirements to support 6Rx and 8Rx

■ Specify RLM test cases with 6Rx and 8Rx

■ Specify UE demodulation performance and CSI requirements to support 6Rx and 8Rx

■ Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4

5 – CHTTL

share the similar view as China Telecom

6 – ZTE Corporation Neutral on this topics and at least currently we don't see big market demand on 6Rx CPE yet, if the additional workload compared with 8Rx, it might be also okay to be included.
7 – Skyworks Solutions Inc. In our view 6Rx, if supported should be associated with 8Rx. Then 6Rx applicability to smartphones should be part of the discussion and especially in terms on frequency boundary that enables fiting 6 antennas with low correlation (most probably it will be limited to TDD >2.3GHz for smartphone)
8 – Orange same view as China Telecom
9 – vivo Communication Technology We support the modification proposed by Intel.
10 – Ericsson France S.A.S Considering the demodulation workload, we prefer to focus on 8RX
11 – Huawei Technologies France For FWA/CPE, we prefer only consider 8Rx in Rel-18.
12 – China Mobile Group Device Co. we prefer only consider 8Rx in Rel-18 for FWA/CPE.
13 – Spreadtrum Communications We think 8Rx takes the priority over 6Rx in case of FWA/CPE.

3.1.3 6Rx for smart phone

Continue to discuss the following objectives.

- Investigate and enable 6Rx on higher frequency bands targeting at support of smartphone (RAN4)
  - Investigate the feasibility whether 6Rx can be supported by smartphone
    - Feasibility study includes performance gain and form factor
  - Example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)
    - FFS on the frequency upper bound.
  - Specify the requirements to support 6Rx subject to the conclusion of feasibility study
    - Specify the UE RF requirements to support 6Rx

- □ Specify RLM test cases with 6Rx
- □ Specify UE demodulation performance and CSI requirements to support 6Rx
- □ Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4

Feedback Form 15:

1 – Verizon UK Ltd

The scope of this work should cover the FDD high band too. The band n66 can be an example band.

2 – Spark NZ Ltd

We support the way forward for this item.

3 – Guangdong OPPO Mobile Telecom.

1. In the feasibility study, further clarify in the objective ”form factor **restrictions**” (restriction is missing);
2. The last sub-bullet should be removed, i.e. ”*Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4*”, currently RAN1 doesn’t support 6 port codebook and there is no chance for UE to achieve higher layers than 4.
3. Combine the 6Rx for smart phone together with 3Tx as advanced smartphone architecture.

4 – SoftBank Corp.

We support the objectives.

5 – China Telecommunications

Ok to consider 6Rx in Rel-18 if it is for smart phone.

6 – QUALCOMM JAPAN LLC.

We would prefer not to have a feasibility study since it is unlikely to produce meaningful results but having the study could be a compromise to bring this project forward.

7 – Intel

Our first priority is to support 6Rx for CPW/FWA as a subset of the 8Rx item. However, we are ok to include 6Rx for smartphone form factor in the WI scope as well. In the latter case we do not think that feasibility studies are required.

8 – CHTTL

support the proposal

9 – Skyworks Solutions Inc.

This should be a study and specifically the applicable frequency range needs to be studied. we do not agree that FDD bands are a priority because of the frequency range. at least this should be part of the study to determine which bands may eligible in the future.

10 – Orange we support the proposal
11 – Ericsson France S.A.S We are OK with the objectives, however considering the workload in RF and in demod we think it would be better to focus on 8RX. 6RX can have the lowest priority among the working areas.
12 – vivo Communication Technology We suggest to consider this item as 2nd priority, after the 6Rx requirements of CPE/FWA is finalized.
13 – Huawei Technologies France Our priority for more than 4Rx is for FWA/CPE. Not sure if there could be obvious gain taken the form factor and implemenation aspect into consideration. Also as commented by OPPO, the max MIMO layer is 4layer. If something can be done in Rel-18, investigate and feasibility analysis is necessary for smart phone.
14 – China Mobile Group Device Co. we support the proposals
15 – NTT DOCOMO INC. We support the proposal.
16 – Spreadtrum Communications We are ok with the moderator's proposal. 6Rx on smartphone is challenging, so we agree that there is a study phase to investigate on the performance gain and form factor restriction. Additionally we think 6Rx takes the lower priority than 8Rx on FWA/CPE, considering we can get reference from the outcome of 8Rx on FWA/CPE.
17 – MediaTek Inc. We agree this would at least need a study phase.

3.1.4 3Tx

- Investigate and if necessary, specify requirements to support 3Tx considering two use cases (RAN4)
  - 3Tx simultaneous transmissions for two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band (intra-band non-contiguous UL CA is precluded)
    - Identify and specify Tx switching transmission enhancement if needed (RAN2, RAN4)
      - Cover inter-band UL CA , ENDC and SUL case
      - Identify and specify RAN2 signaling design is needed
      - Identify and specify the necessary RF requirements if needed

- Power enhancement
  - DC_3A_78A, CA_n3A-n78A and CA n3A-n78C
  - Study the definition of power class
    - Both power class defined per band combination as total power and power class defined per band are considered
  - Identify and specify the other necessary RF requirements

    Note: this objective should start after the completion of Rel-17 PowerLimitCA_DC WI.

Feedback Form 16: Confirm the above objectives

1 – TELECOM ITALIA S.p.A. We support in principle the proposal. However, we prefer a study phase followed by normative work: ~~Investigate and if necessary,~~ Study and specify requirements to support 3Tx considering ~~two~~ the following use cases (RAN4)
2 – Spark NZ Ltd We support the way forward for this item.
3 – Guangdong OPPO Mobile Telecom. Agree with Telecom Italia comments, in the main bullet "*Investigate and if necessary*" should be removed. There is no need to study the necessasity.
4 – SoftBank Corp. We are supportive of the objectives.
5 – China Telecommunications Thanks for the moderator proposal. We have some comments on Tx switching enhancement part: - Study is not needed, since this is the easiest use case for 3Tx capable UE, and the standard impact is marginal. - Only two simultaneous transmissions are needed. - Is it correct understanding that it only works for 1Tx-2Tx switching to support 0us switching period? (i.e., cannot achieve 0us switching time for 2Tx-2Tx switching) For power enhancement, we understand the use case, and we don't quite understand the additional requirements for 3Tx capable of UE with the same power class, e.g., 23+26dBm (compared to 2Tx UE). Perhaps we can identify it after the completion of 17 PowerLimitCA_DC WI.

6 – Intel

To minimize workload, we prefer to limit the scope of this item to Tx switching. Prefer to postpone discussion on power enhancement until after 4Tx item, and 3Tx switching is complete.

7 – Guangdong OPPO Mobile Telecom.

To CT comment about the Tx swithcing case: Yes, it only applies to 1T/2T switching with following CC configurations

o 1 carrier on band A and 1 carrier on band B

o 1 carrier on band A and 2 contiguous aggregated carriers on band B

8 – Guangdong OPPO Mobile Telecom.

To Intel comment about the power enhancement:

It is very basic or fundamental benefit that 3Tx can achieve in power domain. And with the already discussion in Rel-17 increase power class high limit topic, most likely the conclusion there can be leveraged and allow UE to use its full power capability.

9 – CHTTL

We are supportive of the objectives.

10 – ZTE Corporation

For power enhancement for 3Tx, maybe it's better to be added with the conclusion of Rel-17 PowerLimitCA_DC WID later on. We are also open for further discussions.

11 – Beijing Xiaomi Mobile Software

We are ok with current content.

12 – Skyworks Solutions Inc.

We are fine with the reduced scope to 1 band 1Tx + 1 band 2Tx. to be complete, example band combination should core a PC1.5 2TX case. one further clrification needed is wthere the band with 2Tx can support 2 contiguous CC+UL MIMO.

13 – Orange

we support the proposal and agree with TIM's proposed revision

14 – LG Electronics Deutschland

We support moderator's proposal

15 – China Unicom

We support moderator's proposals, and also fine with modifications made by OPPO.

16 – vivo Communication Technology

We share the similar view with China Telecommunications, Intel and ZTE, Tx switching is prefered, power enhancement working scope can be further discussed after there is conclusion from controversial Rel-17 PowerLimitCA_DC WI.

17 – Ericsson France S.A.S

We are OK with the proposal. In terms of priority, we think it is somewhat lower than 4TX, 8RX, MSD, A-MPR

18 – Nokia Japan

We are not sure what the power enhancement here means. This must be just power class and uplink band configurations.

Example UL band configurations;

DC*3A*78A, CA_n3A-n78A and CA n3A-n78C

Study of the definition of power class starts after the completion of Rel-17 PowerLimitCA_DC WI.

~~Both power class defined per band combination as total power and power class defined per band are considered~~

~~Identify and specify the other necessary RF requirements~~

~~Note: this objective should start after the completion of Rel-17 PowerLimitCA_DC WI.~~

19 – Huawei Technologies France

We support the work of 1T@band A+2T@band B. Some revision for the first bullet:

- 3Tx simultaneous transmissions for two band inter-band CA with 1Tx on one uplink operating band and 2Tx on the other uplink operating band for single carrier with UL MIMO or intra-band contiguous CA + UL MIMO ~~(intra-band non-contiguous UL CA is precluded)~~

As discussed in 1st round, companies agree that no need to list the example band combinations, then the sub-bullet of specific band combinations should be removed.

- Power enhancement

~~DC*3A*78A, CA_n3A-n78A and CA n3A-n78C~~

20 – China Mobile Group Device Co.

for the power enhancement, we share the same view as China Telecom, it's better to have lower priority and we can identify it after the completion of R17 PowerLimitCA_DC WI.

for the switching period, to China Telecom, our understanding is that 0us switching period for 1T->2T. we are a little concerned why we consider the scenario for 2T->2T?

21 – NTT DOCOMO INC.

For clarification, the scope for 1Tx+2Tx is

”3Tx simultaneous transmission of 1Tx in one band and 2Tx in another band where UL MIMO or intra-band contiguous CA”

and

”Tx switching where maximum simultaneous Tx is 2”.

Is it correct understanding?

We are sorry if we miss something, but we are confused by seeing the comment ”Only two simultaneous transmissions are needed.” above.

We would like to clarify this aspect in the objective.

Further discuss the following objectives:

- [3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band
  - Study the power class framework, impact on MPR/A-MPR and impact on MSD
  - Example band combinations
    - Consider TDD+TDD+TDD without simultaneous Tx/Rx
    - FFS other band combinations, e.g., FDD+FDD+TDD, FDD+TDD+TDD]

Feedback Form 17:

1 – TELECOM ITALIA S.p.A.

We still continue to consider this as an important use case.

To address some of the concerns, it could be added as a second priority scenario

2 – Guangdong OPPO Mobile Telecom.

Agree with Telecom Italia comments, it should be included but can be considered as second priority. And if needed only include the study phase in Rel-18 might be a way out.

3 – SoftBank Corp.

We understand the difficulty of it in many aspects, but we also think that it could be added as a second priority scenario.

4 – QUALCOMM JAPAN LLC.

Given the discussion so far and that other items have a lot more support, this item could be dropped from further discussion. It will also be very complicated to handle the specifications given the number of combinations for MSD calculations, etc

5 – Apple (UK) Limited

Due to the complicated IMD products and its implication to MSD, we still have concern on the objective to include 3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band.

6 – CHTTL

Though we are ok to consider this objective as second priority scenario, we think other band combination type e.g. FDD+FDD+TDD, FDD+TDD+TDD needs to be considered as well.

7 – ZTE Corporation

3Tx with 1Tx on each uplink band, this complicated MSD analysis would be very challenging, in addition, given the workload for 3Tx, it's better to be postponed to future release.

8 – Skyworks Solutions Inc.

We do not see that 3 band with 3UL with simultaneous Tx/Rx can be supported at tghis point. Even if 3 band 3 TDD UL with non-simultaneous Tx/Rx does ot require MSD analysis we still see that coex and band protection might be an issue. We already see many errors/oversight with 2UL combinations and don't see how 3 separate UL frequencies can be handled in an efficient way in RAN4.

9 – Orange

this is a second priority for us

10 – LG Electronics Deutschland

We see this as the second priority

11 – MediaTek Inc.

We don't see the value in enabling this so would support not pursuing it. For handheld devices, it seems mainly a peak rate feature that is only usable when there are 3 bands have no other traffic and the UE is underneath the Base Station, but then the device complexity is there all the time. So the pain vs gain tradeoffs do not seem very well balanced.

12 – Ericsson France S.A.S

We do not support introduction of this objective considering the complexity

13 – Nokia Japan

Though we understand the motivation , we suggest removing this objective at this moment. Before we move to 3Tx with 1Tx on each band, we need to establish handling power class for band combination consisting of different power classes per band like 23dBm+26dBm. Without having the stable way to handle power class, the work is not completed anyway.

14 – vivo Communication Technology

We share same view with other companies, this working scope should be droped. We can consider it in future release.

15 – China Mobile Group Device Co.

We also suggest to drop this working scope

3.1.5 Lower MSD

Continue to discuss the following objectives:

- Investigate and introduce lower MSD for inter-band CA/EN-DC/[DC] combinations (RAN4)
  - [Example band combinations: CA_n1-n77, CA_n3-n41]
  - [Study how the MSD performance can be improved for example band combinations
    - Study correlation of MSD improvement between different MSD resources]
  - [Study whether the generic approach can be applied based on UE indication of capability/interference]
  - Study and specify the requirements and/or capability signaling

Feedback Form 18:

1 – MediaTek Inc.

The Moderator has not reflected in the summary the fact that MediaTek asked this to instead be aStudy Item, and then once we know what is actually feasible, a work item could be considered in a structured manner. We would appreciate this to be reflected.

We would therefore propose to modify at least the following bullets proposed by the Moderator:

- Investigate **the feasibility of** ~~**and introduce**~~ lower MSD for inter-band CA/EN-DC/[DC] combinations (RAN4)
- Study ~~**and specify**~~ the requirements and/or capability signaling

Also, a manner to manage workload has not been reflected in the current objectives. **Therefore, the study should be limited to a small set of band combinations to address that.**

2 – Verizon UK Ltd

We also agree the summary does not reflect the general comments from companies. The objective should be more target on the feasibility and specifying detail requirements to improve MSD and A-MPR for all power classes.

3 – MediaTek Inc.

UPDATE: I now see that the study is limited to a small set of example combinations, so I agree that workload impact has actually been reflected in the proposal.

4 – TELECOM ITALIA S.p.A.

We are ok with the moderator's proposal.

It would be good to add that different band combinations could be added in Release independent way

5 – AT&T GNS Belgium SPRL

We are OK with the moderator's proposal with the following clarifications:

- We would like to add a low-low and a low-mid case to the example band combinations such as CA_n5-n14 and CA_n5-n66 in order to assess the different types of band combinations to maximize the opportunity for a generic solution.
- We support that the study is based on a limited set of band combinations but want to make sure that the outcomes can be considered generically to minimize the RAN4 workload (i.e. no need to consider every band combination individually). If this is the intent of the 3rd bullet, we are OK.
- We would like the one sub-bullet to be modified as "Study correlation of MSD improvement between different MSD resources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)"

6 – Guangdong OPPO Mobile Telecom.

We support the changes made by MTK and also suggest it to be a **study item** instead of work item since all the contents are subject to "study".

7 – SoftBank Corp.

We are fine with the moderator's proposals.

8 – Intel

We would prefer to prioritize the item "Study whether the generic approach can be applied based on UE indication of capability/interference" and remove square brackets. We see "generic approach" as a means to utilize the improved MSD capability of certain UEs that signal the capability.

9 – Samsung Electronics Co.

In general, we support Moderator proposals. For the bullet with [ ], especially the 3rd bullet (generic approach), as we comment, it shall be based on the RAN4 study as indicated in 2nd sub-bullet. Therefore, we suggest to remove the 3rd sub-bullet and start the RAN4 study first

10 – Apple (UK) Limited

We also suggest to start as a study item.

11 – ZTE Corporation

We also agree to remove the square bracket on "study whether generic approach can be applied". Otherwise it's still unknown from network perspective to handle the UE with worse MSD and improved MSD.

12 – CHTTL

We are supportive of the objective.

Just wonder whether the example band combo needs to include EN-DC as well, would like to propose DC_1_n77/78, DC_3_n77/78, and we also hope the outcomes to be generic.

13 – LG Uplus

We support the moderator's proposal with the following suggestion :

For example band combination we would like to add following:

- CA n5-n77 : IMD4(8.3dB for PC3), IMD5(5.5dB for PC3), IMD4(18.6dB for PC2) from TS38.101-1(h40)

(CA_n1-n77 : IMD2(29.8-32.5dB for PC3), IMD4(8.0-10.7dB for PC3) - already added from proposal just for information)

We also think that from harmonics, IMD perspective, DC can reuse the result of CA study.

Also agree with the AT&T's suggestion which is "Study correlation of MSD improvement between different MSD resources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)"

14 – Beijing Xiaomi Mobile Software

we also support the keep 3rd bullet in the study phase and the square bracket shall be removed.

15 – Orange

we are supportive of the objective

16 – Skyworks Solutions Inc.

We also suggest it is a study item. the scope should be better clarified. for example my comment on wether this would apply to all 1UL and 2UL power classes has not been captured. given this I suggest the study only covers PC3 1UL and PC3 2UL cases. We also suggest that 1UL 2CC/Band (nXXA/B/C/(2A) UL config) and 2UL with one band with 2 contiguous CCs (nXXA+nYYB/C) are out of scope.

We also agree that all sources of MSD needs to be tackled and based on the investigation focus on the cases that drives highest MSD.

17 – LG Electronics Deutschland

We support the moderator's proposal

18 – vivo Communication Technology

We support moderator's proposal in general. We also prefer to keep the 3rd bullet, but with the following changes:

[Study whether the generic approach can be applied based on UE indication of capability~~/interference~~]

SI is prefered.

19 – Sony Group Corporation

We are general fine with the proposal, but think the newly proposed objectives can be included as well.

20 – Nokia Japan

We are OK most of the parts. However, regarding "[Study whether the generic approach can be applied based on UE indication of capability/interference]", we don't understand the intention of the addition of "interference". We don't agree with the addition of it. Also, there was a question on what "generic approach" means. So our alternative is as follows.

"Study whether common lower MSD indication signaling mechanisms applicable to all the band combination with MSD can be developed or not",

21 – Ericsson France S.A.S

We support the proposal. The [] can be removed from most of the objectives; we could keep it around the example combinations for further checking

22 – NTT DOCOMO INC.

We are generally supportive of the proposals.

Further discuss the following newly proposed objectives:

- [Investigate dynamic configuration of simultaneous and non-simultaneous Rx/Tx operation as a means to mitigate MSD impact on network performance.]
- [Study on how to introduce UE signal to self-interference ratio measurement mechanism for assisting network scheduling on band combinations subject to MSD impact.]

Feedback Form 19:

1 – Guangdong OPPO Mobile Telecom.

These are new proposals, the 1st concepts look ok, but may need more information and time to check the details in next meeting. 2nd concept seems was discussed before but no conclusion? May need more time to check details.

2 – QUALCOMM JAPAN LLC.

These are new proposals, it is not clear how they would work and at least the first one seems to have big RAN1/2 impact. Also, the network could already use existing techniques to enable such mitigations.

3 – Intel

For the new proposals, our understanding is that these are specific solutions, which can be discussed in the WI stage and not precluded by other objectives. For instance, the objective "Study whether the generic approach can be applied based on UE indication of capability/interference" includes possible interference reporting mechanism. Therefore, we do not see the need to list them explicitly.

4 – Samsung Electronics Co.

As same as generic approach proposed before, these newly proposed proposals shall also based on RAN4 study first. So, we also suggest NOT to include these bullets

5 – Apple (UK) Limited

We are the proponent of these two objectives. As MSD only occurs under certain worst-case operating conditions, scheduling band combinations solely relies on MSD would not be very efficient. Having a signal-to-interference detection mechanism or operating condition indicator (such as aggressor power level) to assist network on band combination scheduling and decision on switching between simultaneous and non-simultaneous Rx/Tx can help mitigate the concern of high MSD for certain band combinations. We would like to encourage companies to consider the benefits of these two objectives apart from the study of MSD improvement.

6 – ZTE Corporation

We are supportive on these two objectives which could be further improve the network performance in the practice. In addition, regarding UE signal to self-interference ratio measurement in 2nd sub-bullet, it should be real time instead of assumed with maximum output power ,right?

7 – Beijing Xiaomi Mobile Software

For the newly proposed objective 2, we support the view from intel, it can be covered by the 3rd bullet "Study whether the generic approach can be applied based on UE indication of capability/interference" , no need to list it separately.

8 – Skyworks Solutions Inc.

We agree that UE indicating the need for sheduler assistance is a more generic approach to MSD and has the benefit to be "as needed".

9 – Sony Group Corporation

we are also positive to consider those items into the study phase

10 – Ericsson France S.A.S

Specifying the signal/self-interference ratio aspect may be complex to specify and test. For simultaneous RX/TX, the issue is more blocking and cross band isolation than MSD. We would like to see more motivation before including these objectives.

11 – vivo Communication Technology

We also prefer not to include these bullets.

12 – China Mobile Group Device Co.

we support the proposal.

3.1.6 smaller A-MPR

Continue to discuss the following objectives with adding "study the feasibility"

- [Investigate and define UE requirements with smaller A-MPR (RAN4)
    - The example band is [n1]

- Study the feasibility and how to define smaller A-MPR considering the following solutions
  - Generic approach meaning that a certain improvement is always applicable to A-MPR for any conditions, and/or
    - e.g., If 1dB improvement is possible, the 1dB is applied to all the specified A-MPR values regardless of position, length of RBs, modulation, waveform and/or CBW etc
  - A specific approach meaning that a certain improvement is applicable to A-MPR only for specific condition, and/or
    - e.g., the conditions are tied with the position of the LO location
  - Other ways are not precluded]

Feedback Form 20:

1 – MediaTek Inc. In the summary, the Moderator has not reflected the MediaTek 1st round comment that there is a parallel ”Coverage Enhancements” WI that is RAN-1 led which considers to ”study and if necessary specify” improvements to MPR, and that it does not make much sense to us to also study improvements to A-MPR in parallel totally independent of that until that study has been done, and potentially end up with various solutions to a similar problem. We would appreciate for this comment to be reflected. Therefore we **object** to this objective, as it seems an illogical approach to 3GPP work.
2 – Verizon UK Ltd We agree this work will target on wider channel bandwidth in higher power classes, in which the UL DC location could be tied to more center of the BWP for lower A-MPR. This is an approach of this work.
3 – TELECOM ITALIA S.p.A. ok in principle with the moderator’s proposal
4 – AT&T GNS Belgium SPRL We are OK with the moderator’s proposal.
5 – Guangdong OPPO Mobile Telecom. We are not positive to this topic, as commented in 1st round generally we understand the intention of reducing AMPR, but it is not clear how this smaller AMPR can be achieved and how much people expect this can be improved. If in the end there is only 0.5dB for example, then it doesn’t deserve RAN4 time to spend on this.
6 – SoftBank Corp. We are fine with the moderator’s proposals. The feasibility study is appreciated because it may contribute the UL coverage enhancement.

7 – QUALCOMM JAPAN LLC.

As we commented in the first round, we do not think this work can bring any meaningful improvements. RAN4 spends already a very large amount of time deciding A-MPRs, this will just lead to a lot of time wasted in RAN4.

8 – Intel

We still see this objective as low priority even with the updated text. We agree with Qualcomm that A-MPR takes are large amount of time. We see limited overall system performance benefits for this item compared to (4Tx, 6/8Rx, MSD improvements)

9 – ZTE Corporation

Based on the workload in other FR1 UE RF requirement, it might be lower priority from our perspective especially considering this would be quite implementation related at the end, it might be quite difficult to move forward at the end.

10 – Skyworks Solutions Inc.

Since AMPR is an allowance UEs that have better DC and Image leakage, PA linearity or flexible LO location can already deliver higher power is they can. We do not see the need for this as it will create a large amount of work with little real benefit in the network.

11 – Beijing Xiaomi Mobile Software

How to derive MPR and A-MPR has spent lots of time in the beginning of R15, we have no confidence that this can be completed easily, so we still think this only can be as a low-priority.

12 – Ericsson France S.A.S

We support also investigating A-MPR, although lower priority than MSD. A big problem is the impact of tolerances on output power combined with A-MPR.

13 – KDDI Corporation

We agree with the moderator's proposals on both the example band and the stduy of smaller A-MPR. It may improve UL coverage and utilization of radio resources actually. Generally speaking, UL is a bottle neck of an area coverage and a link budget for many operators.

14 – Nokia Japan

We still believe this should be handled in high priority since almost the same number of supports from operator as that for lower MSD can be seen so that demand is clear.

We agree with comments from Skyworks to some extent that "PA linearity or flexible LO location can already deliver higher power is they can". But that is not the point. For some bands, A-MPR value drastically changes according to the number of RBs and its position from more than 10 dB to a few dB in some cases. See n1, for example. But NW has no idea if the UE can transmit higher power thanks to flexible DC location or not. Hence, the network may schedule its resource in the most conservative ways. This is a very similar situation seen in lower MSD. But if there is a UE to change its DC location and can surely reduce its A-MPR, that information needs to be shared with the network. Otherwise, the network would need to handle UE with even smaller A-MPR and UE with larger A-MPR in the same manner.

Again, we don't intend to re-evaluate A-MPR again. We are OK to identify a way to apply A-MPR for a smaller channel bandwidth to actually being configured channel bandwidth if some conditions are met such that the DC location is at around the center of BWP whose width is similar to the smaller channel bandwidth.

And thanks docomo for the comment. Though we originally did not think that 1 dB improvement is helpful but we agree that this may reduce test burden.

15 – Huawei Technologies France

A-MPR is case by case specified. We think it may have less improvement with such study.

16 – NTT DOCOMO INC.

As we commented in initial wound, we are generally supportive. And the proposals from moderator is fine for us.

3.1.7 UL Tx switching for UL CA with multiple TAG

Specify UL Tx switching for UL CA with multiple TAG (2 bands scenario) in Rel-18 RAN1 Multi-carrier enhancement WI.

The description in Multi-carrier enhancement WI is copied as below (RP-213577).

- UL Tx switching schemes across up to 3 or 4 bands with restriction of up to 2 Tx simultaneous transmission for FR1 UEs, including mechanisms to enable more configured UL bands than its simultaneous transmission capability and to support dynamic Tx carrier switching across the configured bands for both single TAG and multiple TAGs configurations (RAN1, RAN4)
    - UE capability and RRC configuration related signalling (RAN2)
    - Note: strive for RAN1/2 design agnostic with the number of bands, i.e., common design between 3 and 4 bands
    - Note: no additional TAG is introduced for UL transmission on a carrier without corresponding DL carrier
    - Note: this objective does not target to extend the SUL framework to support more than 1 SUL for 1 NUL

Companies please check whether any modification of clarification is needed in RAN1 Multi-carrier enhancement WI (RP-213577) .

Feedback Form 21:

1 – Guangdong OPPO Mobile Telecom.

We are ok to further discuss the modification of RAN1 lead WI, but actually it is out of RAN4 scope to change RAN1 lead WI. It should be discussed in RAN plenary and decided by RAN, therefore, we suggest proponents to propose this in RAN and RAN1.

2 – China Telecommunications We are ok to discuss it in Rel-18 multi-carrier enhancement WI, and maybe some clarifications on the RAN1-led WID would be needed to make it clear. We'd like to avoid the situation that multiple TAGs is supported in 3/4 bands scenario, but not in 2 bands scenario.
3 – Nokia Japan We'd like to restate that RAN1 Multi-carrier enhancement WI (RP-213577) must cover this objective since without addressing two bands, it cannot address 3 or 4 bands. We are open to discuss if some modification of the current WID(RP-213577) is necessary or not as far as the objective is handled in the RAN1 WI of RP-213577.
4 – Ericsson France S.A.S It seems companies think that multiple TAG for 2 bands is included in the RAN1 scope if needed. That is good, although it is not quite clear why the wording says "up to 3 or 4 bands"; it could just say "up to 4 bands" if all numbers from 2-4 bands are included. Also there may be some ambiguity because 2 bands switching is already introduced in a previous release. A bullet "Multiple TAG for 2 bands is in the scope of this WI" can be added in RANP if the issue really can't be resolved by the clarification CR in Rel-17.
5 – AT&T GNS Belgium SPRL We support the comments from China Telecom, Nokia, and Ericsson that multiple TAG support in 2 bands needs to be addressed. We support the suggested updates made by Ericsson.
6 – China Mobile Group Device Co. we share the same view as previous companies that multiple TAG support in 2 bands needs to be addressed.
7 – Huawei Technologies France We agree that the work should be done under the RAN1 WI. If any objectives need to be revised, we think that is not the scope in RAN4 discussion.

3.1.8 Others

Companies are welcome to comment on the following proposal:

NR-U contiguous UL CA is not finalized in Rel-17

Feedback Form 22:

1 – TELECOM ITALIA S.p.A. We do not support this proposal
2 – Skyworks Solutions Inc. the question here is that NR-U ULCA is in R17 but may not finish. if there is no support for it to move to R18 then we can cancel it in R17 too.

3 – Ericsson France S.A.S We support finishing in Rel-18 if not completed in Rel-17.
4 – China Mobile Group Device Co. we don't support NR-U contiguous UL CA for R18.

3.2 Summary for intermediate round

3.2.1 4Tx

1 company comment that 4Tx and 8Rx should be a package for enhancement of FWA and CPE. From moderator's understanding, all companies support the working areas of 4Tx and 8Rx. Both of them can be considered as high priority for FR1 RF enhancement. No further discussion on this point is needed.

For the other PC, 8 companies support or open to consider other PC (including 4 operators). PC2 and PC3 are proposed to be considered. Moderator suggests taking PC1.5 as high priority and PC2/PC3 as second priority.

- For power class
  - first priority: PC 1.5
  - second priority: PC2 and PC3

For TXD, 7 companies support, 2 companies consider TXD as second priority. 2 companies comment that if TXD is considered, RAN4 should not consider multiple PA configuration assumptions (only 23dBm x 4). There are also some proposals about 20dBm x 4 / 26dBm x 4 and comments to not restrict detailed UE architectures. From moderator perspective, it is better to choose one assumption of PA configuration in the objectives to save RAN4 efforts. So the following changes are proposed:

- Specify the UE RF requirements to support 4Tx
  - First priority: 4x4 UL MIMO
  - Second priority: investigate and if necessary specify TXD requirement to support the same power class in UL MIMO and single antenna port
    - PA configuration assumption: 23dBm x 4

For the bands, some company comment that only TDD bands should be considered since there is no PC1.5 for FDD. Since PC2 and PC3 are considered as second priority, moderator suggests not restricting on TDD only considering the strong interest from operators on FDD. So it is suggested to keep the current objective as it is.

The following objectives are to be discussed in final round:

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices

- Investigate framework and architecture
- Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)
- Specify the UE RF requirements to support 4Tx
  - First priority: 4x4 UL MIMO
  - Second priority: investigate and if necessary specify TXD requirement to support the same power class in UL MIMO and single antenna port
    - PA configuration assumption: 23dBm x 4
  - For UE power class
    - first priority: PC 1.5
    - second priority: PC2 and PC3
- Specify the BS demodulation performance requirements to support 4x4 UL MIMO UE operation

3.2.2 8Rx

Verizon comment that this work should also cover FDD and propose n66 as an example band. 2 companies have concern on adding additional example bands. As summarized in the initial round, considering the workload and comments on the number of example bands, moderator suggests to keep existing example bands, other bands can anyway be introduced in the release independent manner.

Qualcomm, Softbank and Huawei support to define 8 layer requirements. Moderator suggests to check whether following changes on the last bullet are acceptable in the final round:

■ ~~Investigate the feasibility and if necessary define~~ Specify the requirements with 8 MIMO layers ~~larger~~

Skyworks comment on whether SRS antenna switching for 8 antennas should be defined. Companies are welcome to provide feedback on the question in final round.

For 6Rx for CPE/FWA: 8 companies support focusing on 8Rx only, 1 company support 8Rx as high priority. 2 companies support to define 6Rx together with 8Rx. Due to this situation, it is difficult to reach consensus on 6Rx in the final round. Moderator suggests focusing on 8Rx discussion in the final round. Whether to consider 6Rx for CPE/FWA in Rel-18 RAN4 package can be further discussed in RAN#95. Moderator will document this in the final summary

Whether to consider 6Rx for CPE/FWA in Rel-18 RAN4 package can be further discussed in RAN#95. No more discussion in final round.

The following 8Rx objectives are to be discussed in final round.

- Enable 8Rx for CPE/FWA/vehicle/industrial devices
  - Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)

- Specify the UE RF requirements to support 8Rx
- Specify RLM test cases with 8Rx
- Specify UE demodulation performance and CSI requirements to support 8Rx
- ~~Investigate the feasibility and if necessary define~~ Specify the requirements with 8 MIMO layers ~~larger than 4~~

3.2.3 6Rx for smart phone

3 companies comment that the feasibility study is needed, while 2 companies think study is not needed. Considering the different views, moderator suggests to keep the feasibility study.

On the bands, Verizon comment to add FDD and n66 as example band. Skyworks comment that the applicable frequency range needs to be studied. Considering 6Rx is for smartphone, study on the applicable frequency may be needed. FDD and other bands can be considered later after the study. Moderator suggests following changes:

- Example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)
  - Study the applicable frequency upper bound to support 6Rx.
  - ~~FFS on the frequency upper bound.~~

2 companies comment that RAN1 does not support 6 layer MIMO. So the last bullet is suggested to be removed.

~~Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4~~

The following objectives are to be discussed in final round:

- Investigate and enable 6Rx on higher frequency bands targeting at support of smartphone (RAN4)
  - Investigate the feasibility whether 6Rx can be supported by smartphone
    - Feasibility study includes performance gain and form factor restricsons
  - Example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)
    - Study the applicable frequency upper bound to support 6Rx.
  - Specify the requirements to support 6Rx subject to the conclusion of feasibility study
    - Specify the UE RF requirements to support 6Rx
    - Specify RLM test cases with 6Rx
    - Specify UE demodulation performance and CSI requirements to support 6Rx
    - ~~Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4~~

3.2.4 3Tx

6 companies comment to consider power enhancement after the completion of Rel-17 PowerLimitCA_DC WI.

Based on companies' comments, there are some confusion on 3Tx or 2Tx simultaneous transmission and the swithing scenarios. Moderator suggest following changes to further clarify the objectives.

The following objectives are to be discussed in final round:

- Study and specify requirements to support 3Tx considering the following use cases (RAN4)
    - 2Tx simultaneous transmissions for two band inter-band UL CA/ENDC/SUL with 1Tx on one uplink operating band and 2Tx on the other uplink operating band for single carrier with UL MIMO or intra-band contiguous CA+UL MIMO
        - Specify Tx switching transmission enhancement (RAN2, RAN4)
            - Cover inter-band UL CA , ENDC and SUL case
            - Identify and specify RAN2 signaling design is needed
            - Identify and specify the necessary RF requirements if needed
        - Power enhancement
            - Study of the definition of power class starts after the completion of Rel-17 PowerLimitCA_DC WI.

For 3Tx on 3 bands, 9 companies do not support this objective, 6 companies think this objective can be considered as second priority. Considering the concerns from companies, moderator suggests to keep existing objectives in [] and no further discussion in final round. Whether to consider this in Rel-18 RAN4 packge can be further discuss in RAN#95. Moderator will document this in the final summary.

Whether to consider 3Tx on 3 bands in Rel-18 RAN4 package can be further discussed in RAN#95. No more discussion in final round.

- [3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band
    - Study the power class framework, impact on MPR/A-MPR and impact on MSD
    - Example band combinations
        - Consider TDD+TDD+TDD without simultaneous Tx/Rx
        - FFS other band combinations, e.g., FDD+FDD+TDD, FDD+TDD+TDD]

3.2.5 Lower MSD

In general, 5 companies comment this should be a study item first. Since this discussion is only focusing on the objectives, moderator suggests modifying the objectives to reflect the "study".

For band combinations, 5 additional band combinations are proposed: CA_n5-n14, CA_n5-n66, DC_1_n77/78, DC_3_n77/78, CA n5-n77. Considering the workload of study, it is not possible to list all band combinations and the study is also aimed to define a generic approach applying to all band combinations, moderator suggests to keep the existing example band combinations in [] for now.

For the 3rd sub bullet, some company comment to it this and some company comment to keep it. Also there are concern on the added "interference". So moderator suggests to keep the bullet in [] by keeping the original wording.

For the newly proposed objectives by Apple, 3 companies comment they need more time to check, 4 companies comment the specific solutions are not needed and can be discussed in the WI stage. It is difficult to reach consensus and moderator suggests no further discussion in final round.

The following objectives are to be discussed in final round:

- Investigate the feasibility of lower MSD for inter-band CA/EN-DC/[DC] combinations (RAN4)
    - [Example band combinations: CA_n1-n77, CA_n3-n41]
    - Study how the MSD performance can be improved for example band combinations
        - Study correlation of MSD improvement between different MSD resources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
    - [Study whether the generic approach can be applied based on UE indication of capability/~~interference~~]
    - Study the requirements and/or capability signaling

3.2.6 smaller A-MPR

8 companies support this objective (including 6 operators). 6 companies object this objective, 1 company think A-MPR improvement should not considered in parallel with MPR improvement (RAN1-led coverage enhancement WI), 2 companies consider this objective as low priority.

Considering the different views, it is difficult to conclude on this objecitve. Since no more comments received on the detailed objectives in the intermediate round, moderator suggests keeping the following objectives in [] and no more discussion in final round. Whether to consider this objective in Rel-18 RAN4 package can be further discussed in RAN#95. Moderator will document this in the final summary.

Whether to consider smaller A-MPR in Rel-18 RAN4 package can be further discussed in RAN#95. No more discussion in final round.

- [Investigate and define UE requirements with smaller A-MPR (RAN4)

- The example band is [n1]
- Study the feasibility and how to define smaller A-MPR considering the following solutions
  - Generic approach meaning that a certain improvement is always applicable to A-MPR for any conditions, and/or
    - e.g., If 1dB improvement is possible, the 1dB is applied to all the specified A-MPR values regardless of position, length of RBs, modulation, waveform and/or CBW etc
  - A specific approach meaning that a certain improvement is applicable to A-MPR only for specific condition, and/or
    - e.g., the conditions are tied with the position of the LO location
  - Other ways are not precluded]

3.2.7 UL Tx switching for UL CA with multiple TAG

All companies agree that multiple TAG for 2 bands need to be addressed before 3 or 4 bands. Further clarification on RAN1 multi-carrier enhancement WI can be discussed on RAN plenary. Hence no more discussion is needed in final round.

No more discussion in final round.

3.2.8 Others

Proposal: NR-U contiguous UL CA is not finalized in Rel-17

Not much discussion in the intermediate round, 2 companies support and 2 companies do not support. Since this depends on the progress of onging Rel-17 NR-U discussion, moderator suggests that no further discussion in final round. Further discussion can be considered when the situation is more clear.

No more discussion in final round.

4 Final round

4.1 General

Companies are welcome to commet on how to organize the working areas for FR1 RF enhancement.

Option 1: a single WI on FR1 RF enhancement covering all working areas similar as Rel-16/17

Option 2: a seperate SI on lower MSD and a single WI on FR1 RF enhancement covering remaining working areas

Option 3: other options

Feedback Form 23:

1 – Guangdong OPPO Mobile Telecom.

It depends on how many and which items are approved, if many then separate WI/SI would be more efficient and focusing in discussion, if little then one WI/SI would be ok. In general, our understanding is at least the advanced UE architectures for CPE 4T/8R and/or Smartphone 3T/6R can be combined as one or two WI.

2 – Huawei Technologies France

We prefer option 1. Considering the discussion also in other threads on many topics, it may not be possible to have too many WI/SIs in RAN4. Also a single WI would be easier for relevant delegates to focus on the discussion.

3 – Intel

Given the number of topics, we prefer option 2 so that we don't have a single giant WI.

4 – Samsung Electronics Co.

We prefer option1 which will better control the overall RAN4 workload

5 – Apple (UK) Limited

Some of the work areas need study phase and some may be ready for work item phase. Having a single WI to cover all working areas may not be the right way to go.

6 – China Mobile Group Device Co.

we also prefer a single WI on FR1 RF enhancement (option1) to include all the topics.

for lower MSD, this could be included as one of the objectives with a study phase and we could update WID based on the outcome of study.

7 – ZTE Corporation

Option 2 might be better since low MSD is different from other higher order transmitter and receivers.

8 – Skyworks Solutions Inc.

For all the topics that are going into a WI from the begining this can be under a single WI for FR1 enh. for the SI and WI with a study phase, they should be sepaprate.

9 – MediaTek Inc.

As the lower MSD is purely a feasibility study currently with no agreement to specify anything, Option 2 is clearly the most appropriate way forward. This is not about workload.

10 – China Telecommunications

One WI including lower MSD as a study phase is ok, but no strong view.

4.2 Woking areas

4.2.1 4Tx

Continue to discuss the following objectives:

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices
    - Investigate framework and architecture
    - Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)
    - Specify the UE RF requirements to support 4Tx
        - First priority: 4x4 UL MIMO
        - Second priority: investigate and if necessary specify TXD requirement to support the same power class in UL MIMO and single antenna port
            - PA configuration assumption: 23dBm x 4
        - For UE power class
            - first priority: PC 1.5
            - second priority: PC2 and PC3
    - Specify the BS demodulation performance requirements to support 4x4 UL MIMO UE operation

Feedback Form 24:

1 – Ericsson France S.A.S We propose to add the following to the objectives: · ULFPTx modes used for support of UL-MIMO and full-power transmission for single-port
2 – QUALCOMM JAPAN LLC. We are fine with the moderator proposal
3 – vivo Communication Technology We are not clear whether the ”TxD” means ”transparent TxD”, if this is the common understanding of the group, it should be clearly stated in the WID as transparent TxD.
4 – Guangdong OPPO Mobile Telecom. PA configurations should be left to WI disucssion rather than restrcting in the WI and only enable 23x4 UE type. This is usual handling of power class and UE architectures. Although puting rstrictions on UE architecture 23x4 in WID can make the discussion easier, at the same time it will make this feature not fully advanced.

5 – Spark NZ Ltd

We support the moderator's proposed way forward

6 – SoftBank Corp.

We are fine with the proposed objectives.

7 – Huawei Technologies France

We support the moderator's proposal. It's not clear what should be considered for ULFPTx modes for the current objectives. If needed, that can be discussed in the WI work, but no need to consider it here for the moment.

8 – T-Mobile USA Inc.

To Vivo who says "We are not clear whether the "TxD" means "transparent TxD"." TxD is in the Abbreviations in 38.101-1: **TxD Tx Diversity**. Also, 4.2 says **e) The requirements for Tx diversity in this release are applied for UE which indicates IE [*txDiversity-r16*].** Since there is no mention of "transparent TxD" in the RAN4 specs, we are not sure why "transparent" should be added here. Our understanding was that initially it was called "transparent" because the gNB wouldn't know anything about it, but now that there is a capability IE, it doesn't seem to be "transparent" any more. :)

9 – China Telecommunications

Thanks for the updated proposal.

One minor comment on the "4x4 UL MIMO" in the last bullet on BS demod:

Does the "4x4" means 4Tx at UE and 4Rx at BS? If so, we don't agree, since we also need BS demod requirements at least for 4x8. Maybe we can update it as:

- Specify the BS demodulation performance requirements to support **~~4x4~~ UL <u>4-layer</u> MIMO** UE operation

10 – Intel

For UE power class, it is unclear what the PC levels are indicating in the bullets, total combined power or individual power of each Tx. In our understanding, the first priority should be combined PC1.5 = 23dBm x 4. Second priority should be combined PC1 = 26dBm x 4 PAs since UE vendors already have 23dBm and 26dBm PA technology.

11 – TELECOM ITALIA S.p.A.

We are generally fine with the moderator's proposal.

We rend to agree with OPPO that the power class could be discussed in the Work Item. However, to speed up the work, we are ok to start with 23x4 configuration and then consider other possibilities.

We support also the comment from China Mobile:

- Specify the BS demodulation performance requirements to support **~~4x4~~ UL <u>4-layer</u> MIMO** UE operation

12 – China Mobile Group Device Co.

We support moderator's proposal.

for "transparent TxD", as T-mobile said that there is even no such definition in 3GPP so it's not suggested to be included.

for PA configuration, it's better to start with 23*4 at first.

13 – NTT DOCOMO INC.

Thank you for the proposal. We support the objective.

14 – ZTE Corporation

Tend to agree with Intel, the power class should be clarified further to avoid the confusions. Regarding the 4x4 or 4x8 for UL MIMO, we are also open for further discussion.

15 – Skyworks Solutions Inc.

If FDD is in the scope then REFSENS degradation with 4Tx should also be studied with an example band (n7 as it overlaps with n41) otherwise the framework will not be complete for adding new FDD bands. the following objective should be added: Study REFSENS degradation due to 4Tx FDD operation in band n7. We do not agree with "(other bands to be introduced in the release independent way later)" for FDD bands if we do not study this REFSENS degradation aspect.

16 – LG Electronics Deutschland

We support the moderator's proposal

17 – MediaTek Inc.

For PC1.5, there would need to be some studies of applicability for FDD bands. It is not a straight copy-paste. We would like that to be captured as a note in the objectives.

On Release-independence for future bands, I had understood this to mean "Release-independence from Rel-18". This should be clarified in the WID.

18 – China Unicom

We are fine with moderator's proposal.

19 – Nokia Japan

We don't believe that we need the following text. We need to understand what this intends. The target is CPE device. Why is PC2 or PC3 needed?

second priority: PC2 and PC3

It's better to remove it.

And we don't agree with OPPO's comment that just leaving PA configurations to RAN4. Rel-17 FR1 enhancement has already experienced chaotic situation. We would see even more number of assumptions....if we just leave everything to RAN4...

20 – Spreadtrum Communications

We are fine with moderator's proposal. We also support China Telecomumication's comment on 4 layers MIMO:

Specify the BS demodulation performance requirements to support **~~4x4~~ UL 4-layer MIMO** UE operation

21 – AT&T GNS Belgium SPRL

The objectives are OK. We are also OK with the proposed updated text from China Telecom.

We would like that the final discussion summary outcome show the moderator view that there is no need to restrict to TDD band only since any new bands request will be discussed individually in the future.

22 – QUALCOMM JAPAN LLC.

Regarding the power class, since the main target is a CPE type of device for which SAR is not a major concern, higher Tx power should be enabled. WE shouldn't limit the study to PC3, but we should also include a power class with 4x26dBm PAs. PC2 is becoming the standard for TDD bands so 4x26dBm should also be considered.

4.2.2 8Rx

Continue to discuss the following objectives:

- Enable 8Rx and for CPE/FWA/vehicle/industrial devices
  - Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)
  - Specify the UE RF requirements to support 8Rx
  - Specify RLM test cases with 8Rx
  - Specify UE demodulation performance and CSI requirements to support 8Rx
  - ~~Investigate the feasibility and if necessary define~~ Specify the requirements with 8 MIMO layers ~~larger than 4~~

Feedback Form 25:

1 – Intel

In the intermediate round we have not seen any comments with major concerns on allowing 6Rx work. We would like to stress that additional workload for supporting 6Rx on top of 8Rx is minimal or even close to zero and majority of 8Rx conclusions can be reused for 6Rx. As we commented previously, 3GPP should strive to open new market opportunities and not all CPE/FWA form factor devices can efficiently fit 8RX antenna implementations with sufficiently low antenna correlation, and therefore additional implementation flexibility to support 6Rx antennas can be helpful to allow FWA/CPE device implementations.

We also note that LTE 8Rx requirements were defined under assumption of low antenna correlations, which are quite unrealistic. Under assumption of practical antenna correlations 6Rx designs may have relatively close performance to 8Rx for the same form factors.

So, we suggest companies to reconsider 6Rx position and allow both 8Rx and 6Rx implementation especially given the fact that vehicle/industrial devices were added into the scope.

As a compromise we suggest adjusting the objectives as follows and further discuss in RAN #95e on 6Rx and 8Rx prioritization.

○ Enable **[6Rx and]** 8Rx for CPE/FWA/vehicle/industrial devices

o Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)

o Specify the UE RF requirements to support **[6Rx and]** 8Rx

o Specify RLM test cases with **[6Rx and]** 8Rx

o Specify UE demodulation performance and CSI requirements to support **[6Rx and]** 8Rx

o ~~Investigate the feasibility and if necessary define~~ Specify the requirements with 8 MIMO **for 8Rx**layers ~~larger than 4~~

2 – Ericsson France S.A.S

The objectives are OK. The 8 layer MIMO should be taken into account when considering the demodulation workload.

3 – QUALCOMM JAPAN LLC.

We support the moderator proposal

4 – AT&T GNS Belgium SPRL

The objectives are OK. We would like that the final discussion summary outcome show the moderator view that there is no need to restrict to TDD band only since any new bands request will be discussed individually in the future.

5 – vivo Communication Technology

We support the modified objectives from Intel.

6 – Guangdong OPPO Mobile Telecom.

We are ok with Intel proposal to add 6Rx UE type to CPE/FWA considering no much RAN4 efforts in supporting this kind of UE when discussing 8Rx UE type.

7 – Spark NZ Ltd

We also support Intel's proposal to add 6Rx alongside 8Rx UE type.

8 – SoftBank Corp.

We support the moderator's proposals.

9 – Huawei Technologies France

We support the moderator's proposals.

10 – China Telecommunications

We support the moderator's proposals.

11 – TELECOM ITALIA S.p.A.

We are generally fine with the moderator's proposal, but support the point raised by AT&T.

concerning the Intel's proposal, maybe 6Rx could be added as a second priority after completion of 8Rx

12 – Orange

We support the proposal and also agree with AT&T that we should not preclude any FDD bands in the future. Besides, 8 Rx is a higher than 6 Rx from our pesrpective.

13 – NTT DOCOMO INC.

Thank you. We support the moderator's proposal.

14 – China Mobile Group Device Co.

We support moderator's summary.

for 6Rx, at least it should have lower priority than 8Rx for CPE/FWA

15 – ZTE Corporation

We support the moderator's proposals. To add the 6Rx as second priority than 8Rx is also fine for us.

16 – Skyworks Solutions Inc.

we still think extending SRS antenna switching to 8 antenna should be studied to enable better MIMO channel estimation especially for 8x8.

17 – LG Electronics Deutschland

We support the moderator's proposal and are fine with Intel's modification to add 6Rx with square bracket.

18 – Skyworks Solutions Inc.

In the case where 8Rx is associated with 4Tx, extension to 8 antenna SRS antenna switching may be easier as it can use 1T2R approach

19 – MediaTek Inc.

The "Release-independence for future bands" text needs to be clarified. We understand it means Release-independence from Rel-18. Otherwise existing signalling would need to be verified for relevant configurations.

20 – China Unicom

We support the moderator's proposals.

21 – Spreadtrum Communications

We are fine with moderator's proposals, we also support Intel's proposal to add 6Rx for FWA/CPE.

4.2.3 6Rx for smart phone

Continue to discuss the following objectives:

- Investigate and enable 6Rx on higher frequency bands targeting at support of smartphone (RAN4)
  - Investigate the feasibility whether 6Rx can be supported by smartphone
    - Feasibility study includes performance gain and form factor restrictions
  - Example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)
    - Study the applicable frequency upper bound to support 6Rx.
  - Specify the requirements to support 6Rx subject to the conclusion of feasibility study
    - Specify the UE RF requirements to support 6Rx
    - Specify RLM test cases with 6Rx
    - Specify UE demodulation performance and CSI requirements to support 6Rx

Feedback Form 26:

1 – Intel Based on the latest summary from the intermediate round, 6Rx CPE/FWA type of devices are excluded from all items. We support defining 6RX requirements for CPE/FWA and/or smartphone use cases.
2 – Ericsson France S.A.S The objectives are OK, but further discussion could take place on whether this is needed to be included considering overall workload.
3 – QUALCOMM JAPAN LLC. We support to have this item even if it is a SI.

4 – Guangdong OPPO Mobile Telecom.
If this is a SI, then we suggest to modify the last item as below:
- ~~Specify~~**Study** the requirements to support 6Rx subject to the conclusion of feasibility study
  ○ ~~Specify~~**Study** the UE RF requirements to support 6Rx
  ○ ~~Specify~~ **Study** RLM test cases with 6Rx
  ○ ~~Specify~~ **Study** UE demodulation performance and CSI requirements to support 6Rx

5 – Spark NZ Ltd

We support the moderator's proposed way forward

6 – SoftBank Corp.

We support the moderator's proposals.

7 – Huawei Technologies France

We are fine with the moderator's proposals. But we still think it does not need to be considered in Rel-18 given lots of other topics which would be more useful for the industry are under discussion.

8 – China Telecommunications

Clarification on 6-layer MIMO:

In our understanding, RAN1 has supported 6-layer MIMO for DL in terms of both CSI reporting and PDSCH DMRS ports configuration. Companies can further check.

9 – China Telecommunications

Update:

For UE capability reporting, 6-layer MIMO has not been supported, the current spec is as below:

MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers}

10 – Apple (UK) Limited

If there would be constraint on RAN4 TU, we suggest 6Rx for smartphone to be deprioritized.

11 – China Mobile Group Device Co.

we support moderator's proposal.

12 – Skyworks Solutions Inc.

Similar to 8Rx, if 6Rx for smartphone is pursued, studing the need for 6 antenna SRS antenna switching should be covered

13 – MediaTek Inc.

As it is not yet clear that we specify it, then the first part should say:

"Investigate ~~and enable~~ 6Rx on higher frequency bands targeting....."

And then a separate major bullet for:

Specify the requirements to support 6Rx subject to the conclusion of feasibility study

We also understand the Release independence of this feature to be from Release 18 onwards. Otherwise we understand signalling changes would be required. This should be clarified in the text.

14 – Spreadtrum Communications

We are fine with moderator's proposals.

4.2.4 3Tx

Continue to discuss the following objectives:

- Study and specify requirements to support 3Tx considering the following use cases (RAN4)
  - 2Tx simultaneous transmissions for two band inter-band UL CA/ENDC/SUL with 1Tx on one uplink operating band and 2Tx on the other uplink operating band for single carrier with UL MIMO or intra-band contiguous CA+UL MIMO
    - Specify Tx switching transmission enhancement (RAN2, RAN4)
      - Cover inter-band UL CA , ENDC and SUL case
      - Identify and specify RAN2 signaling design is needed
      - Identify and specify the necessary RF requirements if needed
    - Power enhancement
      - Study of the definition of power class starts after the completion of Rel-17 PowerLimitCA_DC WI.

Feedback Form 27:

1 – Guangdong OPPO Mobile Telecom.

Ok with the objectives.

For the intermediate round summary, suggest moderator to update the 1T+1T+1T contents as below about the example band combinations as already proposed in first round discussion:

[3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band

- Study the power class framework, impact on MPR/A-MPR and impact on MSD
- Example band combinations
  - For FDD+FDD+TDD, take DC_3A-7A_n78A as example
  - ~~Consider~~ For TDD+TDD+TDD, non simultaneous Tx/Rx is assumed
  - ~~FFS other band combinations, e.g., FDD+FDD+TDD, FDD+TDD+TDD]~~

2 – Huawei Technologies France

For the main bullet, is it a typo for 3Tx rather than 2Tx

- **2Tx** simultaneous transmissions for two band inter-band UL CA/ENDC/SUL with 1Tx on one uplink

For the first sub-bullet, as it depends on further study to identify and specify if needed, better to make it clear for the upper bullet as well

- Specify Tx switching transmission enhancement **if needed** (RAN2, RAN4)

Other parts of the moderator proposals are fine for us.

3 – China Telecommunications

For Tx switching enhancement:

Regarding DOCOMO's comment in the intermediate round, not sure if we understand correctly, is the suggestion to add "up to" before "2Tx simultaneous transmissions"?

To avoid confusion on the **2Tx or 3Tx** simultaneous transmissions, may be we can an sub-bullet for Tx switching as below:

Study and specify requirements to support 3Tx considering the following use cases (RAN4)

~~**2Tx simultaneous transmissions for**~~ two band inter-band UL CA/ENDC/SUL with 1Tx on one uplink operating band and 2Tx on the other uplink operating band for single carrier with UL MIMO or intra-band contiguous CA+UL MIMO

- Specify Tx switching transmission enhancement (RAN2, RAN4)
  - □ Cover inter-band UL CA , ENDC and SUL case
  - □ Identify and specify RAN2 signaling design is needed
  - □ Identify and specify the necessary RF requirements if needed
    - Note: Up to two simultaneous transmissions for Tx switching enhancement

4 – Intel

We support the proposed objectives.

5 – SoftBank Corp.

As commented by Huawei, we also think that "**2**Tx simultaneous transmissions" is a typo of "**3**Tx simultaneous transmissions". If that is the case, we are fine with the moderator's proposal.

6 – TELECOM ITALIA S.p.A.

we support the moderator's proposal (with correction of the typo, as indicated by Huawei and Softbank)

7 – Orange

we support the proposal

8 – China Mobile Group Device Co.

we support moderator's proposal.

9 – LG Electronics Deutschland

We support the proposal from moderator

10 – ZTE Corporation

For further clarifications,

For Tx switching case, Up to two simultaneous transmissions, is that correct understanding?

For power enhancement, up to three simultaneous transmissions, is that correct understanding.

11 – Skyworks Solutions Inc.

We support the work on 3Tx with 1TX in one band and 2TX in the second band.

But we do not support 3Tx with FDD+FDD+TDD. For TDD+TDD+TDD, non simultaneous Tx/Rx it may be further discussed as the tripple beat products are only an issue for coexistence (band protection) but not MSD.

12 – China Unicom

We support the moderator's proposals.

13 – NTT DOCOMO INC.

To China Telecom

Sorry for confusion.

Our understanding and also preference is to include "3Tx simultaneous transmissions", which is described in the moderator proposal in intermediate round. On top of that, your comment in intermediate round was "Only two simultaneous transmissions are needed" for UL tx switching.

More specifically, for 3Tx capable UE,

Feature 1: 3Tx simultaneous transmission without UL Tx switching

Feature 2: 3Tx simultaneous transmission with UL Tx switching

Feature 3: 2Tx simultaneous transmission with UL Tx switching

We would like to include Feature 1 (and 2). But I wonder if the intension of your comment of "Only two simultaneous transmissions are needed" is to include Feature 3? I am neutral to include Feature 3, but we would to surely include Feature 1 (and 2).

I may miss something. I just would like to avoid any misunderstanding.

Regarding the description of objective, we think the modification from Huawei is good.

14 – MediaTek Inc.

The switching enhancement is not clear, it needs to be clear what sort of enhancement we are talking about. Is this switching among those 3 antennas, or switching across something else? Suggest to remove that or keep it in brackets until it is clear, and for the moderator to highlight that this sub-objective would need more discussion at RAN#95-e.

15 – China Telecommunications

To DOCOMO and MTK,

For Tx switching, in our understanding, the enhancement is to enable 0us switching period for 1Tx-2Tx switching for UE capable of 3Tx. Although UE is capable of 3Tx, the max simultaneously active Tx number is 2 (which is the basic idea of Tx switching), and UE power consumption and heating issue can be controlled.

This enhancement requires very marginal spec impact, something like adding a new number for the capability of switching period.

4.2.5 Lower MSD

Continue to discuss the following objectives:

- Investigate the feasibility of lower MSD for inter-band CA/EN-DC/[DC] combinations (RAN4)
  - [Example band combinations: CA_n1-n77, CA_n3-n41]
  - Study how the MSD performance can be improved for example band combinations
    - Study correlation of MSD improvement between different MSD resources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
  - [Study whether the generic approach can be applied based on UE indication of capability/~~interference~~]
  - Study the requirements and/or capability signaling

Feedback Form 28:

1 – Intel

We would prefer to remove the square brackets to fully support bullet 3. We are ok with the other bullets as written.

2 – Ericsson France S.A.S

The objectives are broadly OK, but we think this should be a WI with “Study and specify if needed” objectives (anyhow if it is part of an RF enhancements WID it is a WI).

3 – QUALCOMM JAPAN LLC.

It is not very clear what the last bullet is meant for? RAN4 knows how to define requirements and what to ask for from RAN2 to define the capability

4 – AT&T GNS Belgium SPRL

We agree with the objectives in principle. We support the Intel comment to remove the brackets from bullet 3. We believe that the study of the generic approach is necessary to avoid overall RAN4 workload. We also agree with Ericsson that it would be better to use ”Study and specify, if needed, ...” objectives given that it is part of the RF enhancements WID.

5 – LG Uplus

Thanks to moderator for organizing the discussion and we understand the workload regarding more band combinations. We are OK with the proposed objectives with the suggestion from AT&T.

6 – Guangdong OPPO Mobile Telecom.

1. Suggest to remove 3rd bullet, i.e. generic approach with signaling. We don't think this is meaningful to just indicate a signaling without a conclusion on how the MSD performance can be improved. This should be a requirement discussion in RAN4 rather than a signaling discussion from the beginning, if signaling is needed during the discussion LS can be sent to RAN2 as usual, there is no need to list it in WID.

2. For the "Study **correlation** of MSD improvement between different MSD resources", what is the meaning of correlation, and what is the target of this bullet? Clarification is needed.

7 – Beijing Xiaomi Mobile Software

In our view, the main intention of this topic is to identify the solutions for avoiding the identified performance loss for the high MSD inter-band CA/DC combinations in the actual network, MSD is defined as the worse case scenario, which does not reflect the interference issue in the actual network. Thus, if a generic approach is considered, we still think the method based on UE indication of interferece as one of generic approach shall be also worth to invertigate and would like to keep "interference" in the 3rd bullet.

8 – Huawei Technologies France

We agree with comments from QC and OPPO for the signaling part. It's too early to consider the signaling aspects in the objectives. The main target of the SI is to study whether and how MSD can be improved. So we think 3rd and 4th bullets should be removed for the moment.

9 – Huawei Technologies France

Just to correct our above comments, we didn't meant a separate SI, but some feasibility study for this topic, where it should be considered depends on further discussion of all topics as a whole picture.

10 – Apple (UK) Limited

We support the study of MSD improvement in a way to prompt UE vendors to tighten their device design tolerance. However, this does not solve all the problem as it would not be feasible to suddenly turn a 30dB MSD down to zero. MSD is a minimum UE RF requirement under certain worst-case operating condition which may rarely happen in real field operations. Scheduling band combinations solely relies on MSD would not be very efficient. It would be a pity if we preclude other techniques to mitigate MSD issues, such as self-interference detection, and dynamic simultaneous/non-simultaneous Rx/Tx operation during the study phase under this work area.

11 – TELECOM ITALIA S.p.A.

We are generally fine with the moderator's proposal

12 – KDDI Corporation

We are generally fine with the moderator's proposal except for example band combinations. We would like to add CA_n3-n77, but also, as moderator said, RAN4 work load needs to be considered. If there is no additional requirements on n3-n77 from other companies, we will agree with current example band combinations eventually.

13 – Orange

we support the objective

14 – NTT DOCOMO INC.

We are generally supportive of this objective.

15 – China Mobile Group Device Co.

we support moderator's proposal. it's better to start with a study phase as part of the RF enhancements WID.

16 – ZTE Corporation

we tend to agree with Apple on other techniques to mitigate MSD problem in real field should be also taken into account, otherwise even with some capability signalling with maximum output power assumption, this is not aligned with the actual experienced interference by UE anytime and anywhere.

17 – Skyworks Solutions Inc.

UL harmonic MSD: none for CA_n3-n41, ~20dB for CA_n1-n77 MSD

harmonic mixing MSD: none for CA_n3-n41 and CA_n1-n77

IMD MSD: CA_n3-n41 is 8dB while CA_n1-n77 is ~30dB

cross band MSD: ~0.7dB for CAn3-n41 none for CA_n1-n77

At this point we do not see that the example bands are really relevant as the difficult case being when multiple MSD cases are present. we think it is better that example combinations are chosen during the study phase so that the multiple MSD issue is understood and covered.

18 – MediaTek Inc.

The text is ok for us, given that it does not suggest that we have agreed to specify something.

19 – Sony Group Corporation

We are basically fine with the proposal form the moderator.

- We support to investigate the dynamic configuration of Tx and Rx and also the self-interference signaling mechanism, but we are fine with the objectives as long as the aforementioned aspects are not precluded from the SI /WI.
- We also think a clarification is needed on the definition of "generic approach" in the SI or WI.

20 – SoftBank Corp.

We are supportive of the proposal.

21 – Nokia Japan

We support

- removing the square brackets
- removing the last bullet

We don't agree with

- including [interference] in the 3rd bullet
- adding "self-interference detection, and dynamic simultaneous/non-simultaneous Rx/Tx operation" etc., in the objective

Regarding small A-MPR, we still believe this should be included. It has obtained many operators' support. It was mentioned in the last e-mail discussion, the objective is stable. Having said so, we also understand the challenges in moderating this.

It would be great if the moderator could update the objective captured in the summary as follows as alternatives based on the comments that objective is not clear. Thus, we made the objective more specific.

- Investigate and define UE requirements with smaller A-MPR (RAN4)

○ An example band is n1 and NS_05

○ Identify condition(s) that A-MPR for a CBW can be replaced with A-MPR for smaller CBW(s) with a following specific case study

- Identify conditions that A-MPR for 20 MHz CBW can be replaced with A-MPR for 5, 10 or 15 MHz CBW in terms of relation between BWP within 20 MHz CBW, the position of BWP and UL DC location
- Study if the identified condition(s) can be generalised or not

○ Specify the requirements based on the outcome of the study

○ Note that no re-valuation of the existing A-MPR is needed

4.3 Summery for final round

4.3.1 General

10 companies comment on how to organize the working areas for FR1 RF enhancement. 5 companies support a single WI covering all working areas similar as Rel-16/17. 2 companies support the working area of lower MSD can be a separate WI. 3 companies preferred to have more than 1 WI but how to structure the WIs still

depend on the objectives.

Since there is no consensus on how to organize the working areas at this moment. **So moderator suggests one single WI is used for the outcome of this email discussion, further discussion can happen in RAN#95e.**

4.3.2 4Tx

Ericsson propose to add bullet about "ULFPTx mode", Huawei comment there is no need to consider it. Since there is no consensus, the bullet is not added at this moment.

Vivo comment to change "TXD" to "transparent TXD". T-mobile comment that "transparent TXD" is not used in RAN4 spec. Moderator agrees with T-mobile's comment and suggests keeping existing wording.

China Telecom comment on the wording change on "UL 4-layer MIMO" and multiple companies support. So the following changes will be made:

- Specify the BS demodulation performance requirements to support ~~4x4~~ UL 4-layer MIMO UE operation

OPPO, ZTE, Intel comment that PA configurations should be left to WI and not restricted. Nokia disagree and think it is important to clarify the PA configurations. Intel and Qualcomm propose to also consider 26dBm x 4. Moderator thinks it is better to clarify the PA configurations to save RAN4 efforts and suggests following changes in [], further discussion in RAN#95e is needed:

- [PA configuration assumption: 23dBm x 4, 26dBm x4]

Skyworks has concern to adding FDD without studying the REFSNES degradation with an example band. Considering the workload and concern on adding more example bands, one possible compromise is to replace one TDD band with FDD band (e.g. n77->n7) . Since this is the final round, moderator suggests following proposals and further discuss in RAN#95e.

- Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later)
    - [FFS on FDD example band]
    - [Note 1: the total number of example band should be limited to 3.]
    - [Note 2: if FDD example band is added, study the REFSNES degradation due to 4Tx FDD operation in the example band]

Intel comment on the PC levels, since UE power class definition in RAN4 spec (PC1.5, PC2, PC3) means UE total power, no individual power of each Tx is defined in RAN4. Moderator thinks there is no ambiguity. No further clarification is needed.

Nokia comment on the necessity of PC2 and PC3. Since multiple operators support to add additional PCs, moderator suggests keeping them as second priority for now.

MediaTek comment PC1.5 is not applicable to FDD bands. Moderator agrees with this and if FDD would like to support PC1.5, a separate WI should be created. So one note can be added:

- For UE power class
  - first priority: PC 1.5
  - second priority: PC2 and PC3
  - Note: PC1.5 is only applicable for TDD bands

MediaTek also comment on the release independent should from Rel-18. Moderator agrees and thinks this should be the common understanding. This aspect will be reflected in the final proposal.

To summerize, the updated objectives are:

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices
  - Investigate framework and architecture
  - Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later **from Rel-18**)
    - **[FFS on FDD example band]**
    - **[Note 1: the total number of example band should be limited to 3.]**
    - **[Note 2: if FDD example band is added, study the REFSNES degradation due to 4Tx FDD operation in the example band]**
  - Specify the UE RF requirements to support 4Tx
    - First priority: 4x4 UL MIMO
    - Second priority: investigate and if necessary specify TXD requirement to support the same power class in UL MIMO and single antenna port
      - [PA configuration assumption: 23dBm x 4, **26dBm x4]**
    - For UE power class
      - first priority: PC 1.5
      - second priority: PC2 and PC3
      - **Note: PC1.5 is only applicable for TDD bands**
  - Specify the BS demodulation performance requirements to support ~~4x4~~ UL **4-layer** MIMO UE operation

4.3.3 8Rx

5 companies support to add 6Rx, moderator suggest add [6Rx] in [] and further discuss in RAN95e.

AT&T and Orange would like to clarify FDD band is not precluded. Moderator thinks existing objectives do not preclude FDD bands. To make it more clear, a note can be added:

- Note: FDD bands are not precluded to be introduced in the release independent way later from Rel-18.

Skyworks comment to add "Study the extension to 8 antenna SRS antenna switching", since no sufficient discussion on this point, moderator suggests put it in [] and further discuss in RAN#95e.

To summerize, the updated objectives are:

- Enable **[6Rx and]** 8Rx for CPE/FWA/vehicle/industrial devices
    - Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later **from Rel-18**)
    - Specify the UE RF requirements to support **[6Rx and]** 8Rx
    - **[Study the extension to 6/8 antenna SRS antenna switching]**
    - Specify RLM test cases with 8Rx
    - Specify UE demodulation performance and CSI requirements to support **[6Rx and]** 8Rx
    - Specify the requirements with 8 MIMO layers
- **Note: FDD bands are not precluded to be introduced in the release independent way later from Rel-18.**

4.3.4 6Rx for smart phone

Ericsson, Huawei and Apple think this objective get lower priority,

OPPO comment to change "specify" to "study". Considering the objective is "specify… subject to the conclusion of feasibility study", moderator suggests keeping the current wording.

MediaTek comment to remove "and enable" in the main bullet and "release independent should from Rel-18 onwards", this will be applied in the final proposal.

Skywork has the similar comments on study SRS antenna switching, this can be added in [] and further discuss in RAN#95e.

China Telecom comment on the support of 6 MIMO layer and would like to further check. So the last bullet is suggested to keep in [] for further discussion in RAN#95e.

To summerize, the updated objectives are:

- Investigate ~~and enable~~ 6Rx on higher frequency bands targeting at support of smartphone (RAN4)
    - Investigate the feasibility whether 6Rx can be supported by smartphone
        - Feasibility study includes performance gain and form factor restrictions
    - Example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later **from Rel-18**)
        - Study the applicable frequency upper bound to support 6Rx.
    - Specify the requirements to support 6Rx subject to the conclusion of feasibility study
        - Specify the UE RF requirements to support 6Rx
        - **[Study the extension to 6 antenna SRS antenna switching]**
        - Specify RLM test cases with 6Rx
        - Specify UE demodulation performance and CSI requirements to support 6Rx
        - **[Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4]**

4.3.5 3Tx

It seems companies have different views on whether "3Tx simultaneous transmission without UL Tx switching" is included. China Telecom thinks only Tx switching with 2 UL simultaneous transmission is included. Huawei, Softbank, TelecomItalia, skyworks, DOCOMO support to include 3Tx simultaneous transmission without UL Tx switching.

Moderator's understanding is that:

1. For Tx switching, only consider 2 Tx simultaneous transmission.
2. For 3Tx simultaneous transmission, no Tx switching is needed, this is inter-band CA/ENDC with 1TX on one uplink band and 2Tx on the other uplink band. Consider multiple companies support this, moderator add a new bullet in [] for further discussion in RAN#95e.

To summerize, the updated objectives are:

- Study and specify requirements to support 3Tx considering the following use cases (RAN4)
    - 3Tx simultaneous transmissions for two band inter-band UL CA/ENDC/SUL with 1Tx on one uplink operating band and 2Tx on the other uplink operating band for single carrier with UL MIMO or intra-band contiguous CA+UL MIMO
        - Specify Tx switching transmission enhancement **[if needed]**(RAN2, RAN4)
            - Cover inter-band UL CA , ENDC and SUL case

        - Identify and specify RAN2 signaling design is needed
        - Identify and specify the necessary RF requirements if needed
    - **[Specify 3Tx simultaneous transmission for inter-band UL CA and EN-DC]**
    - Power enhancement
        - Study of the definition of power class starts after the completion of Rel-17 PowerLimitCA_DC WI.

4.3.6 Lower MSD

For the 3rd bullet: [Study whether the generic approach can be applied based on UE indication of capability/~~interference~~]

- Intel and AT&T support this bullet and want to remove [].
- OPPO, Huawei do not support and want to remove this bullet.
- Xiaomi support to add "interference" back to this bullet.
- Nokia disagree to add "interference " to this bullet
- Sony would like to get clarification on the definition of "generic apporach"

Consider the 3rd bullet is still in [], moderator suggests keep the bullet as it is in [] and further discuss in RAN#95e.

For the 4th bullet: Study the requirements and/or capability signaling

- Ericsson and AT&T support to change "Study" to "Study and specify if needed".
- Qualcomm , Huawei and Nokia comment the necessity of this bullet, and want to remove it.
- Moderator suggests to remove the bullet considering the whole objective is for study.

Skyworks comment to choose example band combinations in the study phase. Given the example band combinations are in [], moderator suggests to keep as it is.

To summerize, the updated objectives are:

- Investigate the feasibility of lower MSD for inter-band CA/EN-DC/[DC] combinations (RAN4)
    - [Example band combinations: CA_n1-n77, CA_n3-n41]
    - Study how the MSD performance can be improved for example band combinations
        - Study correlation of MSD improvement between different MSD resources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
    - [Study whether the generic approach can be applied based on UE indication of capability/~~interference~~]
    - ~~**Study the requirements and/or capability signaling**~~

4.3.7 Controversial objectives which need more discussion in RAN#95

4.3.7.1 1T+1T+1T on 3 bands

OPPO proposed updated objectives in the final round. Moderator suggests using following objectives for further discussion in RAN#95e

- [3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink operating band
    - Study the power class framework, impact on MPR/A-MPR and impact on MSD
    - Example band combinations
        - For FDD+FDD+TDD, take DC_3A-7A_n78A as example
        - For TDD+TDD+TDD, non simultaneous Tx/Rx is assumed

4.3.7.2 Smaller A-MPR

Nokia proposed updated objectives in the final round. Moderator suggests using following objectives for further discussion in RAN#95e

- [Investigate and define UE requirements with smaller A-MPR (RAN4)
    - An example band is n1 and NS_05
    - Identify condition(s) that A-MPR for a CBW can be replaced with A-MPR for smaller CBW(s) with a following specific case study
- Identify conditions that A-MPR for 20 MHz CBW can be replaced with A-MPR for 5, 10 or 15 MHz CBW in terms of relation between BWP within 20 MHz CBW, the position of BWP and UL DC location
- Study if the identified condition(s) can be generalised or not
    - Specify the requirements based on the outcome of the study
    - Note that no re-evaluation of the existing A-MPR is needed]