**RAN94e-R18Prep-22 - Version 0.0.10**
**RAN**

**3GPP TSG-RAN Meeting #94-e**
**RP-212682**

**Electronic Meeting, December 6 – 17, 2021**

**(Pre-RAN#94e email discussion October 20 – 29, 2021)**

**Agenda item:** 8A.4

**Source:** RAN4 Chair (Huawei)

**Title:** Moderator's summary for discussion [RAN94e-R18Prep-22]

**Document for:** report

# 1 Introduction

In this email thread, the moderator follows the guidance in RP-212657 to organize the pre-RAN#94e discussion for potential RAN4 enhancements and additional two topics, i.e., <5MHz in dedicated spectrum and DSS aspects. For <5MHz and DSS, the justification and objectives will be discussed in this email thread, although some of objectives may belong to other working groups.

The summary for initial round is mainly based on the outcome of RAN#93e RAN Chair summary (RP-212608), September Pre-RAN email discussion (RP-211667), summary of additional RAN1/2/3 candidate topics set 2 for <5MHz topic (RP-211665), summary of additional RAN1/2/3 candidate topics set 1 for DSS (RP-211664), and June workshop summary RWS-210659. The contributions, which were submitted in RAN#93e, are also considered.

The moderator as the RAN4 Chair first provides the Rel-18 RAN4 TU planning, and then categorizes the topics mainly into three classes, i.e., spectrum related, non-spectrum related with RF centric, non-spectrum related with RRM & demodulation centric to match the TU planning. And please note that the topics categorized as non-spectrum related with RF centric may also need relatively small RD TUs. The same thing would happen for non-spectrum related topics with RRM & demodulation centric. Besides, there are two separate sections for <5MHz and DSS because RAN1/2 aspects are included.

The target of this email discussion is to try converging on a set of topics with working areas and stabilizing the justification and objectives for them.

# 2 RAN4 TU planning

## 2.1 Initial round

### 2.1.1 Proposals and comments collection

In the endorsed RP-212608, the guidance for Rel-18 RAN4-led items was provided.

- *It is critical to maintain RAN4 load reasonable*
  - *The load from the projects led by RAN1/2/3*
    - *An estimate of RAN4 TU impact is necessary for all RAN1/2/3-led items*
    - *A certain amount of RAN1/2/3 WG capacity is to be reserved when approving the package in December*
  - *The load from RAN4-led projects*
- *It is critical to make sure the projects are rooted to commercial interests*
- *A single email thread is used to manage RAN4-led items for subsequent discussion till RAN#94-e*

And in the RAN4 meeting report RP-211614 the RAN4 TU budget for Rel-18 was provided and considering the newly approved WIs in RAN#93e we provide the TU budget in the following. The TUs for newly approved WIs were provided in RP-212638. And 1TU is reserved for RF and RD separately according to RAN Chair's guidance to keep flexibility for RAN4 project management in the future.

**Reserved TU table for Rel-18 in RAN4 (Total TU: 45; RF TU 24.5, RD TU 20.5, assume Rel-18 work starts from Q3 2022)**

| Reserved TU (Average TU for Quarter with two meetings) | 2022 Q2 | | 2022 Q3 | | 2022 Q4 | | 2023 Q1 | | 2023 Q2 | | 2023 Q3 | | 2023 Q4 | | 2024 Q1 | | 2024 Q2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD |
| Maintenance </= R17 closed | 19.5 | 5.5 | 4 | 3.5 | 3 | 3.5 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | | | | |
| Rel-18 RAN1~3, 5 impacts on RAN4 | 0 | 0 | 0 | 0 | 1 | 1 | 7 | 8 | 7 | 8 | 8 | 10 | 8 | 10 | | | | |
| Rel-18 RAN4-led spectrum | 0 | 0 | 6.5 | 0 | 6.5 | 0.25 | 6.5 | 0.25 | 6.5 | 0.25 | 6.5 | 0.25 | 6.5 | 0.25 | | | | |
| Rel-18 RAN4-led non-spectrum | 0 | 0 | **7.5** | **4** | **12** | **13.75** | **7** | **8.25** | **7** | **9.25** | **7** | **7.25** | **8** | **7.25** | | | | |
| Rel-17 performance part | 5 | 15 | 4.5 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| Reserved TU for Rel-18 LS reply | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| Reserved TU | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | |

Finalize Rel-17 Perf. Part, Rel-17 maintenance

**Figure 1: Rel-18 RAN4 TU planning**

Regarding the timeline to approve RAN4 items, the proposals from the previous discussions captured in the summary document RP-211667 are:

- *Timeline for approval of RAN4-led package*
  - *Approve the minimum number of non-spectrum WIs for Rel-18 based on consensus in December 2021*
  - *Approve the RAN4 package for non-spectrum related WI/SIs for Rel-18 in March 2022*

In this section, please provide the feedback on the reserved TU budget in Rel-18 stage. And other comments are also welcome.

**Feedback Form 1:**

**1 – KDDI Corporation**

We agree with chairman's proposal.

**2 – Nokia Japan**

Rel-17 performance part does not have any TUs from 2022Q4. Taking into account the knowledge from previous Releases, some TUs may need to be reserved in 2022Q4. For Rel-18 RAN1-3, 5 impacts on RAN4; there is a fixed number of TUs reserved even objectives for these items are not agreed yet. How this would work in practice? Would objectives of these items be adjusted to meet the exact allocated TU numbers? Or the reserved TU numbers for Rel-18 RAN1-3, 5 on RAN4 are adjusted based on the final objectives of each of the WIDs?

**3 – QUALCOMM JAPAN LLC.**

Thank you for providing the available TUs. Our understanding is that this a tentative table since the number of TUs for the Rel.18 RAN 1,2,3 led items is not yet known. The split for RAN4-led and non-RAN4-led will be adjusted based on the outcome of the December plenary Rel.18 package approval, is this correct? Based on the experience from previous releases, it seems overly optimistic to us to assume that there will be more TUs available for RAN4 -led items than for non-RAN4 led items.

For the approval timeline, since we have a package approval, we believe all items should be approved at the same time in March plenary.

**4 – Samsung Electronics Co.**

We support the ideal to endorse detailed TU budget first. Taking previous release experience, RAN4 workload extremely heavy without well planning and scope control. TU budget will be best tool to control RAN4 workload in a transparent and measureable way.

Based on previous release experience, some general observations:

1) Exclude basket spectrum WI TUs (4 TUs), RF and RD almost take half and half TUs i.e. 20, 20 TUs.

2) TU budget over RAN4 led proposals and RAN1-3 led proposals almost occupy half and half TUs.

3) Typically, RAN4 impact on other WG led proposals are strongly depending on the progress on other WGs; allocating much TUs on other WGs led proposals in early stage seems unnecessary and inefficient.

4) In initial stage, much effort need to be taken for previous release maintenance.

With all above observations, we think the current proposed TU budget seems reasonable.

We can use such TU budget to control the load from both other WGs led proposals and RAN4 led proposals.

**5 – Samsung Electronics Co.**

To be clarified, our previous comment "We can use such TU budget to control the load from both other WGs led proposals and RAN4 led proposals.".

We believe Endorsed TU budget can be used to control the load of **RAN4 impact** from other WG led proposals and RAN4 led propoals.

**6 – Intel Corporation (UK) Ltd**

- **TU budget**: We agree with the proposed TU budget assessment and agree with Samsung's assessment of the typical TU split between RF/RD and also between RAN1/2-led and RAN4-led items. We acknowledge that the exact scope of RAN1/2/4-led items is unknown at the moment. However, we believe it is important to agree on the proposed TU split to ensure that there is sufficient TU budget available for RAN4-led item in the March plenary (i.e. a certain reasonable amount of TUs shall be reserved). We also suggest endorsing the proposal from the September email discussion that "*If the pre-allocated RAN4 TUs for Rel-18 WI/SI led by other WGs are exceeded, down-scoping of RAN4 objectives for Rel-18 WI/SI led by other WGs would be required*"
- **Approval timelines:** We prefer to have RAN4 package approval in March 2022. Additional items including NR < 5MHz CBW and DSS are suggested to be RAN1-led and can be discussed in Dec 2021.
- **Spectrum/Non-spectrum WIs**: We propose to clearly clarify the boundary between spectrum and non-spectrum WIs for Rel-18 timeframe. Spectrum items are typically driven by urgent operator/market requests and can be approved during the release mainly due to isolated scope and limited amount of work. Meantime, in the previous releases many items were treated as spectrum items, while they had impact on the generic RF requirements. We recommend to further clarify that newly spectrum related items shall aim to introduce band-specific and/or band combination specific requirements without impacting generic RF Core requirements. All other items shall be defined as non-spectrum items.

**7 – ZTE Wistron Telecom AB**

It's good to have a stable TU budget table at first as shown by Chair, and it should be enforced once it gets approved. This is critical to avoid overloading RAN4 later.

(1) For non-RAN4-led TUs, if we follow the TU numbers for them, can RAN4 say no if these numbers cannot accommodate the requested RAN4 TUs from other WGs ? Or will these TU numbers play impacts on these RAN1/2/3/5-led WIs' approval in December?

(2) For reserved TU for Rel-18 reply LS, it ends at 22Q4. What about LSs from other WGs after 22Q4? It might be reasonable to keep some reserved TUs after 22Q4 for this purpose.

**8 – vivo Communication Technology**

We agree with the proposals from Chair.

Regarding the spectrum or non-spectrum projects, we share similar view with Intel, it seems now is the good timing to let RAN4 people get clear understanding on the boundary between spectrum and non-spectrum WIs.

**9 – Huawei Technologies France**

In general, we support the timeline proposal by moderator. The non-spectrum WIs to be considered in Dec should be as minimum as possible, and should be fully justified by the necessity and urgency.

**10 – Apple AB**

We support the moderator's proposal to clarify and stabilize the TU budget first. Regarding the timeline, it is desirable that all proposals can be considered and approved with the same timeline. Considering the starting time of R18 has been postponed to Q2, 2022, we don't see the urgency to separately approve limited number of non-spectrum proposals in Dec.

| |
|---|
| **11 – Apple AB**<br>We support this effort subject to TU availability. |
| **12 – Ericsson LM**<br>Proposed timeline for approval of RAN4-led package looks fine. |

### 2.1.2 Summary for initial round

**RAN4 TU budget**

Moderator:

To Nokia, the intention is to decide the RAN4 Rel-18 TU split between RAN4-led and non-RAN4-led WI/SIs before approving them, because many operators and vendors commented in previous discussions that the RAN1/2-led WI/SI pre-occupied many RAN4 TUs such that RAN4 had no room to accomodate the urgent work to address issues from practical deployment in previous releases. Each WG will decide their TU capacity before approving the new WI/SIs. What we plan to do is similar. The only difference is that RAN4 is going to set the TU caps separately for RAN4-led and non-RAN4-led WI/SIs. In that way, we can control the RAN4 workload from other WGs and from RAN4 itself separately. The discussions on RAN4 objectives of the Rel-18 package for RAN4 and other WGs should respect the TU caps.

According to feedback from previous meetings, the moderator observed a lot of companies preferred to adjust the RAN4 objectives to fit the reserved TU for RAN4 and other WGs.

To Qualcomm, it is a tentative table. As RAN4 Chair, I would like to provide it to RAN#94e in the RAN4 meeting report as a starting point for discussion and formal endorsement to address the concern in previous meetings about balancing the workload between RAN4-led and non-RAN4-led work. And such split TU should be taken into account when RAN1/2 decides the RAN4 objectives of RAN1/2 led WI/SIs and RAN4 decides objectives of RAN4-led WI/SIs.

Regarding the adjustment based on outcome of December plenary for Rel-18 package, the RAN4 TU split should not be adjusted once it is decided. Like the available TU cap for each WG, RAN won't adjust it based on the objectives to be approved. But as the RAN4 Chair, to facilitated the discussions on TU split, I would like to suggest allowing the adjustment of RAN4 TU split within certain amount of margin depending on the discussion in the future.

The TU reserved for RAN1,2,3, RAN5-led items and RAN4-led items are provided based on the statistics of Rel-17 allocated TUs for different working groups. It is observed that total amount of allocated TUs for non-RAN4-led items including performance part should be larger than RAN4-led items, but it is unnecessary to allocate more TUs for non-RAN4-led items each meeting than RAN4-led items because most of RAN4 work should wait for RAN1/2 conclusions and in the first quarters of Rel-18 there would be less RAN4 work to do for RAN1/2-led items as commented by other companies.

To ZTE, in principle the total amount of allocated TUs for RAN4 objectives of finally approved non-RAN4-led items should be within the reserved cap for them in the RAN4 TU splitting table. The intention is to balance the workload between RAN4-led items and items led by other working groups, which targets addressing the concerns from operators and companies since long time ago.

After Q4 2022, the LSs from other WGs will be treated either in the requested RAN4 TU for Rel-18 items if

the LS belongs to Rel-18 or in the reserved TU for maintenance if the LS belongs to the WIs of previous releases. In the first two quarters, not all the RAN1/2 led items need to request RAN4 TUs for defining RAN4 requirements according to previous experience, but some TU could be reserved to treat the issues raised by other WGs to help them finalizing the work. It is nothing new compared to what RAN4 did in Rel-17 and previous releases.

**Proposal to endorse the previous proposal from September email discussion related to RAN4 TU splitting**

Intel, Vivo proposed to endorse

- if the pre-allocated RAN4 TUs for Rel-18 WI/SI led by other WGs are exceeded, down-scoping of RAN4 objectives for Rel-18 WI/SI led by other WGs would be required.

**Timeline to approve RAN4-led items**

It seems all the companies are OK to approve all the RAN4-led items (except for <5MHz and DSS in this email thread) in March 2022.

**Spectrum related/non-spectrum related items:**

Intel, Vivo proposed to clearly define the boudnary between the spectrum related and non-spectrum related items.

- Spectrum related items are items which aim to introduce band-specific and/or band combination specific requirements without impacting generic RF core requirements [and/or core specifications of other WGs].
- All the other items shall be defined as non-spectrum related.

*NOTE: [and/or core specifications of other WGs] is added by moderator.*

## 2.2 Intermediate round

### 2.2.1 Proposals and comments collection

In the intermediate round, the following topics need further discussions.

**RAN4 TU budget**

The moderator proposes to further comment on the TU table taking into account the responses from the moderator in the Section 2.1.2. Based on discussion, the moderator would like to provide the TU to RAN#94e in the RAN4 meeting report.

**Proposal to endorse the previous proposal from September email discussion related to RAN4 TU splitting**

Please comment on the following proposal. If agreeable, the moderator would like to propose to endorse it.

Reserved TU table for Rel-18 in RAN4 (Total TU: 45; RF TU 24.5, RD TU 20.5, assume Rel-18 work starts from Q3 2022)

| Reserved TU (Average TU for Quarter with two meetings) | 2022 Q2 | | 2022 Q3 | | 2022 Q4 | | 2023 Q1 | | 2023 Q2 | | 2023 Q3 | | 2023 Q4 | | 2024 Q1 | | 2024 Q2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD | RF | RD |
| Maintenance </= R17 closed | 19.5 | 5.5 | 4 | 3.5 | 3 | 3.5 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | | | | |
| Rel-18 RAN1~3, 5 impacts on RAN4 | 0 | 0 | 0 | 0 | 1 | 1 | 7 | 8 | 7 | 8 | 8 | 10 | 8 | 10 | | | | |
| Rel-18 RAN4-led spectrum | 0 | 0 | 6.5 | 0 | 6.5 | 0.25 | 6.5 | 0.25 | 6.5 | 0.25 | 6.5 | 0.25 | 6.5 | 0.25 | | | | |
| Rel-18 RAN4-led non-spectrum | 0 | 0 | 7.5 | 4 | 12 | 13.75 | 7 | 8.25 | 7 | 9.25 | 7 | 7.25 | 8 | 7.25 | | | | |
| Rel-17 performance part | 5 | 15 | 4.5 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| Reserved TU for Rel-18 LS reply | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| Reserved TU | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | |

Finalize Rel-17 Perf. Part, Rel-17 maintenance

**Figure 2: RAN4 Rel-18 TU planning**

– if the pre-allocated RAN4 TUs for Rel-18 WI/SI led by other WGs are exceeded, down-scoping of RAN4 objectives for Rel-18 WI/SI led by other WGs would be required.

**Feedback Form 2:**

**1 – China Telecommunications**

We appreciate the efforts to assess RAN4 TU for Rel-18, which is based on many companies' comments in pre-RAN #93e email discussion.

We are ok with moderator's proposed TU as the starting point.

**2 – QUALCOMM JAPAN LLC.**

If we will assess anyway, we do not really see the point of pre-allocating RAN4 TUs. It seems that anyway we will just look at what is agreed in December for other WGs and then see how much time is left.

**3 – QUALCOMM JAPAN LLC.**

The balancing of load has to be done by controlling the RAN4 scope of the items to be approved in December.

**4 – Apple AB**

we support the proposals. not only the TU budget of non-RAN4-led items should be well managed, but also the related scope should come with sufficient information.

**5 – LG Electronics Deutschland**

We support the moderator's proposal.

**6 – ZTE Corporation**

As we mentioned in 1st round, related RAN4 scope in non-RAN4-led items should also been discussed and the regarding TUs should be also discussed as well in coming RAN-P meeting.

**7 – Intel Corporation (UK) Ltd**

We agree with moderator's proposal. Balancing the load should be performed not only for RAN4-led items, but RAN1/2/3-led items as well. Pre-allocated TU budget is a convenient tool to balance the scope.

**8 – Nokia Japan**

Conceptually, we understand the proposal by moderator, but we don't think that in practice, it is realistic to do so. Because at the beginning of WI/SI led by other WGs, the objectives are not clear enough so that estimation of the required TU budge for RAN4 is challenging without progress of the WI/SI. Of course, it is possible if we estimate the required TU on RAN4 for WI/SI led by other WGs in a conservative way and reduce available TUs for WI/SI led by RAN4 and/or reduce the reserved TUs for the WI/SI led by other WGs

OR

if we reduce the number of WIs/SIs led by other WGs at the beginning of Rel-18.

Otherwise, unfortunately, RAN4 needs to limit the amount of TUs for WIs led by RAN4 and if we can find additional available TUs later in Rel-18, we can re-discuss new WIs/SIs led by RAN4.

**9 – Samsung Electronics Co.**

We agree with Moderator proposal. If TU exceed, down-scoping of other WG led item shall be discussed in Dec RAN

**Timeline to approve RAN4-led items**

The moderator would like to propose to endorse:

- Approve all the RAN4-led items (except for <5MHz and DSS in this email thread) in March 2022.

Please provide your comments.

**Feedback Form 3:**

**1 – QUALCOMM JAPAN LLC.**

we agree with this proposal

**2 – vivo Communication Technology**

We support this proposal, approve all the WIs in a package is better to control the whole workload for RAN4 Rel-18.

In addition, we also have a suggestion that considering there are some Rel-17 late-started WIs, if urgent market demand cases or critical cases are identified for Rel-18, further approve limited number of WIs should not be precluded, e.g. after Q3 2022.

**3 – Apple AB**

The proposal is OK for us.

**4 – Ericsson LM**

The proposal is fine for us

**5 – LG Electronics Deutschland**

We support the moderator's proposal.

**6 – Samsung Electronics Co.**

We supports RAN4 chairman proposal

**7 – ZTE Corporation**

in general, we are also fine with chairman's proposal.

**8 – Intel Corporation (UK) Ltd**

We agree with proposal and propose to slightly rephrase as "Approve Rel-18 RAN4 WI package (except for <5MHz and DSS in this email thread) in March 2022".

**Spectrum related/non-spectrum related items:**

The moderator would like to propose to endorse:

- Spectrum related items are item which aim to introduce band-specific and/or band combination specific requirements without impacting generic RF core requirements [and/or core specifications of other WGs].
- All the other items shall be defined as non-spectrum related.

Please provide your comments.

**Feedback Form 4:**

**1 – Skyworks Solutions Inc.**

One aspect that we further need to keep in mind is that there are cases where we have agreed to cover some new feature under a spectrum item (as an example PC2 FDD) but the study was linked to some example bands that could not cover all the possible bands. So if we choose some example bands for non-spectrum items they should cover the key band scenarios so that the related general requirements can cover any upcoming bands. This is essential to enable a basket approach after a new feature is introduced.

**2 – AT&T GNS Belgium SPRL**

We are OK with the moderator proposal but also share the same concern as Skyworks. We need to ensure that the set of example bands and/or combinations identified in non-spectrum related WIs are sufficient to ensure that the RF core requirements are developed in a generic way.

**3 – China Telecommunications**

Thanks for the proposal. We'd like to ask that:

1) Before agreeing on some generic boundary between spectrum and non-spectrum related WIs, we need to make sure companies have the same understanding on the boundary.

2) We need to consider how to treat the follow-up WIs of Rel-17 spectrum SIs.

3) Do we need to reserve TUs in case some proposals belonging to spectrum work in Rel-17 and will be moved to non-spectrum items in Rel-18?

**4 – LG Electronics Deutschland**

We support the moderator's proposal with the understanding that MSD requirements for band-specific and/or band combinations are spectrum-related items.

**5 – Samsung Electronics Co.**

We support moderator's proposal

**6 – ZTE Corporation**

we are also fine with RAN4 chairman's proposal.

**7 – Intel Corporation (UK) Ltd**

We agree with proposal

**8 – Nokia Japan**

We agree with necessity of clarification of the boundary between spectrum related items and non-spectrum items. We, however, don't agree to make a conclusion over this e-mail discussion. We propose to make sure that this will be discussed in the next RAN with more specific examples.

With the proposed definition, WIs handled as spectrum related in Rel-17 such as NR*SAR*PC2*interB*SUL*2BUL*, *HPUE*PC1*5*n77_n78 etc. would be categorized as non-spectrum related WIs from Rel-18. Note that they need specific signaling and inclusion of specific tables and texts into generic requirements. We need to make sure that if people have a common understanding with more specific examples for future proof.

### 2.2.2 Summary for intermediate round

The summaries for each issue are provided below.

**Proposal to endorse the previous proposal from September email discussion related to RAN4 TU splitting**

Companies are OK to use the TU table as a stating point for further evaluation in next RAN plenary. But there was no consensus on the proposal to pre-allocate RAN4 TU and endorse the proposal to down-scoping RAN4 objectives in items led by other WGs.

The moderator suggests to have discussion in RAN#94-e and seek the agreement for the concrete approach to balance work load between items led by different WGs. So no final round discussion is needed.

**Timeline to approve RAN4-led items**

Almost all the companies can agree the proposal. So the moderator would like to propose to endorse the following proposal:

- **Proposal #1-1: Approve Rel-18 RAN4 WI/SI package (except for <5MHz and DSS in this email thread) in March 2022.**

**Spectrum related/non-spectrum related items:**

Moderator: to Skyworks and AT&T, I agreed with your summarized approach, i.e., enable a basket approach after a new feature is introduced by example bands or band combinations and the example bands or band combinations should be typical enough to ensure that the specified general requirements can be applied to the other bands or band combinations.

To China Telecom, the group can further check if the wording for boundary is clear enough in final round. In my view, there is no reserved TU for the leftover issues from Rel-17 ”spectrum related work”. Such leftover issues should be discussed as the non-spectrum topics/working areas in Rel-18 and need non-spectrum related items’ TU. But for Rel-17 since we did not have such clear boundary agreement before, the related items can still be treated as ”spectrum related”.

## 2.3 Final round

### 2.3.1 Proposals and comments collection

In the final round, the moderator would like to discuss the proposal for boundary between spectrum related/non-spectrum related items.

- **Proposal #1-2: for RAN4 spectrum related and non-spectrum related topics,**
  - Boundary between RAN4 spectrum related items and non-sepctrum related items
    - Spectrum related items are item which aim to introduce band-specific and/or band combination specific requirements without impacting generic RF core requirements and/or core specifications of other WGs.
    - All the other items shall be defined as non-spectrum related.
  - Approach to specify RAN4 related features with both general requirements and band specific requirements
    - A non-spectrum related item with the chosen example band(s) and/or example band combination(s) is needed to study and/or specify the general RAN4 requirements as well as other necessary mechanism and the band or band combination specific requirements for examples
      - The example band(s) or band combination(s) should be chosen sufficient enough to ensure that the finalized general requirements can be applied to other bands or band combinations.

Please companies provide the feedback in the table below.

**Feedback Form 5:**

| **1 – AT&T GNS Belgium SPRL** |
| --- |
| OK with Proposal #1-2. Suggest to modify the last sub-bullet to use ”and/or” as done in the main bullet.<br>The example band(s) **and/or** band combination(s) should be chosen sufficient enough to ensure that the finalized general requirements can be applied to other bands **and/or** band combinations. |

| |
|---|
| **2 – Nokia Japan**<br>In our interpretation, the proposed definition means that many of the WIs/SIs treated as spectrum related items in Rel-17 and before would be categorised as non-spectrum related items in Rel-18 and beyond. If people have the same understanding, we are OK with the definition. However, ”sufficient enough to ensure” seems encouraging to have as many as examples with no upper limit. Hence, we propose a following alternative.<br>- **The minimum sufficient set of** example band(s) **and**/or band combination(s) should be chosen ~~sufficient enough~~ to ensure that the finalized general requirements can be applied to other bands **and**/or band combinations. |
| **3 – Apple AB**<br>we support the proposals |
| **4 – QUALCOMM JAPAN LLC.**<br>We are fine with the proposals. This issue has been discussed already in the plenary a few meetings ago. |
| **5 – Intel Corporation (UK) Ltd**<br>We agree with proposals. |
| **6 – LG Electronics Deutschland**<br>We support the moderator’s proposal #1-2. |
| **7 – Ericsson LM**<br>We are fine with the proposals |
| **8 – ZTE Corporation**<br>we are also fine the proposals. |
| **9 – vivo Communication Technology**<br>We are fine with the proposals |

### 2.3.2 Summary for final round

Companies suggested some modification. Almost all the companies were OK with this proposal. In the moderator view, if the proposal was endorsed, then in the future more items should be considered as non-spectrum related items.

Based the feedback, the moderator would like to modified proposal #1-2.

- **Proposal #1-2: for RAN4 spectrum related and non-spectrum related topics,**
  - Boundary between RAN4 spectrum related items and non-sepctrum related items,
    - Spectrum related items are item which aim to introduce band-specific and/or band

combination specific requirements without impacting generic RF core requirements and/or core specifications of other WGs.
    - All the other items shall be defined as non-spectrum related.
  - Approach to specify RAN4 related features with both general requirements and band specific requirements
    - A non-spectrum related item with the chosen example band(s) and/or example band combination(s) is needed to study and/or specify the general RAN4 requirements as well as other necessary mechanism and the band or band combination specific requirements for the examples
      - The example band(s) and/or band combination(s) should be chosen ~~sufficient enough~~ to ensure that the finalized general requirements can be applied to other bands and/or band combinations.

# 3 Spectrum related topics (except for basket WIs and WIs for new bands)

## 3.1 Simplification of band combination specificiation

### 3.1.1 Initial round

#### 3.1.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***Simplification of band combination specification (FFS whether to be approved as continuation of Rel-17 SI)***

The comments, questions, and responses in September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- Simplification of band combination specification (FFS whether to be approved as continuation of Rel-17 SI)
  - Potential justifications: (refer to RP-212482, RWS-210455)
    - There are too many band combinations introduced, which cause the complexity of specifications and the testing burden for UE
    - Address the issue caused by big number of band combinations in terms of UE implementation and testing
  - Potential objectives: (refer to summary RP-211667 and RP-212482/RWS-210455)

        - Investigate the feasibility and optimize the specification structure by defining common RF requirements independent of features including CA, DC and etc, and defining other RF requirements specific to features including CA, DC and etc. (RAN4)
    - Leading working group:
        - RAN4
    - SI or WI:
        - SI

**Comments and suggestions**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether the secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 6:**

| |
|---|
| **1 – China Telecommunications**<br>In general, we support to continue this SI in Rel-18. |
| **2 – Charter Communications**<br>We also support to continue this SI in Rel-18 |
| **3 – T-Mobile USA Inc.**<br>We support this SI in Rel-18 |
| **4 – MediaTek Inc.**<br>We are in general fine with the SI, but would like to add a note for clarification that the work should not change any existing UE requirements. |
| **5 – ZTE Wistron Telecom AB**<br>Simplification and optimization works on band combination specifications is still needed in new releases, and we support the SI to be continued in Rel-18. |
| **6 – SoftBank Corp.**<br>We support this SI in Rel-18 as well. |
| **7 – KDDI Corporation**<br>We support this SI in Rel-18. |
| **8 – Nokia Japan**<br>We support the continuation of the SI. We, however, strongly suggest that before the Rel-18 is approved , RAN4 resolve an issue that the current RAN4 basket WIDs have been arranged in a way that leads to redundancy in text proposals, TRs and CRs, which leads to unnecessary work for the rapporteurs, for MCC to implement CRs which has led to errors in the CR implementation. Otherwise, our efforts for simplification work cannot be maximized. |

**9 – China Unicom**

We support to continue the band combination simplification work in Rel-18.

**10 – QUALCOMM JAPAN LLC.**

We believe there could be some value to this work but it would be good if proponents could provide some concrete examples of what and how could be improved. Having an open ended study will consume much time with potentially little overall improvements. More targeted objectives would be useful.

**11 – Samsung Electronics Co.**

We are supportive to continue the effort on simplification of band combination specification. More and more band combinations proposed in RAN4, current working approach seems not sustainable to the accumulated request. New method and working procedures need to be adopted in RAN4

**12 – Intel Corporation (UK) Ltd**

We support the work on Simplification of band combination specification. The current amount of BCs and associated RF requirements become an issue for implementation and testing. Development of new approaches is important to improve RAN4 working efficiency.

**13 – Huawei Technologies France**

We support to have a SI in Rel-18 for simplification of band combinations in Rel-18.

In the current specifications, the UE RF requirements are specified per feature (e.g., CA, DC, EN-DC, SUL) for a band combination (e.g., band A+B+C). But most of RF requirements depend on which spectra are combined and how many UL and on which spectrum UL will be transmitted, and are independent of those features. As a result, there are redundancy during the verification of RF requirements for a combination of bands. Particularly, UE needs to pass some similar CA and EN-DC RF requirements on the same combination of bands, e.g., CA*nA-nB, EN-DC*A-nB, EN-DC_B-nA, where A and nA correspond to the same spectrum for LTE and NR separately. But the RF implementation under the verification for CA and EN-DC would be the same.

In our view, if RAN4 could identify for which requirements if UE passes NR-CA RF requirements then UE does not need pass the similar RF requirements for other features including EN-DC on the same combination of bands, then a lot of testing effort could be saved considering the huge number of CA and EN-DC band combinations. Such work would not be straightforward. For some requirements, there are difference between EN-DC and CA, e.g., CA*nX-nY-nZ and DC*X-Y_nZ for which the uplink configurations and applicable requirements would be different.

In addition, inter-band CA RF requirements refer to single band RF requirement. We wonder if we could save verification of some single band RF requirements as long as the corresponding inter-band CA requirements covering that band are met.

Secondly, we would like to consider further study simplification of specification. We observed the main complexity of specification is due to the huge number of band combination + configurations for band combinations (with information of bandwidths per band and uplink configurations). In our observation, most requirements are specified based on the band combinations, while some requirements like MSD depend on configurations especially bandwidth combinations. If we can remove the dependency on bandwidth combinations, then we can further simplify the RF requirements. This topic is under discussion in Rel-17, but there seemed no systematic study. Maybe those things need further discussion in Rel-18.

Justification:

- There are redundancies of RF requirements especially between NR-CA and EN-DC on the same band combination. It is better to avoid duplicating the similar tests for UE supporting both features on the same band combination.
- There are too many band combinations as well as RF requirements introduced, which cause the complexity of specifications. The simplificaiton of RF specification would be needed.

Objectives:

- Identify the UE RF requirements for which UE only needs pass the test once with either NR-CA or EN-DC configured on the same band combination when UE supports both NR-CA and EN-DC on that band combination.
- Identify the UE RF requirements for which if UE can pass the test on the NR-CA band combination then UE does not need pass the test on any one of bands composing the band combination.
- Study the methodology to simplify the RF requirements which depend on bandwidth combinations, e.g., MSD requirements for EN-DC. (depending on the progress of Rel-17 SI)

**14 – VODAFONE Group Plc**

We support the need to simplify the process of creating specifications for new band combinations.

**15 – Ericsson LM**

We also support the need to simplify the process. The main issues for improvement are:

- To improve the quality, the reviewing process need further improvement for band combinations.
- Big CRs are for email approval directly after the RAN4 meeting, but not until after RAN is it possible to see the full impact how these big CRs interact and work together. Technical issues such as fallbacks missing, not valid channel BWs, not possible references, etc, are not found until it is too late to make such comments.
- There is ongoing SI on improvement of band combination work. This work might need to continue depends on outcome of the R17 SI.
- For band combos improvement, one option is that the current SI can be further extended to R18 to enhanced CA/DC specification procedures.

**16 – Verizon UK Ltd**

We support to continue the effort on simplification of band combination and support this SI in Rel-18.

**17 – AT&T GNS Belgium SPRL**

We also support to continue this SI in Rel-18. In addition, finding concrete ways to simplify the specification will improve the specification quality.

**18 – Apple AB**

We support this efforts subject to TU availability.

#### 3.1.1.2 Summary for initial round

Almost all the companies are supportive for this topic and direction. The main comments are that the concrete objectives (some concrete examples of what and how could be improved) should be provided to avoid open ended discussions, and the improvement on procedures for basket WIs is needed including avoiding the redundancy, conflict between CRs and TPs.

### 3.1.2 Intermediate round

#### 3.1.2.1 Proposals and comments collection

Moderator suggests further discussion on the potential justifications and objectives. Based on the comment, moderator provides the following bullets for discussions in the intermediate round.

**Justification and objectives for Rel-18 study on simplification of band combination specifications**

- Potential justifications:
  - Working procedure needs be improved. There are more and more band combinations introduced, which makes current working procedure not sustainable and less efficient
    - Improve the quality of specifications by avoiding the conflict between big CRs and avoiding incomplete CRs
    - Reduce the redundancy and unnecessary work
  - Address the issues caused by big number of band combinations for UE implementation and testing. Some tests for a band combination seems redundant.
- Potential objectives:
  - Investigate and improve the working procedure for band combination specifications
    - Improve the CR and specifciaitons
    - Reduce the redundancy and unnecessary work for big CRs, draft CRs and TPs
  - Investigate the feasibility and optimize the specification structure and reduce the test burden
    - Study the methodology to simplify the tests for the band combination
    - Study the methodology to simplify RF requirement specifications

In the intermediate round, there is no need to discuss whether to have a new SI or extend the existing SI. The discussion is expected to focus on the justification and objectives. Once the justification and objectives are stable, the group can further discuss how to proceed the work in the future meeting.

Please provide your comments.

**Feedback Form 7:**

**1 – Skyworks Solutions Inc.**

Sorry that we could not participate in first round due to the contribution deadline for RAN4. One input from our side is that the key to simplification is to accept a low number of test points for band combinations: we should not specify all the BW combinations but chose the test point such that it exacerbates the UE behavior we are trying to verify: i.e use the worst case configuration. It should be noted that simplification

is anyhow hapening later in RAN5 or test houses due to the too high number of tests so we believe that RAN4 is the best placed to select the scenario that allows to verify the UE behavior.

**2 – AT&T GNS Belgium SPRL**

We generally support the proposed justification and objectives as presented by the moderator. In particular, we would like to focus on efficiency improvements to the process of introducing new band combinations such that we reduce redundancies, implementation level of effort, specification readability, and specification quality.

For the test reduction effort, we would prefer to add RAN5 as secondary WG or to add a statement to liaise with RAN5 as necessary. As RAN5 has external certification bodies as customers, we need to ensure that RAN5 is covering the test points required for their customers.

**3 – QUALCOMM JAPAN LLC.**

The proposed objectives do not address the comments to have more targeted description of the objectives, they are still open ended. For the reduction of testing time, this could be useful but would require RAN5 input also because RAN4 may not have a good understanding of what are the major contributors to test time.

**4 – Ericsson LM**

We are generally fine with the proposal. But our preference is to continue the ongoing R17 SI by modifying/adding new objectives. One specific issue to address is how to improve the ”Big CR and reduce redundancy”.

One main problem is that there is overlap among some of the Big CRs. Th is because RAN4 has approved too many basket WIs without paying any attention to similarities.

Therefore one concrete objective can be that, ”RAN4 identify potential consolidation of basket WIs resulting in overlapping Big CRs (or significant overlap in Big CRs”. In our view concrete examples are given below: and there can be more:

- Basket WIs on NR CA 3DL/1UL and NR CA 3DL/2UL need to be merged into new 3DL/xUL
- Basket WI NR CA 4DL/1UL and NR CA 4DL/2UL need to be merged into new 4DL/xUL
- Basket WI on NR CA 5DL/1UL changed to new NR CA 5DL/xUL (instead of creating multiple WIs with 2, or 3 UL).

**5 – LG Electronics Deutschland**

We support the proposal in general but it would be better to have some description on the example methodology and corresponding RF requirement for better understanding as commented by other companies.

**6 – Samsung Electronics Co.**

In general, we are fine with the objectives. As commented by other companies, RAN4 shall be careful about study the test time reducation in a SI which is mainly targeting on simplifying the basket WIs approach procedure and also specification structure. If RAN4 has to include test time as objective, we agree with AT&T and Qualcomm that RAN5 shall be invovled

**7 – KDDI Corporation**

We agree with the proposed justification and objectives.

**8 – ZTE Corporation**

we also support this SID and we have the following proposals:

1□Analyse and identify the redundant contents of CA/DC combination in the specifications. Remove the redundant contents and re-organize the specification structure.

□2□Further optimization of CA/DC configuration tables and make the specification more concise and readable.

□3□Further improve the rules and guidelines of specifying band combinations.

□4□From the perspective of RAN5 test, optimize the organization for CA/DC configurations.

**9 – Intel Corporation (UK) Ltd**

We support the work on Simplification of band combination specification and proposed objectives are fine. The current amount of BCs and associated RF requirements become an issue for implementation and testing.

**10 – Nokia Japan**

The objectives are highly dependent on the on-going SI progress and discussions on how to re-structure basket WIs. We suggest the on-going SI clarify the remaining issues in Rel-17 SI and new issues to be addressed in Rel-18 in the remaining Jan and Feb RAN4 meetings.

**11 – Nokia Japan**

Thanks Chairman taking into account our comments.

The objective shall clarify the SI does not include any specific new features like ”UL Tx chain switching on > 2 bands” and ”flexible spectrum integration. This is a SI to check if the proposed band combinations work or not with the conventional CA/DC framework. Or we should have a clear agreement on that and the agreement should be captured somewhere like WF or in the minutes.

Focus on power class 3 (PC3) is ambiguous since it seems there are several PCs and we focus on PC3 among them. Some modifications for PC are necessary like below.

Investigate the feasibility to enable up to simultaneous transmission on any two UL bands and simultaneous reception on three bands for ~~700+800+900 band combination~~ **PC3** CA_n8-n20-n28 and

**PC3** DC*8-20*n28 for smart phone with small form factor, including (RAN4)

UE architecture including n-plexing, PA

Wideband antenna ~~tuning~~ □□Performance improvement

~~Focus on power class 3 (PC3)~~

Identify and specify necessary RAN4 requirements including Tx and Rx RF requirements (RAN4)

**12 – Huawei Technologies France**

According to the 1st round discussion, the updated objectives could be as follows:

Investigate the feasibility and optimize the specification structure and reduce the test burden

Study the methodology to simplify the tests for the band combination, e.g. study test simplification and dependency for different combination feature (NR CA, NR DC, SUL, ENDC, etc.)

Study the methodology to simplify RF requirements specifications

1) To simplify the MSD requirements due to harmonic interference and cross band isolation for 38.101-1 and 38.101-3. (Reduce the test configurations with different channel bandwidth combinations)

2) To change EN-DC Configuration into band combination for MSD due to IMD for 38.101-3

3) To specify the general requirements for ΔTIB,c and ΔRIB,c. RAN4 can investigate and specify the ΔTIB,c and ΔRIB,c exceptions for some special band combinations.

4) To simplify ΔTC,c in Pcmax low boundary formula.

#### 3.1.2.2 Summary for intermediate round

In the intermediate round, companies provide some concrete proposals, which can be captured. Qualcomm and LGE asked to make more targeted descriptions of the objectives to avoid the open ended discussions.

Moderator: to Ericsson, following RAN Chair guidance, the moderator would like to suggest focusing on justification and potential objectives for a topic at the current stage. Either extension of Rel-17 SI by modifying or adding objectives or approval of new items are all on the table for further discussion after the objectives are stable.

For the merger of basket WI, it would be too late to include it in Rel-18 SI and wait for conclusion. The discussion will be organized in upcoming RAN4 meeting. The balance between the efficiency and workload for each basket WI would be needed. But as the moderator, I can keep the tentative bullets in [ ] for the objective that you suggested

### 3.1.3 Final round

#### 3.1.3.1 Proposals and comments collection

Based on the feedback from companies, the moderator proposes the modified potential objectives for discussion in the final round.

- **Proposal #2-1: for RAN4 spectrum specification simplification, the following potential objectives can be considered**
  - Investigate and simplify ~~improve~~ the working procedure for approving documents for TS and TR for band combinations to improve the quality of specifications
    - ~~Improve the CR and specifciaitons~~
    - RAN4 reduces the redundancy and unnecessary work for big CRs, draft CRs and TPs
    - RAN4 improves the procedures for cross-checking to avoid conflict between big CR/CRs across basket WIs
    - [RAN4 identifies the potential consolidation of basket WIs]
  - Investigate the feasibility and optimize the specification structure and reduce the test burden
    - Study the methodology to simplify the test efforts for a UE supporting multiple features, e.g., NR-CA, EN-DC on the same band combination
      - Study of similarity and dependency of RF requirements for different features on the same band combination
    - Study the methodology to simplify RF requirements specifications for

- MSD requirements in 38.101-1 and 38.101-3, e.g., reducing the test configurations with different bandwidth combinations.
- [Leftover issues from Rel-17 SI including Delta_TIB, Delta_RIB, Delta_TC,c in Pcmax for low boundary formula.]

- Leading working group:
  - RAN4, RAN5 as secondary group

Please companies provide comments in the table below.

**Feedback Form 8:**

| |
|---|
| **1 – T-Mobile USA Inc.**<br>Instead of RAN4 identifies the potential consolidation of basket WIs we'd like to suggest: RAN4 identifies the potential consolidation/**re-alignment** of basket WIs As we have pointed out in the past in R4-2114238, instead of having 3DL/1UL cover FR1 and FR1+FR2, and 3DL/2UL also cover FR1 and FR1+FR2, we could have one basket be 3DL/xUL for FR1 and another basket be 3DL/xUL for FR1+FR2. That would be the same number of WIs, but with a more efficient split in terms of less redundant work. |
| **2 – AT&T GNS Belgium SPRL**<br>We agree with T-Mobile's suggested modification for the basket WIs. We would also like to see that particular item without brackets since we believe that it is an important aspect to resolve the redundancy and conflicts between big CRs which have resulted in implementation issues. |
| **3 – Nokia Japan**<br>We are OK with the proposal at this moment and would like to refine the objectives further in the future RAN meetings considering the outcome of the on-going Rel-17 SI and discussion about basket WI realignment in RAN4 as we commented in the initial round. The realignment must be definitely necessary in our view before approving Rel-18 basket WIs. |
| **4 – QUALCOMM JAPAN LLC.**<br>The changes/clarifications are definitely a step forward. We also agree with Nokia's comment that this can be further refined based on ongoing work. |
| **5 – LG Electronics Deutschland**<br>Proposals in the final round become clearer than before by adding some example cases. We are OK with the proposals at this moment and also think these need more update in the next round maybe in RAN#94. |
| **6 – Ericsson LM**<br>Looks fine for the time being. But agree with previous comments that the objectives could be updated as we come closer to the approval of the SI as more ideas may emerge at the end of R17. |
| **7 – ZTE Corporation**<br>we are also awear of the potential conflicts on the big CR between some NR CA basket WID, such as 1UL/3DL and 2UL/3DL, 1UL/3DL and 2UL/3DL. Re-alignment of basket WIDs would be needed. We also have some proposals in last RAN meeting, and proposed that split 3DL and 4DL into FR1 and FR1+FR2 |

associated with xUL. Also we agree with T-Mobile USA that same number of WIs should be kept but with a more efficient way to avoid the redundant work

**8 – KDDI Corporation**

We agree with proposed objectives, and we are also fine with T-Mobile suggestion.

#### 3.1.3.2 Summary for final round

Companies made comments on potential objectives for consolidating basket work items. The moderator agrees that the potential objectives should be refined based on the outcome of Rel-17 discussion and discussions for basket work item in the upcoming RAN4 meeting.

Based on the feedback, the moderator modified proposal #2-1

- **Proposal #2-1: for RAN4 spectrum specification simplification, the following potential objectives can be considered**
  - Investigate and simplify the working procedure for approving documents for TS and TR for band combinations to improve the quality of specifications
    - RAN4 reduces the redundancy and unnecessary work for big CRs, draft CRs and TPs
    - RAN4 improves the procedures for cross-checking to avoid conflict between big CR/CRs across basket WIs
    - [RAN4 identifies the potential consolidation/re-alignment of basket WIs]
  - Investigate the feasibility and optimize the specification structure and reduce the test burden
    - Study the methodology to simplify the test efforts for a UE supporting multiple features, e.g., NR-CA, EN-DC on the same band combination
      - Study of similarity and dependency of RF requirements for different features on the same band combination
    - Study the methodology to simplify RF requirements specifications for
      - MSD requirements in 38.101-1 and 38.101-3, e.g., reducing the test configurations with different bandwidth combinations.
      - [Leftover issues from Rel-17 SI including Delta_TIB, Delta_RIB, Delta_TC,c in Pcmax for low boundary formula.]
  - Leading working group:
    - RAN4, RAN5 as secondary group

## 3.2 Enhancement for 700+800+900MHz band combination

### 3.2.1 Initial round

#### 3.2.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- *NOTE: how to handle 700+800+900MHz band combination as one of potential candidate topics needs further discussion with more clarification.*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- Enhancement for 700+800+900MHz band combination
  - Potential justifications (Refer to RP-212482):
    - The available spectrum on bands of 700, 800 and 900MHz is small... Although the coverage on those bands is excellent, the small available channel bandwidth cannot fulfill high data rate NR service.
    - Band combination of 700+800+900 can only be supported by FWA devices with larger form factor.
  - Potential objectives: (Refer to RP-212482 and summary RP-211667)
    - Investigate the feasibility to enable up to simultaneous transmission on any two UL bands and simultaneous reception on three bands for 700+800+900 band combination for smart phone with small form factor, including (RAN4)
      - UE architecture including n-plexing, PA
      - Antenna tuning
      - Based on CA, DC, EN-DC features
      - Performance improvement
    - Identify and specify necessary RAN4 requirements including Tx and Rx RF requirements (RAN4)
  - Leading working group:
    - RAN4
  - SI or WI:
    - SI or WI with study phase

**Comments and suggestions:**

Companies are invited to provide the general comments on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether the secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 9:**

**1 – China Telecommunications**

Considering the scarce spectrum in low bands and narrow bandwidth in each band, it is rather important to define the requirements for 700+800+900 band combination for handled UE.

We already proposed a 700+800+900 CA combination with two uplink bands for handled UEs in Rel-17 basket WI. But we understand the implementation difficulty of LB-LB combination for handled UEs, so

we are fine to do the work in Rel-18.

A WI with study phase is acceptable for us.

**2 – TELECOM ITALIA S.p.A.**

if it cannot be done in Rel 17, it should be a WI

**3 – Telia Company AB**

We support that 700+800+900 CA combination improvements are done as WI in Rel-18 taken into account possible and latest information on the UE & chipset restrictions.

**4 – Nokia Japan**

Further clarification should be made.

700+800+900MHz should be replaced with one specific band combination such as nX+nY+nZ, since the level of challenges for 700+800+900MHz band combination is different from band combinations to band combinations.

The band combination should be selected whose one order lower fallback modes are already in the specification.

Also, power class for the band combination should be added to the objective to be PC3 for clarification.

**5 – ZTE Wistron Telecom AB**

We understand that a 3-band combo consisting of 700+800+900M cannot be fully covered under the current basket WI framework for handheld UEs due to its implementation challenges, hence a feasibility study is required. Once the feasibility study outcome indicates the possibility of two simultaneous UL transmission, then the rest works can be left to corresponding basket WIs. With such consideration, we would suggest an SI be sufficient, and after the SI, its standardization works fall into corresponding basket WIs.

**6 – QUALCOMM JAPAN LLC.**

The proposed objectives are not really things that RAN4 can improve since they depend on the hardware capabilities(there isn't much RAN4 can study on how to improve filters or antennas). The biggest issues for combinations with these 3 bands are the filters and antennas and we do not see much room for improvement now. Even if the issues with filters could be solved, such wideband antennas in low bands are not yet possible in our understanding

**7 – Samsung Electronics Co.**

For these band combinations, there are parallel discussion with different solutions i.e. CA and new solution with flexible spectrum integration which involved new design from RAN1 and RAN2.

How to handle these two solutions if both of them included in Rel-18?

We would like to have a single and unified solution to avoid market fragmentation.

**8 – Intel Corporation (UK) Ltd**

First of all, we acknowledge operators interest of enhancement for 700+800+900MHz band combination and open to consider enhancements. Meantime, further clarifications on the objectives are needed. The proposed objectives aim to enable "*... simultaneous transmission on any two UL bands and simultaneous*

*reception on three bands*". We assume that such UEs will have 2Tx chains and will be required to perform UL Tx chain switching across 3 different UL bands. Is it expected that switching is done in a semi-static or dynamic manner? Dynamic Tx switching is relevant to the proposal on enhanced multi-carrier (>2 bands) operation for 2Tx UEs discussed in the RAN94e-R18Prep-02 email thread. In addition, there are proposals on flexible spectrum in email thread RAN94e-R18Prep-27, which seem to address a similar scenario. We would encourage proponents to provide more information on how these 3 proposals are related to each other.

**9 – Huawei Technologies France**

A WI on 700+800+900 and other possible multiple low band combinations is preferred.

Many operators own 700, 800 and 900MHz spectrum or other low bands. The coverage on those bands are very good. But the available spectrum on those bands is quite small, which causes difficulty to meet 5G high data rate requirements on those bands. So they should be aggregated to achieve the larger throughput on both downlink and uplink.

In Rel-17, the EN-DC/CA band combination of 700+800+900 were discussed. But according to our understanding, the use case is limited to CPE/FWA. Although it is challenging, it would be worth to investigate and enable smartphone on that band combination for promote those bands.

In our view, the work is not trivial and the UE architecture and issues related to antenna also need be discussed. It is better to have a dedicated item rather than putting the work in the basket work item.

Justification: we agree with the moderator summary.

- The available spectrum on bands of 700, 800 and 900MHz is limited. Although the coverage on those bands is excellent, the small available channe bandwidth cannot fulfil high data rate NR service. So they should be aggregated to achieve the larger throughput on both downlink and uplink.
- Band combination of 700+800+900 can only be supported by FWA devices with larger form factor. The smartphone should be enabled to promote the commericialization on those bands.

Objectives: we agree with moderator's summary, but are open to other companies' comments.

**10 – VODAFONE Group Plc**

We are aligned with Telia (ie. We support that 700+800+900 CA combination improvements are done as WI in Rel-18 taken into account possible and latest information on the UE & chipset restrictions.)

**11 – Ericsson LM**

We agree with Samsung and Intel that there is parallel or similar discussion on new solution with flexible spectrum integration under RAN1 led Rel-18 items. This will have RAN1 and RAN2 impact. Activating any 2 of the 3 UL bands would need changes in RAN1 and RAN2. Therefore we do not think that this proposal can be considered as spectrum related.

#### 3.2.1.2 Summary for intermediate round

Quite a number of operators including China Telecom, Telecom Italia, Telia, Vodafone showed interests in this topic.

There are mainly two kinds of comments. One is on the feasibility. Qualcomm commented that the proposed work is challenging considering the filter and antenna, and ZTE commented that study on the feasibility is needed. The other comments from Samsung, Intel and Ericsson are about the relation of this work to the other Rel-18 proposals of "UL Tx chain switching on > 2 bands" and "flexible spectrum integration.

Nokia provided constructive comments that the specific band combinations should be decided and for them the fallback modes should be ready, and the power class should be limited to PC3.

### 3.2.2 Intermediate round

#### 3.2.2.1 Proposals and comments collection

In the intermediate round, the proponent(s) needs respond to the comments from Samsung, Intel and Ericsson on the relation of this proposal with the other RAN1/2-led proposals, i.e., UL Tx switching on >2 bands and flexible spectrum integration.

Please provide your responses and comments below.

**Feedback Form 10:**

**1 – Skyworks Solutions Inc.**

Again, we could not participate infirst round due to RAN4 contribution deadline, but we believe a key criteria for 3DL+2UL low band combination should be that it actually provides a better link than a 2DL+1UL case. whaever improvemnt in antenna separation and RF front end, in most cases these combinations have severe 2UL IMD issues such that more DL or UL band not necessarily results into better DL or UL throughputs.

**2 – China Telecommunications**

Here the RF requirements for 700+800+900 CA/DC combination are separate discussion with the other discussion in thread #02 and #27. From the proposed objectives by moderator, it is clear that the RF requirements are for the conventional CA/DC and only RAN4 impact is seen.

May be the confusion comes from the word “any two UL bands”? If so, from our understanding, we’d like to clarify that the “any two” means that all of the possible UL configurations with 2 UL bands are to be covered, for example:

- Band combination configuration: CA_n5A-n8A-n28A
- UpLink configuration: CA*n5A-n8A, CA*n5A-n28A, CA_n8A-n28A

**3 – Nokia Japan**

Thanks Chairman taking into account our comments.

The objective shall clarify the SI does not include any specific new features like ”UL Tx chain switching on > 2 bands” and ”flexible spectrum integration. This is a SI to check if the proposed band combinations work or not with the conventional CA/DC framework. Or we should have a clear agreement on that and the agreement should be captured somewhere like WF or in the minutes.

Focus on power class 3 (PC3) is ambiguous since it seems there are several PCs and we focus on PC3 among them. Some modifications for PC are necessary like below.

Investigate the feasibility to enable up to simultaneous transmission on any two UL bands and simultaneous reception on three bands for ~~700+800+900 band combination~~ **PC3** CA_n8-n20-n28 and

**PC3** DC*8-20*n28 for smart phone with small form factor, including (RAN4)

UE architecture including n-plexing, PA

Wideband antenna ~~tuning~~ □□Performance improvement

~~Focus on power class 3 (PC3)~~

Identify and specify necessary RAN4 requirements including Tx and Rx RF requirements (RAN4)

**4 – Huawei Technologies France**

To accomedate the feasibility concern, we think that the WI can have a study stage firstly, but the target of the WI is for smartphone in Rel-18. The benefit for 2 bands UL is the enhanced capacilty with larger aggregated channel BW.

Based on the feedback, moderator would like to suggest the following bullets for further discussion.

- Potential justifications (based on RWS-210455):
  - The available spectrum on bands of 700, 800 and 900MHz is small... Although the coverage on those bands is excellent, the small available channel bandwidth cannot fulfill high data rate NR service.
  - Band combination of 700+800+900 can only be supported by FWA devices with larger form factor.
- Potential objectives:
  - Investigate the feasibility to enable up to simultaneous transmission on any two UL bands and simultaneous reception on three bands for ~~700+800+900 band combination~~ CA_n8-n20-n28 and DC_8-20_n28 for smart phone with small form factor (RAN4), including
    - UE architecture including n-plexing, PA
    - Wideband antenna ~~tuning~~
    - Performance improvement
    - Focus on power class 3 (PC3)
  - Identify and specify necessary RAN4 requirements including Tx and Rx RF requirements (RAN4)
- Leading working group:
  - RAN4
- SI or WI:
  - SI ~~or WI with study phase~~

Please provide your comments on the moderator's suggested bullets.

**Feedback Form 11:**

**1 – TELECOM ITALIA S.p.A.**

on the Justification: a statement it should be added that we want to extend the feature to smartphone-type UEs

Not clear why it should be a study. It is clear the issue raised by Qualcomm on the components (issue out of scope of 3GPP, however), but the main concern is given by how to manage the intermodulation products. This is something that 3GPP already dealt with in the past for other band combinations. Therefore we think it would still be better to have a focused WI with objectives on management of intermodulation products and fallback combinations.

**2 – Skyworks Solutions Inc.**

We already have had discussions on this 3 band combination and it suffers from 2UL IMD3 issues which makes the benefit unclear for all possible 2UL permutations and at an significant cost adder. There won't be any miracle there. It is wiser to gage which 2UL scenarios really makes sense for a 3DL case and accept single UL or SUO for the critical cases. this should be part of the study.

**3 – China Telecommunications**

For the objective, we suggest to add the BC of CA_n5A-n8A-n28A. As we commented earlier, this BC with 3DL and 2UL have already added in the Rel-17 basket WI, but we can accept to move it to Rel-18 to allow more time for the work.

We still prefer a WI with study phase. Our main concern on going with a SI is that the SI may spend the whole Rel-18 time. For the potential technical difficulties, we can study in the study phase.

**4 – QUALCOMM JAPAN LLC.**

Without a very clear understanding of overall benefits, there isn't much point in just handling IM products or fallbacks. If the end issues are with the components or antennas, the overall performance will still be very poor even if other issues are fixed. We will end up spending a lot of work on something that in the end will not be implemented.

**5 – MediaTek Inc.**

Similar to the comment from QC. We have concern on this WI. With limited font factor, we fail to see the feasibility at this moment.

**6 – ZTE Corporation**

For this topic, we could understand the importance for operators holding these spectrums with sliced spectrum and however as we mentioned in 1st round, the feasibilty study should be placed at the beginning.

**7 – Intel Corporation (UK) Ltd**

We agree ZTE comments that feasibility study needs to be performed first before going into WI stage.

**8 – Nokia Japan**

Thanks Chairman taking into account our comments.

The objective shall clarify the SI does not include any specific new features like "UL Tx chain switching on > 2 bands" and "flexible spectrum integration. This is a SI to check if the proposed band combinations work or not with the conventional CA/DC framework. Or we should have a clear agreement on that and the agreement should be captured somewhere like WF or in the minutes.

Focus on power class 3 (PC3) is ambiguous since it seems there are several PCs and we focus on PC3 among them. Some modifications for PC are necessary like below.

Investigate the feasibility to enable up to simultaneous transmission on any two UL bands and simultaneous reception on three bands for ~~700+800+900 band combination~~ **PC3** CA_n8-n20-n28 and

**PC3** DC*8-20*n28 for smart phone with small form factor, including (RAN4)

UE architecture including n-plexing, PA

Wideband antenna ~~tuning~~ □□Performance improvement

~~Focus on power class 3 (PC3)~~

Identify and specify necessary RAN4 requirements including Tx and Rx RF requirements (RAN4)

#### 3.2.2.2 Summary for intermediate round

Vendors expressed the concerns on 2UL for this band combination and the performance benefit of 2UL over single UL or SUO. Telecom Italia and China Telecom provided concrete proposals, which will be captured. Although operators preferred WI, the vendors had the different views. In the moderator view, SI might be the middle ground to move forward.

Moderator: to Skyworks, the study on performance has already been captured in the tentative objectives.

### 3.2.3 Final round

#### 3.2.3.1 Proposals and comments collection

Based on the feedback from companies, the moderator suggests further discuss the following bullets:

- **Proposal #3-1: for enhancement of 700+800+900 band combinations, the following bullets can be considered**
  - Potential justifications
    - The available spectrum on bands of 700, 800 and 900 MHz is small... Although the coverage on those bands is excellent, the small available channel bandwidth cannot fulfill high data rate NR service.
    - Band combination of 700+800+900 can only be supported by FWA devices with larger form factor.
    - Extend the support of features, e.g., NR-CA, EN-DC, on 700+800+900 band combinations to smartphone
  - Potential objectives:
    - Investigate the feasibility to enable ~~up to~~ simultaneous transmission on ~~any~~ two UL bands and simultaneous reception on three bands for ~~CA_n8-n20-n28 and DC_8-20_n28~~ the band combination of 700, 800 and 900 MHz spectrum for the smart phone with small form factor (RAN4)
      - The following band combinations will be considered:
        - CA_n8-n20-n28 with uplink configurations of CA_n8-n20, CA_n8-n28, CA_n20-n28
        - DC_n8-n20-n28 with uplink configuraitons of DC_8_n28, DC_20_n28, DC_28_n8
        - CA_n5-n8-n28 with uplink configurations of CA_n5-n8, CA_n5-n28, CA_n8-n28
      - The following aspects need be studied
        - UE architecture including n-plexing, PA
        - Wideband antenna
        - Performance ~~improvement~~ due to impacts including inter-modulation products
        - Method to manage the inter-modulation products impacts
      - Focus on power class 3 (PC3)
    - Identify and specify necessary RAN4 requirements including Tx and Rx RF requirements (RAN4)

Please provide your comments and feedback in the following table.

**Feedback Form 12:**

| |
|---|
| **1 – Skyworks Solutions Inc.**<br>Example bands and UL configurations to be considered: it should be clear that part of the aspects to be considered is if all UL configurations are worth specifying and if side conditions like SUO (optional/-mandatory) are better choices. |
| **2 – Nokia Japan**<br>”Focus on” seems there is a possibility to study PCs other than PC3.<br>PC is one of the fundamental factors to impact on feasibility study and the required amount of work. Hence, we still request to make sure the PC to be studied is only PC3. |
| **3 – China Telecommunications**<br>We can accept to start with a SI as suggested by moderator. Meanwhile, as we commented in the intermediate round, we don’t hope the study will spend the whole Rel-18 time. So, we propose to clearly mention that the SI will be completed before the Rel-18 finalization time, e.g., it is a 9-month SI. |
| **4 – QUALCOMM JAPAN LLC.**<br>If the target is 2UL, what is the difference between CA and DC for the same combination? possibility of having async vs. sync?<br>A study is definitely needed since it is not clear at all anything meaningful can be done. We still have concerns that the actual improvements coming out of this SI will be minimal so RAN4 time might be better used in other ways. |
| **5 – Ericsson LM**<br>We are ok with the proposal if this is a SI as there are several issues to study. |
| **6 – ZTE Corporation**<br>we also support to have the SI phase to check its feasibility with the related vendors and find out the best solutions for this band combination request. |

3.2.3.2 Summary for final round

In the moderator view the objective of ”identify the feasibility to enable simultaneous transmission on two UL bands and simultaneous reception on three bands...” is going to answer the questions if the proposed UL configurations are worth specifying and if other scheme would be more proper. Without the study proposed in the potential objectives, it would be difficult to judge which configuration is not worth specifying. In this regard, there seems no need to modify the potential objectives to capture the Skyworks comment. But the moderator agrees that we won’t need to further extend the examples.

To address Qualcomm comment, the moderator suggests removing DC to save some effort since the study would focus on UE RF and there seems less difference between CA and DC. In the moderator understanding, 3DL/1UL configuration for smart phone may also need be studied and covered by the potential objective.

Based on feedback from companies, the moderator modified the proposal #3-1 as below.

- **Proposal #3-1: for enhancement of 700+800+900 band combinations, the following bullets can be considered**
  - Potential justifications
    - The available spectrum on bands of 700, 800 and 900 MHz is small. Although the coverage on those bands is excellent, the small available channel bandwidth cannot fulfill high data rate NR service.
    - Band combination of 700+800+900 can only be supported by FWA devices with larger form factor.
    - Extend the support of features, e.g., NR-CA, EN-DC, on 700+800+900 band combinations to smartphone
  - Potential objectives:
    - Investigate the feasibility to enable simultaneous transmission on two UL bands and simultaneous reception on three bands for the band combination of 700, 800 and 900 MHz spectrum for smart phone with small form factor (RAN4)
      - The following band combinations will be considered:
        - CA_n8-n20-n28 with uplink configurations of CA_n8-n20, CA_n8-n28, CA_n20-n28
        - ~~DC_n8-n20-n28 with uplink configuraitons of DC_8_n28, DC_20_n28, DC_28_n8~~
        - CA_n5-n8-n28 with uplink configurations of CA_n5-n8, CA_n5-n28, CA_n8-n28
      - The following aspects need be studied
        - UE architecture including n-plexing, PA
        - Wideband antenna
        - Performance due to impacts including inter-modulation products
        - Method to manage the inter-modulation product impacts
      - ~~Focus on p~~Power class 3 (PC3) is considered in this study.
    - Identify and specify necessary RAN4 requirements including Tx and Rx RF requirements (RAN4)
  - SI or WI
    - SI

# 4 Non-spectrum related topics: RF centric

## 4.1 FR1 requirements evolution

### 4.1.1 Initial round

#### 4.1.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***UE FR1 requirement focus evolution, with the following example areas:***

- *Enable > 2Tx on a single band including 4Tx for [FWA/CPE] (FFS framework and architecture) and/or [3Tx] (controversial for 3Tx)*
- *Enable >4Rx (including 8Rx, [6Rx]) for FWA/CPE on higher frequency bands (e.g., > 2.3GHz NR TDD bands) (non-controversial)*
- *Enhance UL CA RF requirements (e.g., PC1.5 with necessary investigation on scheduling restriction, [specify RF requirements for inter-band UL CA with UL-MIMO on one band])*
- *Investigate and improve MSD for inter-band CA/EN-DC combinations*
- *Investigate and improve UE performance with small A-MPR*
- *NOTE: further prioritization for above items are needed in future meeting.*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- UE FR1 requirements evolution
  - Potential justifications:
    - Enable support of > 2Tx to improve uplink throughput
    - Enable support of > 4Rx to improve downlink throughput. NR already has support for 8Rx but RAN4 requirements (RF and demod) are not yet defined.
    - For 3Tx, see RP-211814
    - [TBD for others, please comment]
  - Potential objectives:
    - Enable > 2Tx on a single band including 4Tx for FWA/CPE (FFS framework and architecture) and/or [3Tx] (RAN4, RAN1 for 3Tx)
    - Investigate framework and architecture
    - Enable >4Rx (including 8Rx, [6Rx]) for FWA/CPE on higher frequency bands (e.g., > 2.3GHz NR TDD bands) (RAN4)
      - FFS whether 6Rx can support smartphone
    - Enhance UL CA RF requirements (RAN4)
      - PC1.5 with necessary investigation on scheduling restriction
      - [Specify necessary RF requirements for inter-band UL CA with UL-MIMO on one band]
    - Investigate and improve MSD for inter-band CA/EN-DC combinations (RAN4)
    - Investigate and improve UE performance with small A-MPR (RAN4)
  - Additional objectives which seem controversial and need more discussions:
    - Support of 3Tx (refer to RP-211814)
      - Power enhancement with 3Tx
      - MIMO enhancement with 3Tx
      - 3CC or 3 bands Tx simultaneously
      - Tx switching transmission enhancement
      - New low power class for Uu and/or sidelinek (e.g., 14dBm device in NR-U 6GHz) (see RP-211776)

- Leading working group:
  - RAN4
- SI or WI:
  - WI with study phase

**Comments and suggestions:**

Companies are invited to provide the general comments on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether the secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 13:**

**1 – China Telecommunications**

We support the further enhancement for FR1 RF area in Rel-18.

We are interested in the following proposals:

l Enable 4Tx on a single band for FWA/CPE

l Enable 8Rx for FWA/CPE

l Support of 3Tx with the

l Tx switching transmission enhancement, i.e., 0 us switching time

For inter-band UL CA with UL-MIMO on one band:

We'd also like to clarify is it for UE capable of 3Tx? With Rel-16/17 Tx switching for 2Tx UE, inter-band UL CA with UL-MIMO on one or two band have already been supported, and the UL CA and MIMO are not supported/scheduled at the same time. Then if the proposal is for 3Tx UE, not sure whether the existing per band requirements can be directly applied. We are interested in this feature, and just to ask for clarification on the target UE architecture and what are the potential UE requirements?

For lower power class, we have concern on the impact to network coverage/performance if it is considered for cellular bands.

**2 – TELECOM ITALIA S.p.A.**

In general agree with the moderator's proposal.

However, most of the objectives are clearly identified and can be specified without study phase. In our view it is not needed to involve RAN1.

Support of 3 Tx is of high interest to improve UL performance in smartphones.

**3 – Guangdong OPPO Mobile Telecom.**

**1. About 3Tx**

The 3Tx was proposed by UE vendor in previous RAN4 and RAN meetings, and the Operator demands also has been shown in paper R4-2113483 where 2UL LTE + 1UL NR was proposed in RAN4 meeting. Introducing 3Tx for smartphone is needed to further enhance UL performance.

And with 3Tx introduced, power capabilities, MIMO capabilities, 3bands concurrent transmission, and the 0us Tx switching are all potential enhancement aspects that can be considered in Rel-18.

In last RAN discussion, there is comment saying that "*from UE product development perspective, less Tx chain is preferred to achieve the same power level*", however, this is not always true because even with same power class, 3Tx can still provide MIMO throughput gain comparing to 2Tx, otherwise, there was no need to introduce PC2 and PC3 2Tx in the spec since they both can be achieved by 1Tx.

l **Power enhancement with 3Tx**

Regarding the power enhancement, especially for band combinations whose max power is shared among band combinations and Tx power for each band is lower than the power in SA mode. LTE NW is deployed before NR, and is according to the full Tx power of power class. Lower Tx power will cause connectivity problems in NW like CC dropping issues. Therefore, in our view, study the power enhancements with 3Tx UE architecture is beneficial for UE in band combinations. And to reduce the workload it can leverage the discussion in Rel-17 WI Power*Limit*CA_DC where approaches of increasing UE power high limit for CA and DC is ongoing.

l **MIMO enhancement with 3Tx**

One aspect is the 3layer MIMO in one band. More than 50% throughput gain can be achieved with 3Tx comparing to current 2Tx UL MIMO in LLS. And 3Tx actually reuses the same antennas as 4Rx, so there is no antenna isolation issue. Therefore, it is deserved to combine discussion with RAN1 and encourage RAN1 to consider whether there is room to introduce 3port codebook to support 3layer MIMO in RAN1 Rel-18.

Besides, 2Tx in one band and 1Tx in the other band can be supported without impact to other group and also no much impact to UE implementation. TxD might be needed for 3Tx UE to achieve same power class in single antenna port and 3layer UL MIMO.

Therefore, study the MIMO enhancements with 3Tx UE architecture, especially 3Tx in EN-DC and inter-band or intra-band non-contiguous CA is beneficial. And encourage to further discuss with RAN1 whether 3layer MIMO related work can be accommodated in RAN1 Rel-18.

l **3cc /3 bands Tx simultaneously**

3bands concurrent transmission scenario has been studied in RAN4 Rel-14 with a TR outcome, however, work item was not introduced due to no operator demands at that time. Now operator demands has been shown in RAN4, and it is time for RAN4 to continue the normative work in Rel-18.

To reduce the complexity, certain example band combinations based on operator request can be used as starting point.

l **Tx switching transmission enhancement**

0us Tx switching can be achieved with 3Tx chain architecture and be applied in some cases like power saving. Therefore, introduce 0us switching time capability in Tx switching transmission feature is straight forward.

**2. About new Low power class for uu/SL**

Generally, we don't think low power class for uu and SL is beneficial for UE and NW.

It is well recognized that UL is the bottle neck for the whole system performance especially Tx power, that's why high power UEs have been proposed in RAN4, no matter SA HPUE, CA HPUE, EN-DC HPUE and even FDD HPUE, etc. And even PC2 is not enough then PC1.5 was defined in RAN4. Merely no case for a UE to always work in a low power mode since it needs to be connected to the NW, and also moving. From coverage and connectivity perspective, we doubt the benefits of this kind of UE for uu and SL.

And from UE implementation perspective, currently the GaAs PAs is the main stream for UEs in the industry. It is mature, high performance, and low cost. We don't think CMOS PA has obvious advantage in costs or efficiencies especially considering the CMOS PA industry is not as mature as GaAs PAs and actually no much PA choices on the market.

Therefore, we don't think it deserves to introduce a new low power class just for the argument of low costs/high efficiency which are not justified. Current GaAs PAs are mature enough for no matter smart phone or wearable devices and has the advantage of high output power capability. Introducing new power class just for the reason of using rare CMOS PA for NR has the risk of further fragment the 5G industry.

**4 – Ericsson France S.A.S**

Ericsson: As discussed in the last e-mail discussion and in RP-212262, we think that support of UL TX switching for UL CA with multiple TAG should be addressed. Our understanding is that this is a RAN4 change and could be addressed as Rel-17 TEI; we will bring a contribution to the November meeting. The technical discussion on whether the change is indeed small and TEI etc. can happen in RAN4 in November. In case it turns out that more discussion is needed than can be handled in Rel-17, then we think the issue should be considered for Rel-18 (our understanding is that it is a simple Rel-17 change, but we welcome additional expert feedback) . Hence, we propose to add the following under "Enhance Ul CA RF Requirements" (RAN4) as a sub-bullet:

· [Enable multiple TAG for TX switching (if not addressed already in Rel-17)]

We think it should be on the radar when making Rel-18 considerations; after November it will be more clear if it needs to be or not.

Regarding the other objectives on increasing TX/RX, we are generally supportive, although the overall workload becomes high. For 3TX, to keep to a reasonable scope we think the scope should focus on TX switching enhancement for Rel-18 so that as a first step existing switching scenarios are all covered using 3TX.

**5 – Telia Company AB**

We are supportive in general of the moderator's proposals. 3Tx UL for handhelds should be investigated as part Release 18.

**6 – Beijing Xiaomi Mobile Software**

Generally we are open to discuss these proposals in R18. However, some of them such as MSD improvement, A-MPR improvement , 3Tx for some cases, are better to have a study phase. For the objective of MSD improvement, how to treat UEs with high MSD dynamically by considering actual Tx power range and RB allocation can be also studied.

**7 – T-Mobile USA Inc.**

We agree with Ericsson that support of UL TX switching for UL CA with multiple TAG should be addressed, if not in Rel-17 then in Rel-18.

**8 – MediaTek Inc.**

The current package is very big. Down-scoping is definitely needed.

- UL TX switching for UL CA with multiple TAG: We need to guarantee the UL transmissions of 2 TAGs will not overlapped in time.
- >2Tx: RAN4 can start from Tx switching or single band case. For other cases, they can start later or start from a study first.
- >4Rx: supportive

- low MSD: The discussion could be very lengthy. Need a clear guidance from Plenary on what are the particular band combos to be considered. BTW, this may also depend on the on-going RAN4 discussion.

**9 – LG Electronics Deutschland**

**For additional objectives**, we think simultaneous Rx/Tx for intra-band NC CA (REF: RP-211776) should be added to the additional objectives list since this was categorized as controversial meaning further discussion is needed especially on the self-interference and deployment aspect to address concerns raised by other companies.

In our initial analysis for self-interference from Tx to Rx, about 11dB Desense is expected with 150MHz TRX frequency gap and this can be reduced to about 3dB if TRX separation is larger. And MPR/A-MPR along with RB restriction can further reduce the MSD to a reasonable level. We will submit our initial analysis on this topic in the coming RAN4#101e meeting. With this, we ask "Simultaneous Rx/Tx for intra-band NC CA" to be added in the additional objectives.

**For 3Tx Chain UE**, it is not easy to increase the number of UL RF chains, unlike DL. The main issues are power consumption and heating problem and real form factor limitation. RAN4 needs to consider the feasibility of 3Tx depending on the supported bands. In our opinion, 3Tx per 2bands (e.g. 1Tx/low band, 2Tx/high band) should be specified first and 3Tx per 1band (e.g. 3Tx/high band) later. We don't think it is necessary to specify 3Tx per 3bands since this will raise many issues like self-interference and increased implementation complexity.

**10 – LG Uplus**

For low power class for Uu (14dBm),

As you may know, there is the regulation for 6GHz NR-U in South Korea. The maximum transmission power in outdoors is 14dBm and we are not able to use 6GHz NR-U so far due to power class. Therefore, we need to consider low power class in Rel-18.

For simultaneous Tx/Rx capability in TDD intra-band,

We are interested in this item. There will be an auction in South Korea in 2023(TBD), including 3.7 4GHz. Then, we will have two non-contiguous carriers in n79. If this simultaneous Tx/Rx capability is standardized, we can use different TDD configuration for the carriers and it will be very helpful for the various 5G services. So we hope we can study the feasibility in Rel-18.

**11 – SoftBank Corp.**

Thanks everyone for the constructive discussion. Just to iterate our view, 8Rx is very important to us, we appreciate that this scope is included it the potential WI.

We are also interested in 3Tx, and we support the inclusion of this scope.

**12 – KDDI Corporation**

We are basically supportive in general of the moderator's proposals.

**13 – SoftBank Corp.**

Additional comment to our (SoftBank) previous comment:

We also support the proposal by Ericsson: addition of ”Enable multiple TAG for TX switching”. This functionality will be useful for our deployment plan.

**14 – NTT DOCOMO INC.**

We are generally supportive of moderator’s proposal. Above all, we are interested in following three topics:

- 3Tx for UL performance improvement
- 8Rx (and 6Rx for smartphone) for DL performance improvement
- Multiple TAG for TX switching for flexible deployment

**15 – SK Telecom**

We also support that 3Tx UL for handhelds should be investigated as part of Release 18. As an operator, we would like to make the best use of available RF bands. As for complexity of UEs, we hope we can at least evaluate the actual cost and gain with specific bands combinations.

**16 – SK Telecom**

As for the comment from LG Electronics on ”simultaneous Rx/Tx for intra-band NC CA (REF: RP-211776)”, we think this may worth of investigation, since we are genuinely interested in UL enhancements as an operator, and the proposed work/study may bring some of interesting result for other Ul enhancements topic as well.

**17 – China Mobile Com. Corporation**

From CMCC perspective, we are interested in the following topics. Some of our comments are provided here:

a) 4Tx for FWA/CPE

b) 3Tx for smart phone including:

i. 0us Tx switching transmission enhancement

ii. 3CC/3 bands Tx simultaneously

c) 8Rx for FWA/CPE,

i. For 6Rx proposal, we support if 6Rx can support smartphone, for FWA/CPE, prefer to go with 8Rx directly.

ii. For the frequency bands, we propose to also include TDD bands n34, n39, n40 (TDD bands >1.9GHz)

d) Enhance UL CA RF requirements

e) Improve MSD

f) Small A-MPR

**18 – Nokia Japan**

**[WI handling]**

Topics like FR1 4Tx, FR1 8Rx and maybe some others may have significant impact on other areas like RRM, BS demod and/or UE demodulation. These topics should be treated in specific WIs to make our future work more well-organized and visible (in the WIDs as well). If one single WI includes all of them, in the end, e-mail thread is divided into several threads, the objectives and responsibility for each of the topics would become blur so that actual required TU numbers are rounded and look smaller than necessary. This must be avoided.

**[Topics should be included for Rel-18]**

· A dedicated WI for Enable 4Tx for single band with single CC for FWA usage.

o An example band is nX(X must be chosen before the WI is approved)

· A dedicated WI for 8Rx for single band with single CC band for FWA usage.

o The requriements are targeted at TDD bands whos frequency is higher than X GHz(X must be chosen before the WI is approved)

· A dedicated WI for Low MSD for inter-band CA/EN-DC combinations

· A WI for FR1 UE RF enhancement

o Investigate and improve UE performance with small A-MPR (RAN4)

o [UL CA enhancement] decision must be made after clarification is made.

**[Comments on some topics]**

· **Enable support of > 2Tx to improve uplink throughput**

· **Comment:** We support the topic. However, followings should be addressed. First, we should focus on 4Tx for CPE only(We are not sure why we put both FWA and CPE. CPE is for FWA usage). And we need clarification on what framework means here. We don't agree with the inclusion of 3Tx. This makes situation more complicated. And this should have dedicated WI. We need to carefully handle the impact on BS demod and the workload should be clearly visible. Finally, an example band should be captured in the WID. Hence our alternative is the below. The deitail objective should be further discussed as a dedicated WI.

o Enable 4Tx for single band with single CC for FWA usage. An example band is nX(X must be chosen before the WI is approved)

· **Enable support of > 4Rx to improve downlink throughput**

**Comment:** we support this topic but followings should be addressed. We should focus on only 8Rx for CPE only. A range of bands should be clarified without "e.g.,". And this also should have dedicated WI. We need to carefully handle the impact on UE demod/ RRM and the workload should be clearly visible. Hence our alternative is the below. The deitail objective should be further discussed as a dedicated WI.

o Enable 8Rx for single band with single CC band for FWA usage. The requriements are targeted at TDD bands whose frequency is higher than X GHz(X must be chosen before the WI is approved)

· **3Tx from RP-211814**

**Comment:** We are afraid that we cannot support this. The details are as follows.

**Regarding power enhancement with 3Tx**, we understand the imbalance between UL and DL, considering the current RAN4 situation, even simple 1band with 3Tx will require huge amount of work. Even now four architectures are discussed and some of them have specific issues and progress is quite slow. 1band with 3Tx will require more work, for instance, evaluation of MPR. Now when it comes to 3bands with 3Tx, so many IMDs can be seen and even total power is increased if duty cycle is limited due to SAR issue,

resource in terms of time is limited and furthermore DL quality may be degraded due to harmonics, IMD, cross band isolation and/or harmonic mixing.

**Regarding MIMO enhancement with 3Tx**, this requires RAN1 work and the reasons mentioned next, we cannot support this. RAN1 TU allocation would be at full. All the RAN4 work is multiplied because we need to specify requirements for 3Tx. And then, 3Tx with CA, EN-DC, NR DC etc. RAN4 has been struggling from specifying even 2Tx.

**Regarding 3CC or 3 bands Tx simultaneously**, the concern is mentioned in power enhancement with 3Tx in terms of 3 bands with 3Tx.

**Regarding Tx switching transmission enhancement**, we have not seen the reason to discuss this topic. If overheating is a problem, reduction of the number of active carriers and/or layers and/or BW would be needed. And we have already solutions for this with reducedCCsDL/UL, reducedMIMO-LayersFR1/FR2-DL(UL) and reducedMaxBW-FR1/FR2-DL(UL).

- **Enhance UL CA RF requirements**

Comment: More clarification is needed. What does ”with necessary investigation on scheduling restriction” assume more specifically? Duty cycle? Is this only for inter band UL CA and 26 dBm + 26 dBm, where one band is UL MIMO so that 3Tx is assumed at an instant? Which band configuration is assumed?

**19 – ZTE Wistron Telecom AB**

(1) ”PC1.5 with necessary investigation on scheduling restriction”:

It looks a bit confusing. Could proponents clarify its exact meaning?

(2)”[Specify necessary RF requirements for inter-band UL CA with UL-MIMO on one band]”:

This is already done in Rel-17, what more is expected in Rel-18?

(3) MSD and A-MPR improvement:

We are supportive on this objective.

(4) 3Tx:

- MIMO enhancement with 3Tx:
  In addition to RAN4 TUs, this may also burn RAN1 and RAN2 TUs.
- Power enhancement with 3Tx and 3CC or 3 bands Tx simultaneously:
  For 3 simultaneous Tx for 3 bands, we don’t think there is enough RAN4 TUs accommodating this work and we can go that far.
- Tx switching transmission enhancement:
  More inputs would be appreciated on the potential benefits of introducing 0us Tx switching time against the increased costs, e.g., power consumption and complexity etc.

**20 – QUALCOMM JAPAN LLC.**

Regarding the proposed objectives, we would like some clarifications on the following:

- what is meant by scheduling restrictions for PC 1.5 with UL CA?

- what are the power and MIMO enhancements for 3Tx?

For the small A-MPR improvements, what exactly is the target?

For the MSD and A-MPR improvements, the objectives should be re-worded to something like : investigate and introduced/define lower MSD(or A-MPR) for ...

We are generally fine with the other objectives with the understanding that priorities (what to approve or not) will be discussed separately.

**21 – Samsung Electronics Co.**

We are open to have enhancement on FR1 RF side with reasonable scope focused on urgent market demand cases and critical cases.

We are more supportive on the proposals related to enhancement on CPE/FWA.

For "> 4Rx", this is not purely RF item, performance requirements (demodulation and CSI) also need to be considered.

**22 – Intel Corporation (UK) Ltd**

- We agree with companies that further prioritization of the candidate objectives is required and scope shall be limited
- **>4Rx**
  - We prefer to consider both 6Rx and 8Rx implementations to provide more flexibility for UE implementation. In addition, the work scope shall be limited to UE RF and demodulation requirements, while the existing RRM requirements assumptions can be reused.
  - Detailed objectives:
    - *Define requirements for UEs equipped with 6 and 8 receive antennas for FWA/CPE devices for FR1*
      - *Define UE RF requirements*
      - *Define UE demodulation and CSI reporting performance requirements*
      - *Note No impact on RRM requirements.*
- **> 2Tx on a single band**
  - We are ok with the objective. Overall, the support of larger number of TX chain can be helpful to improve UL performance, but feasibility and use case can be quite limited. To limit the scope we suggest to make a down-selection between 3TX and 4TX use cases. From implementation perspective 3TX can be a more reasonable goal for non-FWA/CPE use cases. In case 4TX is agreed, the work shall focus on FWA/CPE use cases
- **Improved MSD for inter-band CA/EN-DC combinations**
  - We agree that possible improvements are important to improve network performance and have a strong market interest. We prefer to consider a generic approach to improve MSD performance based on UE indication of support of improved MSD capabilities without aiming to optimize/revise the performance for different CA/DC combinations
- **Improved UE performance with small A-MPR**
  - We agree that AMPR improvement is beneficial to improve UL performance. Does the proposal consider band-specific improvements or some general framework? Overall certain UEs may have better A-MPR performance and the respective information can be exploited at the network side to improve scheduling decisions. Meantime, we don't think that RAN4 needs to revisit all AMPR value but rather exploit performance benefits for UEs outperforming the minimum requirements.
- **Enhanced UL CA RF requirements**

- In the previous discussion multiple proposals were considered including HPUE, e.g., PC1.5 for UL CA, and RF requirements for inter-band UL CA with UL-MIMO on one band. HPUE enhancements are currently considered as a part of a new Rel-17 WI on Increasing UE power high limit for CA and DC (RP-212622) and additional enhancement can be discussed subject to the progress for that WI.

- **New low power class**
  - We do not see a strong justification to introduce additional low power classes for Uu and/or sidelink operation. During September email discussion support of 14dBm PC for NR-U 6GHz band for VLP mode in South Korea was proposed. In our view the existing power classes can be potentially used to address the use case instead of introducing additional device fragmentation. The discussion on the respective topic can continue as a part of the Rel-17 NR*6GH*unlic_full work item.

**23 – China Unicom**

*We support to have further evolution for FR1 RF requirements, specifically we are interested in the following topics:*

*1. 3Tx for smart phones: relevant power enhancements, MIMO enhancements, and simultaneous 3cc Tx transmissions could be achieved to improve UL performance.*

*2. 4Tx and 8Rx for FWA/CPE performance improvements.*

**24 – Intel Corporation (UK) Ltd**

**Work stage for Rel-17 study items (Irregular BW and pi/2 BPSK)**

Rel-17 study items on irregular CBW and pi/2 BPSK power optimizations are ongoing in Rel-17 timeframe and work continuation should be planned for Rel-18 subject to SI conclusions. The respective scope can be considered as a part of FR1 UE RF requirements evolution and prioritization these objectives is required along with the remaining objectives.

**25 – Sony Group Corporation**

In general, we are supportive of the objectives of Tx/ Rx enhancement for CPE/FWA devices.

Regarding the MSD improvement, we think the study phase might be needed, and its scope will also depend on the Rel-17 RAN4 discussion and the scope of other Rel-18 WI proposals.

For the lower power class for Uu/SL, we think it should be avoided unless this is the only solution to address the regulatory limitation.

**26 – vivo Communication Technology**

Regarding Enable > 2Tx on a single band, we are OK to study 3Tx architecture for FWA/CPE to resolve new challenges introduced by 3Tx in RAN4.

However, for 3Tx smartphone, we share similar views with Nokia, we also have strong concerns on adding 3Tx for smartphone in Rel-18 scope. Our views have been presented in RP-212118.

**27 – Huawei Technologies France**

We support to have further enhancements of UE RF FR1 in Rel-18.

We are interested in the following topics. We think >2Tx, 8Rx, and inter-band UL CA with UL MIMO on one band would be very helpful to boost the UL/DL throughput to industry use cases.

- >2Tx on a single band for FWA/CPE
- Inter-band UL CA with UL MIMO on one band at least for FWA/CPE
- 8Rx on higher frequency bands for FWA/CPE with four layers
- MSD improvement for band combinations, if the issues are not fully identified in Rel-17, a study stage in Rel-18 should be considered

**28 – VODAFONE Group Plc**

We support to have further enhancements of UE RF FR1 in Rel-18.

In priority order, we support work on:

- Enable 2/3 Tx for smartphone
- Enhance UL CA RF requirements
- Investigate and improve MSD for inter-band CA/EN-DC combinations
- Enable >4Rx (including smartphone form factor for 3.5 GHz & 6 GHz)
- Investigate and improve UE performance with small A-MPR

**29 – AT&T GNS Belgium SPRL**

We support the moderator proposal for the UE FR1 requirements evolution. In addition, we agree with Ericsson that support of UL TX switching for UL CA with multiple TAG should be addressed in Rel-18 if it is not addressed in Rel-17.

**30 – Apple AB**

1. On >2Tx proposal, since it is aimed to improve UL throughput, what's the assumption of # Rx at BS, e.g. 4Rx?
2. On >4Rx proposal, we need to understand the feasibility (e.g. channel correlation assumption, operating SNR) to enable more than 4 MIMO layers with up to 256QAM.
3. On 3Tx proposal, it is questionable if existing RAN1 design, e.g. codebook, can support 3Tx. Also, with limited form factor, how much MIMO performance improvement compared with 2Tx should be understood first.

**31 – Verizon UK Ltd**

We are generally fine with the objectives with the understanding that some clarifications (e.g., PC1.5, MSD, A-MPR) are needed for the potential objectives. We are supportive on the related enhancement on CPE/FWA. And, we believe the UL CA with multiple TAG should be addressed in rel-18.

#### 4.1.1.2 Summary for initial round

Many comments were received. Moderator provided the summary for each working area.

**Enable 4Tx on a single band**

Companies seemed OK with 4Tx on single band for CPE. The comment from Meidatek is that RAN4 can start from Tx switching or single band case. Nokia commented that for 4Tx the BS demodulation should also be considered. Apple commented what the assumption of receiver antenna number at BS.

**Simulatenous 3Tx**

Companies' views on 3Tx are diverse. Many operators including China Telecom, Telecom Italia, Telia, Softbank, NTT DOCOMO, SK Telecom, CMCC, China Unicom, Vodafone showed interest in this working area.

The vendors LGE, Nokia, ZTE, Vivo and Apple commented on the feasibility to do the work to support the simultaneous 3Tx and the impact on RAN1 of supporting 3Tx UL-MIMO. Xiaomi, Mediatek would like to have study first. Ericsson showed the interest on Tx switching enhancements part. LGE would like to consider 3Tx per 2 bands and 3Tx per 1 band cases and dos not favor 3Tx per 3 bands. Qualcomm needed clarification on what the power and MIMO enhancement for 3Tx are. Intel would like to consider 3Tx for non-FWA/CPE use cases, while Vivo would like to consider 3Tx for CPE only.

**Enable 6Rx and 8Rx**

Generally this working area is acceptable to the group. NTT DOCOMO and CMCC proposed 6Rx for smartphone. Nokia and Samsung commented that RRM and demodulation performance requirements should be specified for 6Rx/8Rx. Intel thought that there is no impact of 8Rx on RRM requirements. Apple and Huawei proposed to consider 4-layer and need more thinking about the feasibility to enable more than 4 MIMO layers with up to 256QAM.

**Enhance UL CA RF requirements**

China Telecom quested on the whether simultaneous 3Tx is needed to support inter-band UL CA with UL-MIMO on one band and what requirements should be specified. Nokia commented what does "with necessary investigation on scheduling restriction" mean (is it duty cycle), whether only for inter-band UL CA and 26dBm+26dBm, and what band configuration is assumed. Intel commented that the HPUE enhancements are currently considered as a part of a new Rel-17 WI on increasing UE power high limit for CA and DC and additional enhancement can be discussed subject to the progress for that WI.

**Improve MSD**

Xiaomi, Sony and Huawei commented that study on MSD improvement is needed. Xiaomi commented how to treat UEs with high MSD dynamically by considering actual Tx power range and RB allocation can be studied. Mediatek commented that the objective is subject to on-going discussion in RAN4 and particular band combos needs be decided. Intel commented that they preferred to consider a generic approach to improve MSD performance based on UE indication of support of improved MSD capabilities without aiming to optimize/revise the performance for different CA/DC combinations.

**Improve UE performance with small A-MPR**

Qualcomm questioned what exactly the target for small A-MPR improvements. Intel questioned whether the proposal considered band-specific improvements or some general framework and did not want RAN4 to revisit all the A-MPR values but rather exploit performance benefits for UEs outperforming the minimum requirements.

**New low power class for Uu and/or sidelink**

China Telecom had concern on the impact on the network coverage/performance. Vivo shared the similar view and also questioned the benefits. Nokia commented that they did not see a strong justification and the issue can be addressed by the existing power classes. The discussion on this issue can continue in Rel-17 in NR_6GHz_unlic_full WI. Sony had the comments in the similar direction.

LGU+ responded that there is regulation requirement for 6 GHz NR-U in South Korea. The maximum transmission power in outdoor is 14 dBm.

**Simultaneous Rx/Tx for intra-band NC CA**

LGE proposed to add the objective of simultaneous Rx/Tx for intra-band NC CA. Please refer to RP-211776 for more details. According to the previous September email discussion, more analyses on self-interference were provided in the comments of the initial round. LGU+, SK Telecom supported it.

More discussions are needed in the intermediate round.

**UL Tx switching for UL CA with multiple TAG**

Ericsson proposed to add UL Tx switching for UL CA with multiple TAG. T-Mobile USA, SoftBank, SK Telecom, AT&T, and Verizon supported it.

**Others: irregular channel bandwidth follow-up WI and pi/2 BSPK follow-up WI**

Many thanks for company to propose them. The reason why they are not in this initial summary is that no company proposed it in June workshop and September email discussion. And the corresponding Rel-17 SI-s are still on-going.

The moderator suggested to consider them by December or January email discussion depending on the progress. In this email thread, we do not need to discuss them.

### 4.1.2 Intermediate round

#### 4.1.2.1 Proposals and comments collection

**Objectives which seems stable**

Based on feedback, moderator would like to propose the following bullets for further checking.

- Potential objectives:
  - Enable > 2Tx on a single band for CPE including 4Tx (RAN4)
    - Investigate framework and architecture
    - FFS bands for 4Tx
    - Specify the UE RF requirements to support 4Tx
    - Specify the BS demodulation performance requirements to support 4Tx
  - Enable >4Rx including 8Rx, 6Rx for CPE on higher frequency bands (RAN4)
    - FFS whether 6Rx can support smartphone
    - Consider >2.3 GHz NR TDD bands
    - Specify the UE RF requirements to support 8Rx
    - Investigate whether RRM core requirement and performance requirements need be specified to support 8Rx, and if needed specify the necessary requirements
    - Specify UE demodulation performance and CSI requirements to support 8Rx
      - [Investigate the feasibility to enable 4 MIMO layer]

- 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
  - Specify the necessary requirements and/or capability signaling

Please provide your comments on the moderator proposed objective above. For >2Tx, please proponents answer the question from Apple on the BS receiver antenna number.

**Feedback Form 14:**

**1 – TELECOM ITALIA S.p.A.**

in general we are fine with the moderator's proposal.

Considering the comment from Nokia we suggest n258 to be used when specifying 4Tx in the same band.

However for CPE-type devices (i.e., not limited by power or form factor), it seems to be a strong constraint to limit 4Tx to a single band. It would be very useful to allow >2Tx in different bands

**2 – Skyworks Solutions Inc.**

Regarding, 3UL we believe an SI is needed as there is no MSD study or MPR/A-MPR framework for this case and both MSd or emissions can be subject to tripple beat issue. the applicable power class also needs to be addressed.

for 3Tx, in our view it seems natural that it applies to band where 4Rx is already supported. since 4 antennas are already available we do not see the benefit of 3Tx versus 4Tx which is already part of the R18 topics. In our view the options should be 1/2/4Tx and not 3 as it also then questions which power class would apply. 3x23dBm? = 28dBm which is not a power class that exists.

6Rx is also a question for us since it applies to FWA it would make sense it correspond to doubling the smartphone HW and thus be 8Rx. We are affraid that we are creating many "in between" solutions that are not helping with finding leverage to enable the features.

**3 – AT&T GNS Belgium SPRL**

We are OK with the moderator proposal but suggest to change "CPE" to "FWA/CPE" in all places.

Concerning Telecom Italia comment on proposed band, we don't see n258 as an option given that the topic is FR1 requirements evolution. We would prefer n77 to be the example band.

**4 – China Telecommunications**

For >2Tx, the BS receiver antenna number can be different for different frequency bands. For example, UL 4Rx in n1, and UL >8Rx in n78 for marco BSs.

For >4Rx, could we have some feedback on whether 6Rx is for smartphone or CPE? In addition, for the demod part, maybe it should be "Investigate the feasiblity to enable > 4 MIMO layer"?

**5 – QUALCOMM JAPAN LLC.**

For 6Rx/8Rx:

We support having the objective on 6Rx for smartphones, 8Rx for such form factors would be very difficult. In the end, we might not have any device type specific differentiation in the requirements. There could be different performance requirements(e.g. different channel models used for 6Rx or 8Rx).

Based on the LTE work on 8Rx and the NR/LTE work on 4Rx, the only impact to RRM would be to modify the RLM tests to allow UEs using all the receivers to pass the tests. There is no need for any other objectives so that part should be revised.

For low MSD:

The objectives could be further refined after the next plenary when we will have a bit more clarity on where the current RAN4 discussion is heading to.

**6 – vivo Communication Technology**

We think it is better to study >4Rx for CPE first, and then maybe for smartphone form factor at a later stage. So, we suggest to remove the bullet "FFS whether 6Rx can support smartphone".

For lower MSD, considering it is still quite diverged on the basic, many feasibilities are still not confirmed, and it is no clear on what kind of requirements are suitable. It was proposed to do some study first, and an SI is natural choice. Based on this consideration, it is proposed to revise the following bullet:

"Specify the necessary requirements and/or capability signaling" to "Study tentative requirements and/or capability signaling"

**7 – Apple AB**

1. On >2Tx, we still think, as mentioned in the initial round, the Rx antenna configuration at BS should be at least 4. Otherwise, the enhancement is limited. We are OK with China Telecom's comments that the exact number of Rx can be band-dependent.

2. We are OK with 6/8Rx for CPE. As pointed by others, study is needed to understand the feasibility to extend 6Rx or even 8Rx to handheld UE. The feasibility study should include the performance gain as well as power and form factor impacts.

**8 – SoftBank Corp.**

We are fine with the moderator's proposal.

**9 – China Mobile Com. Corporation**

For 4Tx: In addition to n41, n77, n78, n79, we propose to add TDD bands n34, n39 n40.

For >4Rx,: we support 6Rx for smartphone, and 8Rx for CPE. In only CPE is supported for >4Rx, we prefer to go with 8Rx directly. For the BS receiver number, for TDD bands, the BS receiver can be larger than 8.

**10 – LG Electronics Deutschland**

We support the proposal in general.

On **Investigate and introduce [lower MSD] for inter-band CA/EN-DC combinations (RAN4),** we would like to know what is the target Power Class for lower MSD, i.e PC2 or PC3 or both. Our preference is to have PC2 as a target power class. And we also would like to know if this objective would have a study phase in WI or not.

**11 – NTT DOCOMO INC.**

Thank you for summarizing the initial round discussion and we are fine with moderator's proposal.

**12 – Samsung Electronics Co.**

For CPE RF requirements enhancement, we think the current wording of objectives will result in too wide scope. From the discussion, it is also observed that companies are actually interesting in specifying the 4Tx (for <2Tx), 8Rx/6Rx (for >4Rx). If above is correct common understanding, we suggest to revise the objectives explicitly includes the number of Rx/Tx chains instead of range of number of Rx/Tx chains.

**13 – Sony Group Corporation**

In general, we are fine with the proposal with the moderator.

In particular, we support to have a study phase for MSD and aims to create a general solution. Meanwhile, we also notice that MSD is also under discussion in Rel-18 IDC [RAN94e-R18Prep-17]. Therefore, it is possible to include those MSD related content under IDC WI for Rel-18.

**14 – Intel Corporation (UK) Ltd**

- **Enable > 2Tx on a single band for CPE including 4Tx**
  - We would like to check whether the objective precludes 3Tx operation or not. In case we focus on 4Tx, then the general objective shall be adjusted as "Enable 4Tx on a single band for CPE type of devices
- **Enable >4Rx including 8Rx, 6Rx for CPE on higher frequency bands**
  - We are overall fine with moderator's proposal and think the scope shall include both 6RX and 8RX cases to allow sufficient implementation flexibility for different device form factors.
  - RF requirements: objective needs to cover both 6Rx and 8Rx
  - RRM requirements: LTE 8RX requirements do not have impact on RRM. We would like to understand the motivation to define new RRM requirements and would ask proponents to clarify which exactly requirements need to be improved. We are ok to include RLM as mentioned by Qualcomm
  - Number of MIMO layers: existing UE capabilities framework provides a high level of flexibility to allow UE not to support 256QAM x 4 MIMO layers if there are implementation constraints. We prefer not to limit UE implementation. Same time we are open to discuss whether 8 layers are in the scope. Based on LTE 8Rx analysis we think that 8 layers support in the field is not practical.
- **Low MSD**
  - We do not think that MSD performance improvement needs to be assessed for example band combinations and the main goal shall be to introduce a generic approach to allow UE to indicate improved capabilities. We are also ok to wait for RAN4 to further converge Rel-17 discussions.

**15 – MediaTek Inc.**

- >4Rx: Need to start from CPE. Whether to work on smart phone can be FFS for 6Rx. (8Rx probably too challenging)
- Low MSD: we believe that the approach is always from some example BCs. and then see if there is a chance to conclude a general rule.

**16 – Nokia Japan**

Regarding ”**Enable > 2Tx on a single band for CPE including 4Tx (RAN4)**”,

We still have concern on not to make sure that this is for only 4Tx since if 3Tx is included, then, later this may require the discussion on 3 layers and TxD with 3Tx and that will even increase the amount of RAN4 work surely. We need to make our work reasonable level while we need to meet market demand. Hence, we don’t agree with the current objective. Alternative is as follows and the detail can be further discussed in the next RAN.

○ 4Tx on a single band for CPE not including 3Tx (RAN4)

Regarding ”**Enable >4Rx including 8Rx, 6Rx for CPE on higher frequency bands (RAN4)**”,

We believe we should delete ”FFS whether 6Rx can support smartphone” and finish 8Rx for CPE as soon as possible as well as 4Tx for CPE. Next, we can address SRS related requirements after that. With this, almost all the generic work can be completed. Then, we can address 6Rx for smartphone with a new WI later. A way to make everything all in one package does not work in terms of efficiency.

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

We have provided more specific objectives and their justifications in R4-2117035 and R4-2117036 in RAN4#101-e

Finally we believe that the above listed topics should be discussed in the respective dedicated WIs.

**17 – Huawei Technologies France**

In general, we are fine with the the proposals.

**Simulatenous 3Tx**

Please answer the questions from companies as summarized in Section 4.1.1.2.

Based on the feedback, moderator would like to suggest discussing the potential objective bullets:

- Investigate and specify the requirements to support simultaneous 3Tx considering the following use cases
  - Use case #1: 3Tx on single uplink band for power enhancement and MIMO enhancement (RAN4, RAN1)
  - Use case #2: 3Tx on two uplink bands (1Tx on one band and 2Tx on the other band) for power enhancement and Tx switching transmission enhancement (RAN4)
  - Use case #3: 3Tx on three uplink bands for power enhancement (RAN4)

Moderator suggested to further feed back which use case can be taken for Rel-18.

**Feedback Form 15:**

**1 – Guangdong OPPO Mobile Telecom.**

For the use case#2 (1T+2T), from the feedback, at least there seems no strong concern which can be achieved with no big efforts.

For the use case#3 (1T+1T+1T), it seems the concern is on the complexity of IMDs/harmonics that can cause interferences, to solve the concern, maybe it can start with band combinations that doesn't have complex IMD/harmonic interferences since not all band combinations have complex interferences. Actually for these band combinations, no much efforts to solve interference comparing to today's two band combinations.

For the use case#1 (3T), it relys on whether RAN1 can introduce the 3port codebook to make it be used in the field, if not be supported in Rel-18 maybe RAN4 can consider it as a study part or postpone it.

Therefore, in our view, at least case#2 and case#3 with do not rely on RAN1 can be included in RAN4 Rel-18, and further discuss with RAN1 on case#1.

**2 – TELECOM ITALIA S.p.A.**

Support Oppo's statement.

Moreover, it would be interesting to extend the activity to CPE-type devices (i.e., not limited by power or form factor), since it is not clear if there is any activity planned for more than 2Tx in different bands for CPEs. It seems to be a strong constraint to limit 4Tx to a single band for CPEs. It would be very useful to allow >2Tx in different bands

**3 – Skyworks Solutions Inc.**

In our view we should be clear about terminology:

XUL means simultaneous UL in X bands

XTx means UL on X antennas in one band.

so in out view 1UL/1Tx in one band + 1UL/2Tx in another band is already part of the R17 framework (for PC3 or PC2 inter-band combinations) and does no require new generic requirement. in fact 1UL/2Tx bandX + 1UL/2Tx in bandY can also be supported by the R17 framework

3UL (UL in 3 different bands) requires a completelly new MSD and MPR/A-MPR and power class framework. a study is needed first

3Tx as already discussed appears to us as an "in between" solution compared to 2Tx or 4Tx and will create another lengthy power class and TxD/UL MIMO definition. already for 2Tx the number of companies able to provide technical input to MPR is limited.

**4 – Skyworks Solutions Inc.**

For 3UL case at least, if agreed, at least some restriction on simultaneous Tx/Rx or band of operation would help to narrow the scope to something that is managable in a study for the triple beat issues

**5 – China Telecommunications**

We can consider use case 2 with two bands as the starting point, which seems an easier case compared to the other two cases.

**6 – vivo Communication Technology**

Thanks for the good summary from Chair. We also think it is a good approach to discuss the UE feature needed or not separately, but not only for the general architecture. Our views on each Use case is summarized:

For Use case#1: This should be discussed with two directions:

[1] Case#1 a: MIMO case. we believe it's a quite simple and aligned understanding that 3Tx MIMO codebook is RAN1 scope, so we think whether development of 3 Tx MIMO codebook or not should be discussed in [RAN94e-R18Prep-01] MIMO Evolution for Downlink and Uplink. RAN4 should not take more efforts on discussing this aspect. We suggest discussions to be started in RAN1.

[2] Case#1b, power enhancement case. as we discussed before, if we JUST want to achieve "higher power", we really doubt 3Tx can provide enough benefits, the discussion can be separated into three sub-directions:

- Case#1b-a: Target power lower than PC1.5, i.e. 23dBm or 26dBm for single band. Current 1Tx and 2Tx is sufficient to achieve this power level, we do not see the benefits to adopt 3Tx to achieve, 23dBm or 26dBm for a smartphone;
- Case#1b-b: If the motivation is to achieve equal or higher power than PC1.5, i.e. >29dBm for smartphone, at least currently, we do not believe this is urgent market demand cases. Even for PC 1.5, if operator has interests for this power class smartphone, we think 2Tx architecture is the best solution.
- Case#1b-c: Then the question is that, is the main intension to define a new power class between PC2 and PC1.5 for smartphone, based on 3Tx? If so, current 2Tx diversity can support it.

Overall, for both Case#1a and Case#1b, we do not see the 3Tx is necessary at this stage.

For Use case#2: This should also be discussed by two aspects:

[1] Case#2 a: CA+MIMO with Tx switching enhancement. To support 0 us switching transmission enhancement, we are supportive to this study in Rel-18. The UE working with 2TX maximum simultaneously with 0 us switching is supported.

[2] Case#2b: CA+MIMO with 3Tx transmission simultaneously. If the intension is to increase the power, then we think increasing UE power high limit for CA and DC is ongoing in the new WI PowerLimitCA_DC. we need to wait for the outcome of this WI to see how far we can go, and then consider further enhancement.

Overall, for Case#2a, we think RAN4 can start this work in Rel-18.

For Use case#3: Three bands transmission simultaneously.

Even for 2bands discussion, there are several architectures are discussed, and the progress is not positive with specific issues raised by specific architecture. As we can see, significant issues such as complicated interference scenarios will be raised if 3 bands Tx is adopted. From UE vendor perspective, the main issues are power consumption, self-interference, heating problem and form factor limitation. Due to the implementation challenges, we really doubt the gain got from high cost and complexity. Last but not least, we do not think this is urgent market demand case.

**To summarize, we can support CA+MIMO for Tx switching enhancement to support 0 us switching transmission. (Case#2a)**

**7 – China Mobile Com. Corporation**

For case#1, whether 3Tx codebook can be supported depends on the MIMO discussion. We suggest considering case#1 later depends on RAN1 conclusion. Case#2 can be considered as the starting point. For case#2, if Tx switching is applied between 1Tx on one band and 2Tx on other band, there will be no switching time and interruption. We are wondering what is the impact on RAN4 requirements for Tx switching in case#2.

**8 – LG Electronics Deutschland**

We think Case #1 & Case #2 can be treated in WI objectives as a phased approach i.e. Case #2 first and Case#1 second. We think Case 3 needs a study phase on the feasibility in Rel-18 or in Rel-19.

**9 – NTT DOCOMO INC.**

We agree with Oppo's statement. Use case #2 can be the easiest way to apply 3Tx and can be the starting point.

**10 – Ericsson France S.A.S**

In our view, case 2 (3 TX in 2 bands) and TX switching should be a starting point

**11 – ZTE Corporation**

Regarding Case 1 MIMO case, there would be lots of RAN1 impacts, it's better to be discussed in RAN1 MIMO scope. For CA+MIMO with 3Tx transmission, this could wait for the conclusion of Rel-17 discussion.

**12 – Nokia Japan**

Objectives are still quite blur while it is clear that the proposals require huge RAN4 TUs. In addition, it is quite unfortunate if we write something superficially good like just 3Tx in a WID while once the WI starts, we just discuss how to relax RF requirements. The price we have to pay should be shared in advance.

Regarding "**Use case #1: 3Tx on single uplink band for power enhancement and MIMO enhancement (RAN4,**

**RAN1)**", we don't think we need to do something similar in the same release. It would be good to focus on 4Tx for CPE in Rel-18.

Regarding "**Use case #2: 3Tx on two uplink bands (1Tx on one band and 2Tx on the other band) for power**

**enhancement and Tx switching transmission enhancement (RAN4)**" , if one proposal among the three was selected, this would be the one. But still Tx switching transmission enhancement shall be clarified more.

Regarding "**Use case #3: 3Tx on three uplink bands for power enhancement (RAN4)**", this one requires more clarification including the cost(relaxation) we need to pay for. The required work may be totally different according to which duplex are included in the UL bands. FDD+FDD+FDD, FDD+FDD+TDD, FDD+TDD+TDD, TDD+TDD+TDD and individual power classes, which bands are synchronized for TDD combos may require different studies. Just saying 3Tx on three uplink bands for power enhancement is too rough. We understand companies are interested in 3Tx on three uplink bands. At the same time, to achieve this, we really think that realistic objective should be selected and sufficient TUs are required but this means that we need to drop many of the others.

**13 – MediaTek Inc.**

We have concern on 3 bands which will bring a very high work load with unclear benefit.

Case 2 could be a starting point.

Case 1 may need some RAN1 work, which needs to be considered jointly with RAN1 package.

**Enhance UL CA RF requirements**

Please answer the questions from companies as summarized in Section 4.1.1.2. Based on the further feedback, we can discuss the potential objectives.

**Feedback Form 16:**

**1 – Huawei Technologies France**

For inter-band UL CA with UL MIMO on one band, yes, 3Tx is needed. Regarding PC1.5 CA, the methods adopted for SA/MPE can be utilized, no matter it is UE based or network based solution. As for the inter-band CA with MIMO, whether part of the outcome of the Rel-17 new WI can be applicable depends on the progress in Rel-17.

**Improve UE performance with small A-MPR**

Please answer the questions from companies as summarized in Section 4.1.1.2.

Based on the feedback, moderator would like to suggest further discussion on the following potential objectives:

- Investigate and define UE requirements with [smaller] A-MPR (RAN4)
  - FFS on example band combinations
  - Study whether and how to improve A-MPR and whether the general approach can be used

**Feedback Form 17:**

**1 – ZTE Corporation**

we think that A-MPR improvement should be also applied for band

**2 – Nokia Japan**

First, we don't intend to revisit existing A-MPR tables since it requires huge workload.

Secondary, regarding an approach, there are at least two approaches. One is a UE with better linearity and/or filter rejections etc indicates delta from values captured in the exiting A-MPR table. This approach is similar to what we have discussed in Low MSD discussion somehow. This requires the said UE needs to have always better A-MPR value by the indication.

The other approach is that RAN4 has specified A-MPR under the assumption that LO is always at the center of the channel bandwidth. But if some UEs adjust its LO position to the center of e.g., active BWP, the distance that an inter-modulation decreases so that A-MPR can be reduced as briefly discussed in RP-212142 in RAN#93e. So, the UE does not need to always ensure smaller A-MPR. In an extreme case, if

a UE uses 10 MHz Channel bandwidth, where 5MHz active BWP being located at the lower edge of the channel bandwidth, i.e., roughly only the lower 5 MHz can be occupied by RBs if scheduled. And if the UE locates its LO at the center of the BWP, the required A-MPR for this condition can be the same as the A-MPR for the condition that 5MHz channel bandwidth is located at the lower side of the 10 MHz channel bandwidth. So, we don't need to re-evaluate A-MPR but, the UE needs to refer to A-MPR for 5MHz CBW in this case.

Perhaps, we may apply this to FDD reference sensitivity UL configuration improvement as well. More aggressive UL RBs configuration allocation may be possible if network can know if UE can have less impact of the UL on DL thanks to LO position tuning.

In any case, we are open to discuss if there are any approaches or not.

Possible alternative of the objective is (The below is rough so that we can further discuss the details later)

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

○ An example band is [n1]

○ Study how to define smaller A-MPR, e.g.,

· Generic approach meaning that a certain improvement is always applicable to A-MPR for any conditions; and/or

o e.g., if 1 dB improvement is possible, the 1 dB is applies 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 conditions: and/or

o e.g., the conditions are tied with the position of the LO location

o Other ways are not precluded

Note that we are open to discuss which band should be an example band, but the example band should be the one whose A-MPR was intensively discussed in the past.)

**New low power class for Uu and/or sidelink**

Please answer the questions from companies as summarized in Section 4.1.1.2. Based on the further feedback, we can discuss the potential objectives.

**Feedback Form 18:**

**1 – TELECOM ITALIA S.p.A.**

sorry for not having commented on the proposal before. We share the concerns raised by other companies on the need to specify this new class (risk of market fragmentation, impact on coverage and QoE)

**2 – China Mobile Com. Corporation**

If there is power limit for 6GHz band, this can be simply solved by sedning P-MAX to set the maximum output power that UE can transmit. Not sure whether new power class is necessary.

**3 – LG Electronics Deutschland**

Depending on the progress of Rel-17 NR-U, this can be further discussed maybe in December plenary. In South Korea, if not defined in Rel-17, this should be specified in Rel-18 to comply with regional regulation.

**Simultaneous Rx/Tx for intra-band NC CA**

Please provide the feedback on the following potential objective(s). Please take the previous discussion in September email discussions into account.

- Simultaneous Rx/Tx for Intra-band non-contiguous CA/DC in TDD band

**Feedback Form 19:**

**1 – Skyworks Solutions Inc.**

We do not see benefit of such feature which already suffers from high MPR and now will on top suffer from high MSD. or it should be demonstrated if for example it could be a subset of 2Tx/4Rx where 1Tx and 2RX are simultaneous but on different antennas. even this would benefit from good antenna isolation only in the FWA case.

**2 – QUALCOMM JAPAN LLC.**

We do not think this is feasible, as already commented. There is a proposal to have a study of full duplex in Rel.18, those kind of enhancements would probably be better to serve some of the use cases than this.

**3 – Apple AB**

We also doubt the benefit and feasibility.

**4 – LG Electronics Deutschland**

*Regarding the feasibility, as we commented in the initial round, we think it is feasible with reasonable MSD, MPR/A-MPR and frequency separation. Please refer to the Tdoc submitted in the coming RAN4#101e (R4-2118079) for detailed analysis. But we are open to further discuss on this feasibility issue to see other company's analyses. This is one of the reasons why we need a study phase.*

Following is the potential objective.

***Study 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-location/non-colocation 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.***

*This topic has proposed the WI with Study Phase*

Regarding the comment on a study with full-duplex, our understanding is that full-duplex is targeting eNB or IAB with sub-band UL/DL duplexing in a carrier as a first step and may need some additional RF implementation to mitigate self-interference. In this proposal, we are targeting UE, and self-interference between the carriers, and we don't need any additional RF implementation by allowing reasonable MSD with MPR/A-MPR and frequency separation.

**5 – KDDI Corporation**

In general we are fine with the proposed one, but we also fine with adding simultaneous Rx/Tx for intra-band NC CA to improved MSD objectives.

**6 – Ericsson France S.A.S**

As well as achieving a very large isolation within the device, there may also be CLI issues (including inter-operator CLI).

**7 – Intel Corporation (UK) Ltd**

As discussed in September email discussion, feasibility needs to be assessed first. Also, is it correct to assume that the proposal is limited to UE RF only and not applicable for BS (i.e. BS will not have simultaneous Tx/Rx)? Finally, should additional co-existence studies be performed to assess the impacts?

**8 – Nokia Japan**

Our view was captured in RP-212142 in RAN#93e in a way that

**For simultaneous Rx/Tx for Intra-band non-contiguous CA/DC in TDD band, it is not likely that the same isolation assumed for inter band CA/DC inside the same UE is expected so that significant relaxation is expected if RAN4 assumes conventional UE RF architecture assumption. And not only one operator but also the other operators within the same band are subject to interference issues more or less.**

**It is beneficial for the proponents to share the whole picture of deployment scenarios as well as the detailed technical analysis on how the scenario works.**

We think that not only UE RF issues but also deployment issues need to be addressed if we use this feature. And if this is for V2X, that should be clarified and discussed as an independent topic.

**9 – MediaTek Inc.**

The feasibility and benefit are not clear to us.

**10 – LG Electronics Deutschland**

**To Intel,** we think BS also should have a simultaneous Rx/Tx capability but the reason we are focusing this issue on UE RF is if UE RF is feasible with reasonable self-interference as analyzed in our Tdoc (R4-2118079), BS RF having higher channel filter attenuation than that in UE should not have an issue in a co-located scenario. In non-colocated BS deployment, there should be no BS RF issue since the RF chains are separated geographically for UL CC and DL CC and hence can have enough attenuation compared to co-located scenario. But we are open to study BS RF if experts think it is necessary.

**To Nokia**, regarding isolation for inter-band simultaneous Rx/Tx, the attenuation from Duplex filter (e.g. 50dB isolation) is deficient in intra-band case. That's why we are proposing to have a frequency separation and MPR/A-MPR to have an acceptable MSD for intra-band case. Our analysis in R4-2118079 shows MSD can be reduced to around 3dB with a suitable frequency gap which can be assumed in 3.5GHz or 4.2GHz band. But we are open to further discuss our analysis if there are still concerns on the feasibility from other company in the study phase.

Regarding inter-operator scenario, we have observed only Macro-Macro case is not feasible from the adjacent channel co-existence study of CLI in Rel-16. Other than this Macro-Macro, it should be feasible. One example is simultaneous UE is allowed to operate in Indoor or Micro cell.

**11 – KT Corp.**

KT believes that support for Simultaneous Rx/Tx for intra-band NC CA can provide fair spectrum allocation to operator. For example, when multiple operators have n78 already deployed and n77 to be allocated later, some operators may suffer from having non-contiguous spectrum. Simultaneous Rx/Tx for intra-band NC

CA will solve this problem as other operators with non-contiguous spectrum holdings can also benefited from having this supported.

**UL Tx switching for UL CA with multiple TAG**

Please provide the feedback on the following potential objective.

- Enhance UL CA RF requirements (RAN4)
  - [Enable multiple TAG for TX switching (if not addressed already in Rel-17)]

**Feedback Form 20:**

**1 – AT&T GNS Belgium SPRL**

OK with proposed objective but we think that brackets can be removed given the statement that it would be an objective if not addressed in Rel-17.

**2 – Apple AB**

the related interruption and performance impacts should be part of the work.

**3 – SoftBank Corp.**

We support the proposed objective by the moderator.

**4 – NTT DOCOMO INC.**

We are fine with moderator's proposed objective.

**5 – Ericsson France S.A.S**

The moderator proposal is OK, agree with AT&T that the brackets could in principle be removed given the caveat on Rel-17. We have submitted a paper for RAN4#101-e on whether the issue can be solved in Rel-17 TEI for discussion next week.

**6 – Intel Corporation (UK) Ltd**

We are ok with objective to Enable multiple TAG for TX switching and can also wait for Rel-17 conclusions. In case it is handled in Rel-18, then the objective could be merged with UL Tx switching enhancements considered in the UL coverage enhancements email thread.

**7 – Nokia Japan**

Are the required spec changes only for UE RF?

**8 – MediaTek Inc.**

There are still some aspects not clear to us.

- If there are 2 TAGs, which TAGs will be used as the reference timing for the switch period?

- How to resolve the issue that CC#1 is still in transmission but CC#2 needs to start its transmission with 2Tx?

**9 – Huawei Technologies France**

We would like to see more information for the applicable scenario as well as the gain for the proposal.

4.1.2.2 Summary for intermediate round

**Objectives which seem stable**

Many companies provided the constructive comments on the objectives, which will be captured. One issue is for 6Rx. Skyworks, Vivo, Apple, Mediatek, Nokia did not favor 6Rx for smartphone, while Qualcomm, Intel proposed 6Rx for smartphone and all the operators seemed interested in it. Another issue is on the lower MSD working area. Companies still had different views, i.e., checking requirements per band combination vs general signaling solution. Qualcomm suggested to wait for outcome of Rel-17 discussion. Vivo preferred to have study first, LGE proposed to consider PC2 as target power class. Sony proposed to consider this working area under IDC topic.

Moderator: to Telecom Italia's comment "it seems to be a strong constraint to limit 4Tx to a single band. It would be very useful to allow >2Tx in different bands. Firstly, 3GPP can define 4Tx requirements to cover different bands. Secondly, the proponents did not consider the use case inter-band UL CA with 2Tx on each band and totally simultaneous 4Tx at the current stage, which can be added in the future. Maybe we can do single band (single CC and intra-band CA) first.

To CMCC and AT&T, we could not include too many bands. In the moderator view, we can consider n41, n77/78 as example bands. The other bands will be introduced in the dedicated WI in the release independent way later.

**Simulatenous 3Tx**

According to the discussion, it seemed that the compromised way forward is to drop Case#1 (3Tx on single uplink band) since it will have RAN1 impacts, and start with Case#2 (two uplink band inter-band CA with 1Tx on one band and 2Tx on the other band). The moderator wonders if at the current stage Case #3 can be dropped or not. Telecom Italia maybe as well as other operators, Oppo showed the big interest in Case #3. Oppo and Skyworks provided a constructive suggestion to first look at band combinations without simultaneous Tx/Rx for the study.

One thing that the moderator won't fully understand. ZTE, Vivo, Ericsson (and maybe Oppo) explicitly mentioned starting from case 2 and Tx switching. One thing that we should make clear is that UL Tx switching specified in Rel-16 and Rel-17 are features with non-zero switching period. If UE can support 1Tx at one band and 2Tx at the other band simultaneously, then such UE does not need to support Rel-16 and Rel-17 UL Tx switching features. In this regards, there seems no specification impact for a UE supporting 1Tx at one band and 2Tx at the other band simultaneously in order to supporting 0 us Tx switching between two operating bands. If that is the case, we can simply agree to start from enabling UE to 1Tx at one band and 2Tx at the other band simultaneously for power enhancement, which somehow overlapped with the existing Rel-17 WI increasing upper bound of transmission power as commented by other companies.

The other thing is that in the moderator view, "enabling UE to 1Tx at one band and 2Tx at the other band simultaneously" seemed equal to the other working area " Enhance UL CA RF requirements (specify RF requirements for inter-band UL CA with UL-MIMO on one band)". So the moderator would like to suggest

merging those two working areas.

**Enhance UL CA RF requirements**

The proponent answered the questions in the initial round. In the moderator understanding, this working areas can be merged with 3Tx case #2.

**Improve UE performance with small A-MPR**

The proponent provided the detailed justification and potential objectives. The moderator encourages companies to comment them in the final round or in the future.

Based on the feedback and comments, the moderator would like to suggest discussion in the final round given that quite a number of operators showed interests previously and there were not too many feedback in the intermediate round.

**New low power class for Uu and/or sidelink**

Telecom Italia and CMCC expressed the concern on it. The proponent proposed to further discuss it in December RAN plenary depending on the progress of Rel-17 NR-U.

The moderator suggests not to discuss this one in the final round, but keep it as a candidate working area for discussions in the future meetings.

**Simultaneous Rx/Tx for intra-band NC CA**

Ten companies provided the comments. Skyworks, Qualcomm, Ericsson, Intel, Nokia, and Mediatek questioned the feasibility and the benefit. Nokia and Intel had comments related to deployment and BS side. LGE responded that no additional RF implementation is needed and only the proper MPR/A-MPR as well as frequency separation is needed, and LGE also commented that the work focuses on UE and could not consider Macro-Macro BS cases.

LGE as proponent provided the detailed objectives. In the moderator view, there seems less chance for proponent to convince companies to accept this working area. More discussions are needed. The moderator encourages the proponents to talk to companies and also encourage other companies to take LGE's input into consideration for discussion in the future meetings. The moderator would like to list the following bullets as the candidate working area in this FR1 enhancement topic for further discussion and not to continue discussion on it in the final round.

- 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.

**UL Tx switching for UL CA with multiple TAG**

Nine companies provided the comments and feedback. Operators including AT&T, SoftBank, NTT DOCOMO supported it. Intel commented that the proposal should be considered together with UL Tx switching enhancements in UL coverage enhancement email thread. Nokia also implied that the proposal may impact the other working groups. Mediatek questioned how UE decides the timing for switching given that there are two TAGs and how to address the issue when there is overlapping between transmissions from two TAGs. Huawei asked for more information about the proposal.

The moderator thinks that it seems difficult for the proponent to convince other companies, but still keep this working area as the candidate for this topic.

- Enhance UL CA RF requirements (RAN4?)
  - Enable multiple TAG for TX switching (if not addressed already in Rel-17)

### 4.1.3 Final round

#### 4.1.3.1 Proposals and comments collection

**Objectives which seem stable**

Based on the feedback from companies, the moderator suggests further discussing the following bullets:

- **Proposal #4-1: for UE FR1 requirements evolution, the following objectives can be considered**
  - 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
  - Enable 8Rx for FWA/CPE on higher frequency bands (RAN4)
    - Consider >2.3 GHz NR TDD bands and example bands are n41, n77 and n78
    - 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 to define requirements with MIMO layer larger than 4
  - Investigate and enable 6Rx for smartphone on higher frequency bands (RAN4)
    - Investigate the feasibility whether 6Rx can be extended to the smartphone
      - Feasibility study includes performance gain and form factor
    - Consider >2.3 GHz NR TDD bands and example bands are n41, n77 and n78
    - 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 to define requirements with MIMO layer larger than 4

- 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

NOTE: for the above working areas (four big bullets), whether WI, WI with study phase, SI or merging into SI in the other email thread need further discussion after stabilizing the scope.

Please provide your comments and feedback in the table below.

**Feedback Form 21:**

| |
|---|
| **1 – China Mobile Com. Corporation**<br>For 4Tx, considering the workload, we can consider moderator's suggestion on the bands.<br><br>For 8Rx, we suggest to remove the lower limit on the frequency range "consider >2.3GHz NR TDD bands". Since there are other TDD bands close to 2.3GHz, e.g. n39, n34. The similar wording from 4Tx can be reused, our suggestion is:<br>Example bands are n41, n77 and n78 (others bands to be introduced in the release independent way later)<br><br>For 6Rx, we have similar suggestion on the wording of bands:<br>Example bands are n41, n77 and n78 (others bands to be introduced in the release independent way later) |
| **2 – Skyworks Solutions Inc.**<br>for 6Rx the text says "feasibility whether 6Rx can be extended to the smartphone" but then objectives says "specify...", is specify for non smartphone, or subject to feasibility result? |
| **3 – MediaTek Inc.**<br>- For 6Rx and 8Rx, it seems to us that more works should be done in the Demod session than RF or RRM session. We kind of suggest to move these objectives to the discussion of Demod requirement evolution.<br>- As there is a feasibility investigation phase for 6Rx, we think whether to specify RF/RRM/Demod requirements should be subjected to the investigation conclusion. |
| **4 – SoftBank Corp.**<br>Support the suggestion by CMCC. Addition of bands should be treated as release independent manner. |
| **5 – AT&T GNS Belgium SPRL**<br>Generally OK with the proposed objectives and support the example bands identified for 4Tx and >6Rx. Also support the suggestion by CMCC. For the low MSD objective, we may need more detail based on RAN4 progress to date on this topic to ensure that the goal is clear. We are OK to proceed with the existing text but would also like to consider future clarifications of the objectives based on RAN4 discussions. |

**6 – Nokia Japan**

We are OK to have 4 areas here, but the details of the objectives written here specifically Low MSD should be further discussed as commented by AT&T. That must be clarified in the proposal.

Regarding the NOTE added in the bottom, it only says "merge", but we believe that the above working areas should be treated in dedicated WI/SI. Hence, we propose a following alternative.

NOTE: for the above working areas (four big bullets), whether WI, WI with study phase and/or SI is handled in the respective WI/SI, merged with some of the areas and/or merged with some of SI/WI in the other email thread need further discussion after stabilizing the scope

**7 – China Telecommunications**

In general we are ok with the objectives.

We support CMCC's suggestion to remove the limit on the lower frequency range as well as on the duplex mode.

We are also ok to move "6Rx and 8Rx" to demod part as suggested by MTK if needed. Generally, for 4Tx, 6Rx and 8Rx, although they involve two areas (RF and demod), the main spec impact is on one area. We might not to treat them as the other cross-area topics (otherwise, the number of cross-area topics will be increased, and it might be more difficult to control the overall workload).

**8 – Apple AB**

on 6Rx, it should be clarified that the related requirements are subject to the conclusion of the feasibility study.

**9 – QUALCOMM JAPAN LLC.**

We agree with the proposed objectives. Regarding the comments on 6Rx/8Rx, we agree that most of the work will be in demod for the definition of the requirements. However, the feasibility of 6Rx depends on RF. the demod part does not require any feasibility study(if 8Rx demod is feasible, 6 Rx is also clearly feasible).

**10 – Ericsson France S.A.S**

Agree with the comment from CMCC about the 8RX >2.3GHz restriction removal. Also agree that is should be clear whether the 6RX is a feasibility study or already presumes standardization. We are OK to do a feasibility study. Maybe still the objectives should indicate that it is planned to do standardization in Rel-18 with the precondition of 6RX being deemed feasible. Agree the feasibility part is more RF related for 6RX. For the 8RX, the feasibility part is demod related (4 layer MIMO). However, it is better to keep the 6RX and 8RX in the same WI.

**11 – Samsung Electronics Co.**

For 6Rx, we agree with Qualcomm's comments, feasibility from RF perspective considering the implementation complexity, performance benefit have to be careful studied before RAN4 specify the requirements. RAN4 shall spend effort on the requirements which will be highly likely implemented.

**12 – LG Electronics Deutschland**

We are generally fine with the proposal. Regarding lower MSD for inter-band CA/DC, we would like to restrict the power class to PC 2 as commented in the previous round.

**13 – vivo Communication Technology**

We share similar views with other companies, for 6Rx, we should study the feasibility first. So we would like to simplify the 6Rx related scope by only one bullet:

"study the feasibility whether 6Rx can be extended to the smartphone"

**14 – Beijing Xiaomi Mobile Software**

We generally support moderator's proposal. For Low MSD, the objective can be FFS pending on the discussion in R17.

**15 – Intel Corporation (UK) Ltd**

- Enable 4Tx on a single band for FWA/CPE:
  - Overall we agree with proposed objectives
  - For BS requirements, we suggest rephrasing as "*Specify the BS demodulation performance requirements to support 4Tx UE operation*"
- Enable 8Rx for FWA/CPE on higher frequency bands (RAN4)
  - We do not see the need to split the objectives for 6RX and 8RX and they can be treated jointly.
  - Also, we prefer to put the objectives into a separate item due to cross-area impacts
  - For MIMO layers, we suggest adjusting the objective and include definition of requirements if needed
  - Proposed objectives
    - *Enable 8Rx for FWA/CPE on higher frequency bands (RAN4)*
      - *Consider >2.3 GHz NR TDD bands and example bands are n41, n77 and n78*
      - *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 requirements with MIMO layer larger than 4*
- Investigate and enable 6Rx for smartphone on higher frequency bands (RAN4)
  - We do not see the need to split the objectives for 6RX and 8RX and they can be treated jointly.
  - Also, we prefer to put the objectives into a separate item due to cross-area impacts
  - 6RX objectives can cover at least FWA/CPE
  - For MIMO layers, we suggest adjusting the objective and include definition of requirements if needed
  - Proposed objectives
    - *~~Investigate and~~ Enable 6Rx ~~for smartphone~~ on higher frequency bands (RAN4)*
      - *Enable 6Rx at least for FWA/CPE. Investigate the feasibility whether 6Rx can be extended to the smartphone. Feasibility study includes performance gain and form factor*
      - *Consider >2.3 GHz NR TDD bands and example bands are n41, n77 and n78*
      - *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 requirements with MIMO layer larger than 4*

**16 – ZTE Corporation**

Regarding 6Rx for smartphone, we also would like to see its feasibility firstly, then to decide whether it will go into normative WID phase.

In addition, we also fully support the low MSD WID which is helpful for potential network scheduling enhancement.

**17 – TELECOM ITALIA S.p.A.**

fine with moderator's proposal

**18 – Sony Group Corporation**

we are fine with the proposal

**Simultaenous 3Tx**

Based on the feedback and comments, the moderator would like to suggest the following bullets for discussions in the final round.

- **Proposal #4-2: for simultaneous 3Tx working area under FR1 requirement topic, it is proposed**
  - Drop Use case #1: 3Tx on single uplink band for power enhancement and MIMO enhancement
- **Proposal #4-3: for UE FR1 requirements evolution, the following objectives can be considered**
  - Investigate and if necessary, specify requirements to support simultaneous 3Tx considering two use cases (RAN4)
    - Inter-band UL CA with two bands with 1Tx on one band and 2Tx on the other band for power enhancement and [Tx switching transmission enhancement]
      - FFS example band combination(s)
      - Specify the necessary RF requirements
      - Specify BS demodulation performance requirements
      - Considering PC3, PC2 and PC1.5
    - Study inter-band UL CA with three bands with 1Tx on each uplink bands
      - Study the power class framework, impact on MPR/A-MPR and impact on MSD
      - Focus on the cases without simultaneous Tx/Rx and/or TDD+TDD+TDD

Please provide your feedback and comments.

**Feedback Form 22:**

**1 – Guangdong OPPO Mobile Telecom.**

About proposal 4-2:

- The 3Tx in one band may include the cases of 3layer UL MIMO, and 3TxD. For the 3TxD there is no impact to other groups, and possiblly could be further considered in next RAN meeting on whether there is demands.

About proposal 4-3:

- The Tx switching enhancement, i.e. 0us Tx switching could be also supported in 3Tx architecture as one of the possible solution for use cases like power saving, heating purpose, though it is understood there is optional feature (UE assistant information reporting). The impacts of this feature mainly in RAN2 signaling, i.e. adding 0us to the capability.

- The power class for 1T@bandA+2T@bandB need to be futher discussed whether to keep as the current PC3/2/1.5 or futher enhance the power capability since it is possible for this kind of UE to achieve higher power to compensate UL coverage losses due to power sharing among bands. And how to achive the power enhancement can be further studied in the WI.
- Another case for 3bands Tx could be FDD+FDD+TDD as we know. Wether there is demands for FDD+TDD+TDD is up to further discussion for example n1+n77cc1+n77cc2 with cc1 and cc2 non-contiguous.

**2 – China Mobile Com. Corporation**

For Tx switching enhancement (1Tx on one band+2Tx on the other band), based on the feedback from OPPO, the only impact is RAN2 signaling. Then we should make it clear in the objectives. And for Tx switching enhancements, SUL should also be considered together with inter-band UL CA.

**3 – Nokia Japan**

We basically agree with suggestion by moderator. And we would like to do some modifications for following two bullets.

Regarding "Considering PC3, PC2 and PC1.5", this bullet point is not clear if the said PC is total power class or PCs for the respective bands within an UL configuration or all of them. Hence, at this moment, we suggest a following text and further clarification is made in future meetings.

Total PC and PCs for respective bands within a UL configuration is FFS.

Regarding "Focus on the cases without simultaneous Tx/Rx and/or TDD+TDD+TDD", it may look odd to mention "without simultaneous Tx/Rx" if FDD is included within an UL band combination. Hence, our suggestion is as follows.

Study a case for TDD+TDD+TDD without simultaneous Tx/Rx

**4 – China Telecommunications**

**For Inter-band UL CA with two bands with 1Tx on one band and 2Tx on the other band for power enhancement and [Tx switching transmission enhancement]**

Firstly, we support to add 0us switching time if 3Tx is considered. The bracket should be removed, and both CA and SUL should be included as suggested by CMCC. Regarding the spec impact, in addition to the RAN2 signaling, we need also to confirm no DL interruption is needed for 0us UL switching time.

Secondly, regarding "Specify the necessary RF requirements", it is not clear to us what the necessary requirements are? To our understanding, the existing per-band requirements can be used. Could we consider softer wording like "Identify and specify the necessary RF requirements if needed"?

Thirdly, we don't think new BS demodulation requirements are needed for "Inter-band UL CA with two bands with 1Tx on one band and 2Tx on the other band", since the existing BS demod requirements can already cover this case.

**5 – Ericsson France S.A.S**

For the 2 bands, we are OK with most of the objectives, and are OK to work on power enhancement. We do not see a need to specify BS demodulation requirements though. For the 3 band proposal, couldn't TDD+TDD+TDD still imply simultaneous TX/RX ? Considering the rest of the workload, our preference is still to focus on the 2 bands part first.

**6 – LG Electronics Deutschland**

We support the proposal from the moderator.

**7 – Intel Corporation (UK) Ltd**

For Proposal #4-3 Tx switching transmission enhancement shall be clarified. There is ongoing discussion in UL enhancements email thread on "UL Tx switching schemes across 3 bands with restriction of 2 Tx simultaneous transmission for FR1 UEs" and further alignment may be needed.

**8 – vivo Communication Technology**

For Proposal #4-2, we agree with the observation and proposal from moderator that RAN4 should drop use case#1.

For Proposal #4-3, we support 0us Tx switching enhancement. For the power enhancement for inter-band UL CA with two bands, the power enhancement for two bands with 2Tx is just started in the new WI Power*Limit*CA_DC, we need to wait for the outcome first.

For the inter-band UL CA with 3bands, it is not clear what is the practical deployment scenario companies have in mind for TDD+TDD+TDD, would be good to hear the operators view. In addition it is unclear if the self-interference issue can be removed as the DL/UL configuration among different TDD bands can be different. Therefore, we do not support working on 3 UL bands in Rel-18.

**9 – VODAFONE Group Plc**

We support the moderator's proposal.

**10 – TELECOM ITALIA S.p.A.**

We support the moderator's proposal.

**11 – Huawei Technologies France**

For Tx switching enhancement topic, we think 3T with 0us can be supported without addtional requiremets. If signalling could be conisdered in Rel-18, it should be generic for both CA and SUL.

**12 – Huawei Technologies France**

In addtion, the current topic is 3Tx simultaneous transmission, while the other on-going disucssion in UL enhancement is clear that "... with restriction of 2Tx simultaneous transmission ...", they are not relevent.

**Improve UE performance with small A-MPR**

Based on the feedback and comments, the moderator would like to suggest the following bullets for the discussion in the final round given that quite a number of operators showed interests previously and there are not too many feedback in the intermediate round for those bullets.

- **Proposal #4-4: for UE FR1 requirements evolution, the following objectives can be considered**
    - 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

Please provide your comments and feedback in the table below.

**Feedback Form 23:**

| |
|---|
| **1 – Nokia Japan**<br>We agree with current objectives at this moment, and we are fine to further discuss them in the future meetings if necessary. |
| **2 – QUALCOMM JAPAN LLC.**<br>We understand the motivation and target, thank you for the clarifications. To us this item would clearly be lower priority because the gains are likely to be very small relative to the amount of time spent discussing the improvements. |
| **3 – Ericsson France S.A.S**<br>The bullets provide a good baseline |
| **4 – VODAFONE Group Plc**<br>These objectives seem fine as a baseline for now. |
| **5 – TELECOM ITALIA S.p.A.**<br>We support the moderator's proposal. |

4.1.3.2 Summary for final round

4.1.3.2.1 Objectives which seem stable

Companies commented on supporting bands for 6Rx/8Rx, objective related to 6Rx feasiblity study, potential revisit of low MSD objective taking the outcome of Rel-17 discussion into account.

To Intel, most interesting use case from operators for 6Rx is smartphone, some companies were not convinced by supporting 6Rx for FWA/CPE since 8Rx could be used for them with potential better performance

according to the discussions in previous rounds, and the current potential objectives seemed acceptable to most companies. The moderator suggests to keep 8Rx and 6Rx as separate bullets but made a few changes to accommodate Intel's comments. Firstly, in the main bullet, it is suggested to replace "for smartphone" by "targeting at support of smartphone" in the end of sentence. Secondly, add "decide which UE type ... will be considered". So during WI, RAN4 has chance to discuss and decide the applicable UE type for 6Rx.

To Skyworks, Mediatek, Samsung, Apple, Ericsson, Samsung, Vivo, the moderator restructured the bullets by adding dependency on feasibility study for specifying 6Rx requirements. To Vivo, it might be difficult to agree on too simplified bullet in the final round.

To Nokia, the moderator would like to simplify the note a bit to keep how to organize project be open. All the options including unified WI/SI, separate WI/SI, WI with study phase, merger with other SI/WI ... are all on the table.

To AT&T, Nokia, LGE, Xiaomi, firstly the moderator add a note to clarify that the objectives for low MSD are subject to Rel-17 discussions and secondly put the whole sub-bullets in [] to indicate that further modification is needed.

Based on the feedback from companies, the moderator suggests the following modified proposal.

- **Proposal #4-1: for UE FR1 requirements evolution, the following objectives can be considered**
  - 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
  - Enable 8Rx for FWA/CPE on higher frequency bands (RAN4)
    - Consider ~~>2.3 GHz~~ 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 ~~to~~ define requirements with MIMO layer larger than 4
  - Investigate and enable 6Rx ~~for smartphone~~ 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 ~~>2.3 GHz~~ 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 feasiblity 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~~to~~ define requirements with MIMO layer larger than 4
    - 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

NOTE: for the above working areas (four big bullets), how to organize the projects in terms of WI and/or SI ~~whether WI, WI with study phase, and SI or merging into SI in the other email thread~~ needs further discussion after stabilizing the scope.

4.1.3.2.2 Simultaneous 3Tx

For 3Tx use case 1, Oppo, Vivo had comments. The moderator would like to keep 3Tx TxD (without impacts on other WGs) open for the time being.

For 3Tx use case 2, Oppo, CMCC, China Telecom, Intel, Huawei, Vivo had comments on 0us Tx switching. And the operators requested to keep both SUL and UL CA. Oppo, Nokia, Vivo commented on the objective related to power class for 3Tx use case 2. The moderator would like to modify it to keep the discussion of power class be open. China Telecom and Ericsson commented that no BS demodulation performance needs be specified.

For 3Tx use case 3 (3 bands), Oppo, Nokia, Ericsson, Vivo commented on the target band combinations. Ericsson and Vivo expressed the concern on this working area. But considering the interests from operators, the moderator suggests keeping this working area but put [ ] as the compromise. Further discussions are needed for this working area.

Based on the feedback and comments, the moderator would like to modify the proposals.

- **Proposal #4-2: for simultaneous 3Tx working area under FR1 requirement topic, it is proposed**
    - Drop the potential objective in u~~U~~se case #1: 3Tx on single uplink band for ~~power enhancement and~~ MIMO enhancement
    - FFS the potential objective of 3Tx for transmission diversity on single uplink band for power enhancement with the understanding that there is no RAN1 impact
- **Proposal #4-3: for UE FR1 requirements evolution, the following objectives can be considered**
    - Investigate and if necessary, specify requirements to support simultaneous 3Tx considering two use cases (RAN4)
        - ~~Inter-band UL CA with two bands with 1Tx on one band and 2Tx on the other band for power enhancement and [Tx switching transmission enhancement]~~
            - ~~FFS example band combination(s)~~
            - ~~Specify the necessary RF requirements~~

        - ~~Specify BS demodulation performance requirements~~
        - ~~Considering PC3, PC2 and PC1.5~~
    - 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
    - [~~Study~~ 3Tx simultaneous transmission for three band inter-band UL CA with 1Tx on each uplink band
        - Study the power class framework, impact on MPR/A-MPR and impact on MSD
        - ~~Focus on the cases without simultaneous Tx/Rx and/or TDD+TDD+TDD~~
        - Example band combinations
            - Consider TDD+TDD+TDD without simultaneous Tx/Rx
            - FFS other band combinations, e.g., FDD+FDD+TDD, FDD+TDD+TDD]

#### 4.1.3.2.3 Improved UE performance with small A-MPR

Based on the feedback, there seems no need to modify the proposal. The objectives seemed clear and acceptable to most of companies who provided the feedback.

- **Proposal #4-4: for UE FR1 requirements evolution, the following objectives can be considered**
    - 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

## 4.2 FR2 requirements evolution

### 4.2.1 Initial round

#### 4.2.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***UE FR2 requirement focus evolution, with the following example areas:***
  - *Investigate (gain, operating SNR, implementation aspects) and if possible enable UL 256QAM*
  - *RF enhancement in FR2-1, including*
    - *[Vehicular UE requirements for power class in 39GHz]*
    - *Inter-band DL/UL CA*
      - *Vehicular UE requirements for inter-band DL/UL CA, e.g., 28+39GHz*
      - *[Inter-band UL CA based on CBM, depending on input from operators]*
  - *RF enhancement in FR2-2, including*
    - *Intra/inter-band DL/UL CA*
      - *[Inter-band CA support between FR2-1 and FR2-2 based on CBM/IBM depending on the conclusion of Rel-17]*
      - *Intra-band CA for FR2-2 based on CBM/IBM*
    - *[Investigate (gain) and if possible enhance FR2-2 switching time (ON/ON transient time)]*
  - *Other Rel-17 leftover topics*
  - *NOTE: further prioritization for above items are needed in future meeting.*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- UE FR2 requirements evolution
  - Potential justifications:
    - TBD
  - Potential objectives:
    - Investigate (gain, operating SNR, implementation aspects) and if possible enable UL 256QAM (RAN4)
    - RF enhancement in FR2-1, including (RAN4)
      - [Vehicular UE requirements for power class in 39GHz]
      - Inter-band DL/UL CA
        - Vehicular UE requirements for inter-band DL/UL CA, e.g., 28+39GHz
        - [Inter-band UL CA based on CBM, depending on input from operators]
    - RF enhancement in FR2-2, including (RAN4)
      - Intra/inter-band DL/UL CA
        - [Inter-band CA support between FR2-1 and FR2-2 based on CBM/IBM depending on the conclusion of Rel-17]
        - Intra-band CA for FR2-2 based on CBM/IBM
      - [Investigate (gain) and if possible enhance FR2-2 switching time (ON/ON transient time)]

- Additional objectives which need more discussions:
  - Enhance FR2-2 switching time (ON/ON transient time)
  - UE antenna scaling (Refer to RP-212306)
  - Other Rel-17 leftover topics
- Leading working group:
  - RAN4
- SI or WI:
  - WI with study phase

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether the secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 24:**

| |
|---|
| **1 – China Telecommunications**<br>We support the further enhancement for FR2 RF area in Rel-18. We are interested in FR2 UL 256QAM. |
| **2 – T-Mobile USA Inc.**<br>We support UL 256 QAM in FR2. |
| **3 – LG Electronics Deutschland**<br>As we know, enhanced SL operation on FR2 spectrum has been discussed as Rel18 RAN1-led WI proposals which shows that there is a clear interest in FR2 vehicular UE in the industry. In general, SL RF requierments have been specified based on Uu RF requirements in RAN4. Therefore, it is necessary to define PC2 RF requirements in 39GHz. Some operator also showed their interest in this topic. |
| **4 – LG Uplus**<br>We are interested in Vehicular UE requirements for power class in 39GHz. There will be an auction in South Korea in (TBD), including 39GHz. Because this is before the spectrum auction, we have yet to decide how we will utilize 39GHz. However, vehicle service in mmWave is one of the 5G services that can be considered, and for this, we belive that support for 39GHz vehicle UE is required in Rel-18. |
| **5 – KDDI Corporation**<br>We support UL 256 QAM in FR2. |
| **6 – NTT DOCOMO INC.**<br>We also support UL 256 QAM. |
| **7 – SK Telecom**<br>We think that PC2 support in 39GHz is worth of consideration (as commented by LG Electronics above), although we need more clarification on the use of 39GHz in our side yet. |

**8 – SoftBank Corp.**

We are supportive of the FR2-1 RF enhancements in Rel-18 for improving the usability of FR2-1 spectrum including 39GHz. And we are interested in UL 256QAM.

**9 – Nokia Japan**

**[WI handling]**

FR2 4 layers should be handled in a dedicated WI in a more visible way since it impacts on heavily UE RF, UE demodulation [and RRM]. This makes easier coordinate with testing SI/WI. UL 256 QAM can be also handled in the same way, it depends on how many objectives are included FR2 enhancement WI.

**[Topics should be included for Rel-18]**

- A dedicated WI for FR2 4 layers
- A dedicated WI for FR2 UE RF enhancement
  - Beam correspondence requirements for RRC_INACTIVE and initial access
  - Enable UL 256QAM after the investigation of gain, operating SNR, implementation aspects if possible
  - If there are clear demands,

he same frequency group
g on input from operators

  - A dedicated WI for Vehicular UE requirements

for power class in 39GHz
/UL CA, e.g., 28+39GHz

**[Comments on some topics]**

- **Beam correspondence requirements for RRC_INACTIVE and initial access**
  As mentioned in RAN1 LS of R1-2106309, in current NR specification the UE Tx beam determination for both msg1 and msg3 in RACH procedure (in all RRC states) are up to UE implementation while RAN4 beam correspondence requirements currently apply to RRC*CONNECTED state only. Moreover, as RP-212142 explains, UE power savings are especially important for successful FR2 operations and good end-user experience, it would be important that the networks could efficiently utilize RRC*INACTIVE and Small Data Transmissions for FR2 as well. However, without well performing UE beam correspondence support wide usage of RRC*INACTIVE and Small Data Transmission may not be feasible in practical FR2 deployments. Hence we believe that the beam correspondence requirements for RRC*INACTIVE and initial access should be specified in Rel-18.

- **RF enhancement in FR2-2 for switching time (ON/ON transient time)**
  We understand the motivation but we think that the RF enhancement in FR2-2 would not be urgent at this moment. Apart from that, it would be great if the proponent of switching time enhancement would clarify followings. How shorter transient time is achieved technically. Only rely on hardware improvement? Or some coordination between UEs and networks is assumed? For instance, currently we have fixed transient period in the spec for FR2, but may be some of the transient period region can be actually decoded by gNB if some assistance is made? Or just it follows hardware improvement and the resolution is similar to what was made in FR1 shorter transient period?

**10 – MediaTek Inc.**

- FR2-2: It seems not an urgent topic. If agreed, Intra/inter-band DL/UL CA should be handled in the same way as FR2-1, i.e., also need operator inputs on band combo.
- Antenna scaling is currently an UE implementation issue. Need more justification to standardize it.

**11 – ZTE Wistron Telecom AB**

(1) We are supportive of UL 256QAM.

(2) For RF enhancement in FR2-1, we support to include inter-band UL CA based on CBM into Rel-18.

(3) For RF enhancement in FR2-2, we think it should have a lower priority subject to RAN4's TU availability.

(4) For UE antenna scaling, we don't see the need of standardizing the UE antenna scaling behavior at this moment.

**12 – QUALCOMM JAPAN LLC.**

For the vehicular UE requirements in 39GHz, we would like to see more justification to take on this work. In our understanding, these vehicular UEs are not yet deployed in any bands. For all the other CA related improvements, they should be based on some concrete band combination proposals.

For the additional objectives, it would be good to understand if there is a strong motivation to take on this work( big performance improvement that can be justified or strong commercial interest)

**13 – Samsung Electronics Co.**

We are open to have enhancement on FR2 RF side with reasonable scope focused on urgent market demand cases and critical cases.

**14 – Intel Corporation (UK) Ltd**

- We agree with companies that further prioritization of the candidate objectives is required and scope shall be limited
- FR2 switching time enhancements (ON/ON transient time)
  - ON/ON transient time has a big impact on UL performance, especially for high SCS scenarios in FR2-2. Improved UE capabilities to support up to 1us ON/ON transient period can be considered for FR2 similar to FR1. The capability can be helpful for both FR2-1 and FR2-2 and the work can cover the full FR2.
  - To Nokia: we are considering hardware improvement at the UE side
  - Detailed objective:
    - *Define RF requirements for the support of shorter ON/ON transient period for FR2-1 and FR2-2*
    - *Note: values between 1us and 5us are considered*
- Inter-band CA/DC support between FR2-1 and FR2-2 based on CBM/IBM
  - Rel-17 is expected to support CA/DC between FR1 and FR2-2. Support of CA/DC between FR2-1 and FR2-2 is important to ensure the NR technology can fully extract the benefits from the support of FR2-2 operation and increase the set of supported scenarios.
  - Detailed objective:

        - *Define RF requirements for the support of CA/DC between FR2-1 and FR2-2 based on CB-M/IBM*

- Intra-band CA for FR2-2 based on CBM/IBM
    - Support of CA for FR2-2 is important to ensure the NR technology can fully extract the benefits from the support of FR2-2 operation and can cover full unlicensed band. Comparing to FR2-1 the max frequency separation in FR2-2 band is much larger and both CBM/IBM approaches may need to be considered.
    - Detailed objective:
        - *Define RF requirements for the support of FR2-2 intra-band DL CA based on CBM and/or IBM*

- FR2 UL 256QAM
    - We are fine to investigate the benefits and feasibility of support of UL 256QAM in FR2-1
    - Detailed objective:
        - *Investigate (gain, operating SNR, implementation aspects) and if possible, define requirements for UL 256QAM*

**15 – China Unicom**

We support to further enhance FR2 RF requirements. We support to introduce UL 256QAM for FR2 in Rel-18.

**16 – Sony Group Corporation**

· In general, we are supportive of vehicular UE at 39 GHz.

· We are also supporting the Beam correspondence requirements for RRC_INACTIVE and initial access as proposed by Nokia.

**17 – vivo Communication Technology**

– [Inter-band UL CA based on CBM, depending on input from operators]

The CBM for inter-band DL CA is feasible and the requirements are under discussion in R17, and we prefer to take the capability alignment between UL and DL into consideration. The UE behavior and performance may be influenced if only the DL CBM is available.

– Intra-band CA for FR2-2 based on CBM/IBM

For FR2-1, the intra-band CA is only considered to work in CBM with single-chain. If there is no more justification for FR2-2 indeed requiring multi-chain architecture even under intra-band CA, we prefer only to take CBM as the starting point.

- Enhance FR2-2 switching time (ON/ON transient time)

As for RF enhancement in FR2-2, the ON-ON transient time has been discussed in Rel-17 for several meeting in RAN4. There were several proposals on improving the ON-ON transient period less than 5us with UE capability in RAN4#100-e. For now, it is really hard to tell if this topic can come to a consensus in Rel-17. In our preference, we support to enhance the ON-ON transient period in Rel-17. Since the higher SCSes 480/960kHz are introduced for FR2-2, the improved ON-ON transient period can really boost the system performance according to the outcome of the SI. However, we can wait the conclusion on this topic. If it is not solved in Rel-17, we can add it here as an enhancement for FR2-2 in Rel-18.

**18 – Huawei Technologies France**

In general, we support further enhancements for UE RF FR2.

We support UL 256QAM for FR2 and requirements for band combinations based on requests.

FR2-2 switching time: Since RAN4 just made conclusion on transient period for FR2-2 in #100e meeting, as the transient period is UE implementation related, we think the implementation could not be improved dramatically in such a short time compared to Rel-17.

UE antenna scaling: Power saving or beam management are RAN1 topics, it's not clear for the purpose of power saving, whether it is necessary to consider antenna scaling. Still think the necessity should be justified by RAN1 firstly.

**19 – Ericsson LM**

We support enhancement of Intra-band and inter-band CA in FR2-1 and in FR2-2.

Furthermore the following improvements are done in Rel-18:

- **Spherical coverage enhancement for initial access**: specify requirements for msg1.
- **Beam correspondence enhancement for initial access**: measure 'correlation' between msg1 beam and the RAR receiver beam
- **Power-control tolerance**: improve open-loop and close-loop power tolerances

**20 – Apple AB**

It is proposed to include to following objective

As a technique to reduce FR2-1/FR2-2 power consumption, Study to enable/disable antenna elements & RF chains (antenna scaling) by UE

for UL 256QAM, we are ok to study the performance gain and feasibility first before starting the normative work. For RF enhancement of FR2-2, we would like to have more inputs if such work is justified by upcoming commercial deployments.

Many CBM/IBM related proposals should depend on the conclusion of R17 FR2 WI

**21 – AT&T GNS Belgium SPRL**

We support UL 256QAM for FR2 as well as the RF enhancement in FR2-2 to include FR2 switching time enhancements (ON/ON transient time).

**22 – LG Electronics Deutschland**

For the comment from Qualcomm, if we are to study the device that is in the market, it would be quite challenging to justify some FR2 (FR2-1 and FR2-2) studies for devices. In our understanding, there are quite some interests for the FR2-1/FR2-2 devices including vehicular UE for future deployment from operator, UE and NW vendors. Hope this helps address your question.

#### 4.2.1.2 Summary for initial round

Many comments were received. Moderator provided the summary for each working area. In the moderator's view, except for UL 256QAM and maybe RF enhancement for 39GHz, it seemed that companies share less common interests on the other topics.

**UL 256QAM**

Many operators including China Telecom, T-Mobile USA, KDDI, NTT DOCOMO, China Unicom, AT&T supported it. Vendors including ZTE, Nokia, Intel, Huawei can accept this working area.

**RF enhancement in FR2-1 for enhancement for vehicular UE (PC2) in 39GHz**

Operators including LGU+, SK Telecom, SoftBank supported it. Sony also supported it. Qualcomm commented that vehicular UEs are not yet deployed in any bands. LGE provided the responses.

**Inter/intra-band DL/UL CA enhancement for FR1-2, FR2-2 and between FR2-1 and FR2-2 based on CBM/IBM**

Qualcomm commented that the enhancement should be based on some concrete band combination proposals. Samsung commented that the reasonable scope should be based on urgent market demand and critical cases. Mediatek had similar comments. Huawei commented that may CBM/IBM related proposals should depend on the conclusion of R17 FR2 WI.

**Enhanced FR2-2 switching time (ON/ON transient time)**

Nokia commented that such enhancement is not urgent, and had a number of questions about how shorter the transient time is and whether it reply on hardware improvement, whether some coordination between UEs and networks is assumed. Huawei commented that this issue was discussed in Rel-17 and concluded in recent meeting and it would challenging to dramatically improve in a short time.

Vivo commented that they saw the benefit and would like to include it in Rel-18 if it was not resolved in Rel-17.

**Antenna scaling**

Meidatek, ZTE and Huawei were not convinced for this topic.

**Other topics**

Nokia, Sony, Ericsson proposed beam correspondence requirements for RRC_INACTIVE and initial access, although it was not captured in the previous September email discussions.

Ericsson also proposed spherical coverage enhancement for initial access and power control tolerance.

In moderator understanding, some of those topics were discussed in Rel-17.

### 4.2.2 Intermediate round

#### 4.2.2.1 Proposals and comments collection

**Objectives which seems more acceptable.**

- Potential objectives:
  - Investigate (gain, operating SNR, implementation aspects) and if possible enable UL 256QAM (RAN4)

- RF enhancement in FR2-1 for 39GHz band
  - Vehicular UE requirements for power class in 39GHz
  - Vehicular UE requirements for inter-band DL/UL CA, e.g., 28+39GHz

Please proponent provide more justifications and other companies provide the further feedback on those tentative objectives.

**Feedback Form 25:**

| |
|---|
| **1 – TELECOM ITALIA S.p.A.**<br>We think that UL 256 QAM can be approved directly as a Work Item for FWA use |
| **2 – AT&T GNS Belgium SPRL**<br>We agree with Telecom Italia that UL 256QAM can be approved directly as a WI for FWA use case. |
| **3 – China Telecommunications**<br>OK with the proposed objectives for UL 256QAM. |
| **4 – QUALCOMM JAPAN LLC.**<br>We are not convinced of UL 256QAM. It is very difficult to implement and the actual use in the field will be very limited given that FR2 UL is usually power limited. |
| **5 – Apple AB**<br>As said, for UL 256QAM, a study of the performance gain and feasibility needs to be carried out before starting the normative work for smartphone types of UE. If the support of UL 256QAM is limited to FWA UEs, understandably some constraints of smartphones can be removed, but it would still be good to look at the performance gain and feasibility before specifying the requirements. |
| **6 – KDDI Corporation**<br>We are OK with the proposed objectives for UL 256QAM. |
| **7 – Sony Group Corporation**<br>We think UL 256 QAM can be useful for FWA type application. We are also fine with the proposal for Vehicular UEs. |
| **8 – Intel Corporation (UK) Ltd**<br>For UL 256QAM we think that studies on performance gains, implementation impacts shall be performed before requirements definition. The proposed objectives seem fine.<br>For 39GHz Vehicular UE requirements, companies mentioned SL use case in comments. Is it planned to use it for licensed band Uu operation? Overall, we are ok with the objective subject to further prioritization along with other objectives. |
| **9 – ZTE Corporation**<br>We are OK with the proposed objectives for FR2 UL 256QAM |

**10 – Ericsson LM**

We also agree with Apple and Intel that performance gain, system benefit and feasibility of using UL 256 QAM need to be studied first before discussing requirements. UL 256QAM in FR2 requires new BS demodulation requirements so we do not think that UL 256QAM fits well in FR2 RF enhancement work item. Secondly, demodulation work load needs to be considered. There are too many demod proposals and UL 256QAM in FR2 will increase it further.

**11 – Nokia Japan**

We support the inclusion of UL 256QAM. But again, this is not only for UE RF but also related to BS demodulation. Regarding objectives for vehicular UE requirements, they should be treated in a dedicated WI for vehicular UE if they are specified in Rel-18.

**12 – NTT DOCOMO INC.**

We are fine with moderator's proposal for UL 256QAM.

**13 – Huawei Technologies France**

We support the objectives for UL 256QAM.

**14 – KT Corp.**

KT would like to support inclusion of UL 256QAM (or preferably treat this as a separate WI) and Vehicular UE requirements for power class in 39GHz (we are seeking possibility of creating a business model for this spectrum and having Vehicular UE can provide a new opportunity)

**Inter-band and intra-band DL/UL CA/DC RF enhancement**

According to feedback, the moderator proposed the following potential objectives for further discussion:

- Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 and/or FR2-2 depending on operators' requests (RAN4)
  - Define RF requirement for support of inter-band UL CA in FR2-1 based on CBM
    - Take the capability alignment between UL and DL CA into account, e.g., only consider the case where DL CBW is available
  - Define RF requirements for support of FR2-2 intra-band DL CA based on CBM and/or IBM
  - Define RF requirements for support of CA/DC between FR2-1 and FR2-2 based on CBM/IBM
  - [Investigate (gain) and if possible enhance FR2-2 switching time (ON/ON transient time)]

Please the proponent(s) provide more justification and other companies provide more feedback on those bullets.

**Feedback Form 26:**

**1 – TELECOM ITALIA S.p.A.**

Is there any market need for these proposals, apart from FR2-1 enhancements?

According to the moderator, the work is depending on operators' requests.

But no request was raised by operators for FR2-2 and combining FR2-1 with FR2-2

**2 – QUALCOMM JAPAN LLC.**

We think these could be lower priority since there isn't much interest shown

**3 – Apple AB**

at least one example band combination should be proposed by operators before this work is approved. Meanwhile, the impact of MTTD on CBM should be studied.

**4 – Ericsson LM**

RAN4 should wait for the completion of R17 WI on FR2 enhancement before making any agreement on enhancement of FR2 intra-band and inter-band CA. We expect some open issues from R17. For FR2-2, RAN4 should wait for the completion of the 71 GHz WI. It is premature to start discussing enhancement of FR2-2 without having any RF requirements for FR2-2.

In summary we suggest to put this on hold until end of R17 core part.

**5 – LG Electronics Deutschland**

We think FR2-1 is first priority. Fr2-2 needs more consideration.

**6 – Samsung Electronics Co.**

We agree with Ericsson that such objectives can be on hold until March 2022

**7 – Intel Corporation (UK) Ltd**

We agree with proposal including investigation of FR2 switching time. For ON/ON transient time we suggest clarifying that objective is applicable to both FR2-1 and FR2-2.

- *Investigate (gain) and if possible enhance FR2-1 and FR2-2 switching time (including at least ON/ON transient time)*

**8 – ZTE Corporation**

Regarding the discussion on FR2-2, it's better to wait for the outcome of Rel-17 UE RF discussion on FR2-2.

**9 – Nokia Japan**

We believe that we should focus on FR2-1 in Rel-18. And the details on the objectives are subject to the outcome of Rel-17 FR2 RF enhancement WI. Regarding ON/ON transient time, thanks Intel for clarification. We understand the motivation but still we believe that we should focus on FR2-1 if we include switching time enhancement.

**Additional objectives**

The following additional objectives were proposed and discussed. According to the feedback in the initial round, the moderator did not see too many consensus on those working areas. The moderator captures those bullets here for further discussions.

- Enhanced FR2-2 switching time (ON/ON transient time) (RAN4)
- UE antenna scaling (RAN4)
- Beam correspondence requirements for RRC_INACTIVE and initial access
- Spherical coverage enhancement for initial access
- Power-control tolerance

Please proponent(s) provide more justification, and other companies provide further feedback.

**Feedback Form 27:**

**1 – AT&T GNS Belgium SPRL**

We would like to point out that AT&T also supported Enhanced FR2-2 switching time (ON/ON transient time) in the Initial Round but it did not seem to be captured in the summary. Without improvement, there will be a large impact on UL performance, especially for higher modulation schemes in high SCS scenarios in FR2-2 which will significantly impact possible use cases for the spectrum. We agree with Vivo that if it is not solved in Rel-17, we need to add it as an enhancement for FR2-2 in Rel-18.

**2 – QUALCOMM JAPAN LLC.**

We agree with the previous comments stating that antenna scaling is already possible and there is no need for this. The proponents haven't yet shown what problem we are solving and some concrete benefits. A UE compliant with current spherical coverage requirements can have UL EIRP changes of 10 dB or even more, how would that be different compared to changing the number of antennas?

**3 – Ericsson LM**

On, "Enhanced FR2-2 switching time (ON/ON transient time)", we suggest to wait until end of R17.

We fully support the following objectives:

- Beam correspondence requirements for RRC_INACTIVE and initial access
  - The small data transmission is supported in RRC inactive state from R17 on CG-SDT resources (PUSCH). Without beam correspondence the UE transmission may be incorrect/lost.
  - Small data transmission is supported in RRC inactive state from R17 also on RACH-SDT resources. Also there are no requirements for RACH transmission in idle mode but RACH at initial access is quite critical to prevent delay in setup. Beam correspondence is therefore needed for initial access.
- Spherical coverage enhancement for initial access
  - There is no spherical coverage requirement for PRACH msg1 transmission. It is important to enhance initial access performance.
- Power-control tolerance
  - Both absolute and relative tolerances for power control in FR2 are too coarse with large margins. There is potential to improve them to enhance performance. Several procedures reply on pathloss are impacted by the power control tolerance.

| |
|---|
| **4 – Sony Group Corporation**<br>We support Beam correspondence requirements for RRC_INACTIVE and initial access, Spherical coverage enhancement for initial access and power control tolerance. |
| **5 – Intel Corporation (UK) Ltd**<br>We support investigation of switching time improvements. We suggest clarifying that objective is applicable to both FR2-1 and FR2-2.<br>- *Investigate (gain) and if possible enhance FR2-1 and FR2-2 switching time (including at least ON/ON transient time)*<br>For BC for SDT we suggest to wait for outcome of ongoing Rel-17 discussion. |
| **6 – ZTE Corporation**<br>we also fully support to define BC requirement in inactive mode or initial access period especially considering CG-SDT transmission in inactive mode in Rel-17. |
| **7 – Nokia Japan**<br>We believe that it would be really necessary to enhance essential requirements missing from FR2 and need to establish more solid foundation. Regarding priority, our priority is beam correspondence requirements for RRC_INACTIVE and initial access, spherical coverage enhancement for initial access and power control tolerance in order of priority. |

#### 4.2.2.2 Summary for intermediate round

**Objectives which seems more acceptable.**

Regarding FR2 UL 256QAM, operators including Telecom Italia, AT&T, China Telecom, KDDI, NTT DOCOMO, KT Corp. supported FR2 UL 256QAM. And some operators commented that it should be applied for FWA. Intel, Apple, Ericsson commented that the study on gain, implementation impacts need be evaluated but seemed OK with the moderator's proposed objective. Nokia and Ericsson commented that BS demodulation part also needs be considered.

Qualcomm was not convinced. The moderator wonder if starting the work with evaluation of performance and feasibility can address Qualcomm concern.

Regarding 39GHz vehicular UE requirements, no negative comment was received. Intel is OK with the understanding that this working area will be subject to further prioritization along with other working areas or objectives.

Moderator: the current discussions are organized based on the document in previous email discussion. UE FR2 requirements evolution is listed as a topic. Under this topic, we had UL 256QAM, Vehicular UE for 39GHz... as working areas. As clarified in the title of Section 4, the topic in this section is RF centric, which means the RF would be key issue but the RRM or demodulation requirements would also be needed.

At the current stage, companies are encouraged to focus on stabilizing the objectives. In the future meeting, based on the stabilized objectives or tentatively stabilized objectives, we can further discuss how to organize the projects.

**Inter-band and intra-band DL/UL CA/DC RF enhancement**

No operator showed interest in FR2-2 enhancement. Telecom Italia commented that no request was raised by operators for FR2-2 and combining FR2-1 with FR2-2. Other companies including Qualcomm, Apple had similar view. Ericsson, Samsung, ZTE suggested waiting for outcome of Rel-17 especially for FR2-2.

Given that situation, the moderator would like to drop the work for FR2-2 and FR2-1 combining with FR2-2 in Rel-18 to save some efforts and focus on FR2-1 enhancement in the future discussion.

**Additional objectives**

The proponents elaborated more on the proposals. Some feedback was received.

Regarding the enhancement of FR2-2 switching time (ON/ON transient time), AT&T, Intel, Vivo supported. But Ericsson proposed to wait for the completion of Rel-17. Considering the comments collected from Nokia and Huawei, the moderator does not think that the group can reach consensus on it. The moderator suggests to keep it as a candidate working area with some modifications from Intel for discussions in the future meetings.

- Investigate (gain) and if possible enhance FR2-1 and FR2-2 switching time (including at least ON/ON transient time)

Regarding UE antenna scaling, Qualcomm thought that there is no need to work on it, and there was no more feedback in the intermediate round. Considering other companies' comments in the initial round, the moderator does not think that the group can reach consensus on it and thus suggest further discussions in the future meeting.

Regarding the beam corresponding requirements in inactive mode or initial access period, more companies including Ericsson, Sony, ZTE, and Nokia expressed the strong supports. There was no negative feedback in the intermediate round. So the moderator would like to suggest further discuss this working area based on Ericsson detailed proposals.

- Beam correspondence requirements for RRC_INACTIVE and initial access
    - The small data transmission is supported in RRC inactive state from R17 on CG-SDT resources (PUSCH). Without beam correspondence the UE transmission may be incorrect/lost.
    - Small data transmission is supported in RRC inactive state from R17 also on RACH-SDT resources. Also there are no requirements for RACH transmission in idle mode but RACH at initial access is quite critical to prevent delay in setup. Beam correspondence is therefore needed for initial access.
- Spherical coverage enhancement for initial access
    - There is no spherical coverage requirement for PRACH msg1 transmission. It is important to enhance initial access performance.
- Power-control tolerance
    - Both absolute and relative tolerances for power control in FR2 are too coarse with large margins. There is potential to improve them to enhance performance. Several procedures reply on pathloss are impacted by the power control tolerance.

### 4.2.3 Final round

#### 4.2.3.1 Proposals and comments collection

**Objectives which seems more acceptable.**

Based on the feedback and comments from companies, the moderator would like to suggest the following bullets for final round.

- **Proposal #5-1: For UE FR2 requirement evolution, the following objectives can be considered**
  - Investigate and if possible, enable UL 256QAM for FR2 (RAN4)
    - Study the gain, operating SNR, implementation aspects
    - Specify the UE RF requirements
    - Specify the BS demodulation performance requirements
  - RF enhancement in FR2-1 for 39GHz band (RAN4)
    - FFS whether it is for sidelink, Uu or both
    - Vehicular UE requirements for power class in 39GHz
    - Vehicular UE requirements for inter-band DL/UL CA, e.g., 28+39GHz

Please provide your comments and feedback in the table below.

**Feedback Form 28:**

| |
|---|
| **1 – AT&T GNS Belgium SPRL**<br>OK with UL 256QAM objective. We would like to inquire as to how topics such as FR2-2 switching time will be addressed in future meetings. Is the intent to discuss in December or in the Feb email prep in lead up to March 2022 meeting? |
| **2 – Nokia Japan**<br>Considering the remaining time for this e-mail discussion, we are basically OK with the proposal if a NOTE added to feedback form 21 is added to this feedback form 28 as well. Hence, a following note should be included in the proposal. The details on each of the objectives should be further discussed.<br>NOTE: for the above working areas (two big bullets), whether WI, WI with study phase and/or SI is handled in the respective WI/SI, merged with some of the areas and/or merged with some of SI/WI in the other email thread need further discussion after stabilizing the scope |
| **3 – QUALCOMM JAPAN LLC.**<br>The proposed scope is fine, we assume that the objectives will go into the prioritization process |
| **4 – LG Electronics Deutschland**<br>We support the moderator's proposal in general. Regarding RF enhancement in FR2-1 for 30GHz band, the target interface is Uu, not sidelink. With this clarification, the first bullet doesn't seem to be necessary. We suggest to have editorial update 2nd and 3rd bullet as below for more clarity:<br>RF enhancement in FR2-1 for 39GHz band (RAN4) |

- ~~FFS whether it is for sidelink, Uu or both~~
- Specify RF requirement for vehicular UE power class (PC2) in 39GHz
- Specify RF requirement for vehicular UE power class(PC2) in inter-band DL/UL CA, e.g. 28GHz+39GHz

**5 – Ericsson LM**

Looks fine. But in reality some of the aspects need to be downprioritized due to limited TU and work load of other RF topics.

**6 – KDDI Corporation**

We are OK with UL 256QAM objectives.

**7 – Intel Corporation (UK) Ltd**

For "RF enhancement in FR2-1 for 39GHz band" we agree with LGE comment that focus is on Uu link

**8 – ZTE Corporation**

We are fine with the proposed UL 256QAM objectives.

**9 – Sony Group Corporation**

we are fine with the proposal

**10 – TELECOM ITALIA S.p.A.**

We are OK with UL 256QAM objectives.

if there is need to downprioritize, lower priority to the second objective (RF enhancement in FR2-1 for 39GHz band)

**Inter-band and intra-band DL/UL CA/DC RF enhancement**

Based on the feedback and comments, the moderator would like to suggest discussing the following bullets in the final round:

- **Proposal #5-2: Drop the enhancement for FR2-2 and FR2-2 combining with FR2-1 in Rel-18 RAN4 package.**
- **Proposal #5-3: For UE FR2 requirement evolution, the following objectives can be considered**
  - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators' requests (RAN4)
    - Define RF requirement for support of inter-band UL CA in FR2-1 based on CBM
      - Take the capability alignment between UL and DL CA into account, e.g., only consider the case where DL CBW is available

Please provide your comments and feedback in the table below.

**Feedback Form 29:**

| |
|---|
| **1 – Nokia Japan**<br>The proposed direction would look reasonable. But the latter part of the proposal #5-2 seems any proposed enhancements including both FR2-1 and FR2-2 drop. In our understanding, the moderator's intention must have been to drop only FR2-2 part if the proposed enhancements include both FR2-1 and FR2-2 as target. Thus, the proposal #5-2 should be modified as follows.<br>**Proposal #5-2: Drop the enhancements for only FR2-2, and those of FR2-2 part if the proposed enhancements include both FR2-1 and FR2-2 in Rel-18 RAN4 package** |
| **2 – LG Electronics Deutschland**<br>We support the moderator's proposal. |
| **3 – Ericsson LM**<br>We are fine with the proposal |
| **4 – Intel Corporation (UK) Ltd**<br>For Proposal #5-2 we prefer not to drop for now and wait for further progress in Rel-17 before making final decision |
| **5 – ZTE Corporation**<br>We are also fine with the proposal |
| **6 – TELECOM ITALIA S.p.A.**<br>We support the moderator's proposal. |

**Additional objectives**

- **Proposal #5-4: For UE FR2 requirement evolution, the following objectives can be considered** (objectives provided by Ericsson)
  - Beam correspondence requirements for RRC_INACTIVE and initial access
    - The small data transmission is supported in RRC inactive state from R17 on CG-SDT resources (PUSCH). Without beam correspondence the UE transmission may be incorrect/lost.
    - Small data transmission is supported in RRC inactive state from R17 also on RACH-SDT resources. Also there are no requirements for RACH transmission in idle mode but RACH at initial access is quite critical to prevent delay in setup. Beam correspondence is therefore needed for initial access.
  - Spherical coverage enhancement for initial access
    - There is no spherical coverage requirement for PRACH msg1 transmission. It is important to enhance initial access performance.
  - Power-control tolerance
    - Both absolute and relative tolerances for power control in FR2 are too coarse with large margins. There is potential to improve them to enhance performance. Several procedures reply on pathloss are impacted by the power control tolerance.

Please provide your comments and feedback in the table below.

**Feedback Form 30:**

**1 – Apple AB**

Since there is no initial access requirements, it is not clear how the enhancement of BC and coverage extension for initial access can be tested. Clarification from the proponents is needed.

**2 – MediaTek Inc.**

If the motivation is about how UE uses its rough beam to achieve beam correspondence, then it is not unnecessary to consider IDLE mode or INACTIVE mode. In some CONNECTED mode procedures, UE is also expected to use rough beam. In our understanding, the Handover test case defined in TS38.133 already assumes that UE is using rough beam to transmit PRACH. Tests in IDLE/INACTIVE mode is extremely time-consuming. We have concern on this part.

**3 – Nokia Japan**

Thanks moderator for listing the three topics, specifically beam correspondence for RRC_INACTIVE and initial access is important and essential enhancement, we believe. Regarding the objective, some of the texts should be placed in justification section in a corresponding WID so that our alternative is as follows.

Specify following beam correspondence requirements for RRC_INACTIVE and initial access

- ~~o The s~~Small data transmission ~~is supported~~ in RRC inactive state from R17 on CG-SDT resources (PUSCH). ~~Without beam correspondence the UE transmission may be incorrect/lost.~~

- Small data transmission ~~is supported~~ in RRC inactive state from R17 ~~also~~ on RACH-SDT resources~~. Also there are no requirements for RACH transmission in idle mode but RACH at initial access is quite critical to prevent delay in setup. Beam correspondence is therefore needed for initial access~~

**4 – Ericsson LM**

We fully support all the three objectives.

To Apple: The UE sends RACH in idle mode and can be tested like several RRM requirements are tested today in idle mode. Furthermore, small data transmission in RRC inactive state is R17 feature. It allows the UE send data both via RACH or via configured resources (PUSCH). It is one time transmission and beam selection is based on associated SSB resources. If it fails then the UE has to drop data. It is quite important to verify beam correspondence requirements for RRC_INACTIVE and initial access.

To MediaTek: HO test does not guarantee that the UE does proper beam selection and meets BC requirements for data transmission in RRC_INACTIVE and initial access. Secondly BC requirements are RF core requirements. Also there are no RRM core requirements corresponding to BC.

**5 – Intel Corporation (UK) Ltd**

**FR2 switching time enhancements**

We are ok with moderator comment to keep switching time enhancements as a candidate working area with some modifications in the future meeting. However, it is not listed in additional objectives and we prefer to list it explicitly along with other objectives in the summary.

**Other proposals** on beam correspondence, spherical coverage and power-control tolerance require further assessment and we propose to come back at a later stage. BC for RRC_INACTIVE depends on an ongoing

Rel-17 discussion. For spherical coverage enhancements we are interested to know if any field issues are observed and whether the requirements shall be based on rough/fine beam assumptions.

**6 – ZTE Corporation**

we also fully support the beam correspondence requirements for RRC_INACTIVE and initial access especially considering small data tranmission in inactive state supported in Rel-17.

**7 – Sony Group Corporation**

we support the proposals

**8 – Huawei Technologies France**

All RF requirements, including Tx and Rx, defined in TS 38.101 are for all physical channels that is possibly in Idle, Inactive or connected state. However, considering most RF requirements are defined in average approach with at least 1ms, RAN4 specify the RMC(reference measurement channel) under connected state for requirement verification. So now, almost all RF requirements are verified under RRC_connected state, it doesn't mean these RF requirements cannot be used for other states and configurations.

4.2.3.2 Summary for final round

4.2.3.2.1 Objectives which seem more acceptable

Nokia proposed to add note to clarify that how to organize the projects needs further discussion and all the options are on the table. LGE, Intel clarified that RF enhancement in FR2-1 for 39GHz band is for Uu.

Moderator: to AT&T comments about other topic, in my understanding, the other work area in this FR2 enhancement topic or other topic might be discussed in December RAN plenary depending on RAN chair guidance, will be discussed in February email discussion and March 2022.

The prioritization and how to organize the project will be discussed in the future meeting. In this email thread, companies are supposed to focus on stabilizing the objectives.

Based on the feedback, the moderator modified the proposal.

- **Proposal #5-1: For UE FR2 requirement evolution, the following objectives can be considered**
  - Investigate and if possible, enable UL 256QAM for FR2 (RAN4)
    - Study the gain, operating SNR, implementation aspects
    - Specify the UE RF requirements
    - Specify the BS demodulation performance requirements
  - RF enhancement in FR2-1 for 39GHz band (RAN4)
    - ~~FFS whether it is for sidelink, Uu or both~~
    - Vehicular UE requirements for power class in 39GHz
    - Vehicular UE requirements for inter-band DL/UL CA, e.g., 28+39GHz

NOTE: for the above working areas (two big bullets), how to organize the projects in terms of WI and/or SI needs further discussion after stabilizing the scope.

#### 4.2.3.2.2 Inter-band and intra-band DL/UL CA/DC RF requirement

Nokia and Intel commented on Proposal #5-2. The intention of #5-2 is to drop both enhancement for FR2-2 only and enhancement for FR2-1+FR2-2, in other words support of CA/DC between FR2-1 and FR2-2 based on CBW/IBM. But Intel proposed to keep it and wait for the progress in Rel-17 before final decision. The moderator thinks keeping it for the time being is OK.

Based on the feedback, the moderator propose to consider proposal #5-3 only as conclusion in the final round for this working area.

- **Proposal #5-3: For UE FR2 requirement evolution, the following objectives can be considered**
  - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators' requests (RAN4)
    - Define RF requirement for support of inter-band UL CA in FR2-1 based on CBM
      - Take the capability alignment between UL and DL CA into account, e.g., only consider the case where DL CBW is available

#### 4.2.3.2.3 Additional objectives

For the enhancement for idle and inactive mode (including beam correspondence, spherical coverage, maybe power-control tolerance), Apple, Mediatek, Intel, Huawei expressed the concern on the necessity, while Nokia, Ericsson, ZTE and Sony supported them. More discussions are needed.

Moderator: to Intel, all the proposals including FR2 switching time enhancement will be included in the list of the summary.

Based on the feedback, the additional objectives for UE FR2 requirements evolution need more discussion. No conclusion is reached for them in this email discussion.

## 4.3 BS RF requirements evolution

### 4.3.1 Initial round

#### 4.3.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***BS RF requirement focus evolution***

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- BS RF requirements evolution
  - Potential justifications:
    - TBD
  - Potential objectives which seem controversial and need more discussions:
    - mmWave multi-band BS (RAN4) (Refer to RP-212483)
      - Specify RF requirements for mmWave BS capable of multi-band operation
    - Home base station (HBS) (RAN4) (Refer to RP-211986)
      - Specify RF requirements for BS
      - Specify conformance testing requirements
    - Requirements for NTN BS Type 1-O
      - Investigate reference architecture
      - Specify RF requirements
      - Specify conformance testing requirements
  - Leading working group:
    - RAN4
  - SI or WI:
    - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether the secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 31:**

**1 – Ericsson France S.A.S**

Ericsson: Regarding the mmWave multi-band BS, in our view 28+39GHz multi-band support is still far enough away technology wise that it is not essential for Rel-18. On the other hand, it is not difficult to specify. A prioritization can be made when the extent of the rest of the package is clearer.

Regarding the home BS, we would like to clarify the extent of the work needed. Most requirements can in principle be copied from E-UTRA, or are the same for LA. Regarding the output power, if a WI would need a co-existence simulation then the workload would become high as there are a lot of other proposals requiring co-existence (NTN, ATG, Full Duplex etc.). Is the intention to keep the same demod requirements as for the other BS classes ? We are concerned about creating co-existence work due to workload.

Regarding NTN BS type 1-O, we think that this should be solved in Rel-17 NTN.

After further analysis, we have identified a further area that should be discussed and considered; simplification of the declarations. There are a large amount of declarations around EIRP (beam centre, beam peak etc.) and RX (redirection of OSDD). Having now moved further with AAS, not all of these seem needed. Our understanding is that there is a desire in e.g. harmonized standard to reduce the amount of declarations.

So we propose to add: “Investigate and if possible simplify declarations” as an objective to discuss and welcome feedback.

Not sure how this should work in terms of formal organization; possibly some things could be merged into a "BS Enhancements" WI similar to the UE RF enhancements.

**2 – China Mobile Com. Corporation**

For Home Base Station, as we discussed in previous email discussion, from CMCC perspective, we see clear market demand for HBS to enhance indoor coverage as a cost-effective solution.

To Ericsson: co-existence evaluation is one of the most important responsibilities in RAN4. RAN4 has full experience of performing co-existence simulation; we don't think requiring co-existence can be a reason to object introducing HBS in Rel-18. Without co-existence simulation, we cannot define proper requirements for NR HBS. Regarding demodulation, we do not propose to specify new demodulation requirements for HBS.

For NTN BS type 1-O, there is ongoing discussion in Rel-17 NTN WI. This can be treated within NTN WI, no need to create a single WI.

**3 – Nokia Japan**

For mmWave multi-band BS, we would like to understand if there is any operator interested in this BS and for which frequency bands.

**4 – Samsung Electronics Co.**

mmWave multi-band BS (RAN4)

-

We would like to get feedback from companies for realistic band combinations especially the input from operators.

-

NTN BS type 1-O

This is pending on Rel-17 NTN WI progress, in current stage not clear whether 1-O will be covered by Rel-17.

**5 – ZTE Wistron Telecom AB**

(1) mmWave multi-band BS:

More inputs from operators on deployment scenarios, target frequency groups, etc., would very be helpful for feasibility discussion.

(2) Home BS:

We understand that there is a clear market demand. And reusable requirements may reduce the required work for Home BS.

(3) NTN BS type 1-O:

At this moment, we don't see a need to create a new WI in Rel-18 since it is discussed in the Rel-17 NTN WI.

**6 – Huawei Technologies France**

Requirements for FR2 BS are full OTA based, but so far the mmWave BS requirements are only applicable for single FR2 operating band. However, inter-band CA band combinations are already supported for FR2, the TAE requirements for intra-band CA for the BS may limit the performance of common beam

management under these conditions. A multi-band BS implementation would easily meet any tighter TAE requirements and enable better common beam management for inter-band CA cases. Beyond the inter band CA beam management multi-band BS can have advantages for efficient radio design and power sharing between bands which have been seen in the implementation of FR1 dual band systems.

For mmWave multi-band BS, the implementation could be single active component supporting multiple bands, or multi bands are supported by separate RF chains but within the same module, which is similar as that for FR1 MB BS. Regarding the specific requirements for supporting mmWave MB BS, we can bring some inputs in Nov RAN4 meeting for companies with questions in previous discussion for better understanding of the spec impact. Regarding the workload, since FR1 has already supported MB BS, which could be good example for deriving the requirements for FR2. Not much workload are expected.

The possible objectives for the mmWave MB BS could be: Specify RF requirements core requires for FR2 multi-band BS:

- Check FR1 multi-band methods are applicable for FR2, agree appropriate inter RF BW gaps
- Check FR1 exceptions are acceptable for FR2
- Modify appropriate sub-clauses for core RF specification to include FR2 multi-band
- Modify appropriate sub-clauses in EMC specification

#### 4.3.1.2 Summary for initial round

Six companies provided the feedback. Moderator would like to provide the summary for each working area.

**mmWave multi-band BS**

Ericsson commented that supporting 28+39GHz multi-band is not urgent and difficult to specify. Nokia questioned if there is any operator interested in it. Samsung and ZTE also would like to get the input from operators.

Huawei provided the responses and justification for mmWave multi-band BS.

**Home BS**

Ericsson thought most requirements would be copied from E-UTRA, and for output power the co-existence simulation is needed. Besides, Ericsson commented whether the same demodulation performance requirements for other BS classes will be kept. It seemed that workload is the worry.

CMCC provided the responses on co-existence work and clarify the market demand. ZTE supported it.

**NTN BS Type 1-O**

Almost all the companies involved in this discussion thought there is no need to create a dedicated WI rather treating it in Rel-17 NTN WI.

Moderator would like to suggest dropping it.

**Others**

Although it was not proposed during previous June workshop and September email discussion, Ericsson proposed the new topic:

- Investigate and if possible simplify declaration.

For the detailed information, please refer to Ericsson comment in the initial round.

From moderator perspective, it is the late proposal but we can still collect the comments from companies for it. It is not encouraged for companies to provide more new input for this RAN4 Rel-18 package which has already been huge.

### 4.3.2 Intermediate round

#### 4.3.2.1 Proposals and comments collection

**Objectives which seems more acceptable**

- Potential objectives which seem less controversial
  - Home base station (HBS) (RAN4)
    - Specify RF requirements for BS
      - Co-existence simulation for defining the requirements
    - Specify conformance testing requirements
    - No new demodulation performance requirement is needed

Please provide further feedback on the above bullets.

**Feedback Form 32:**

| |
|---|
| **1 – ZTE Corporation**<br>Regarding this sub-bullet, we are not sure what kind of coexistence study might be needed if E-UTRA Home eNB requirements are reused for NR Home gNB.<br>Co-existence simulation for defining the requirements |
| **2 – Ericsson France S.A.S**<br>Regarding the co-existence study, our general concern is that there are a lot of different proposals requiring co-existence study (e.g. NTN above 10GHz, ATG, HAPS, Full Duplex, possibly smart repeater). To move forward, it would be helpful to understand what the scope of a co-existence study would be and which requirements would be impacted. Presumably UE requirements should not be changed. So the co-existence study could impact BS transmit power and emissions, and BS sensitivity. The scenarios would presumably be (i) for DL, a HBS creating interference towards a user connected to an outdoor macro (with low RX power) on the next channel, (ii) HBS sensitivity being too poor and causing indoor users to transmit with large power, impacting other layers, (iii) interference between different indoor HNB. Feedback welcome if these scenarios are correct or if other scenarios should be considered. Then, it may be good to consider further if any simplifications are possible and what is re-usable from previous generations studies. Also is (iii) relevant if the HNB is in a home ? Also, it may be good to clarify which bands are targeted; this impacts both the amount of work needed and what simplifications may be feasible. The aim with such a consideration would be to understand the scope and workload. |

**3 – China Mobile Com. Corporation**

Thanks for the detailed comments on co-existence scenario. The scenarios mentioned by Ericsson are the key scenarios that need to be evaluated for defining HBS requirements. Whether other scenarios should be considered also depends on the input from interested companies. Also, we think the detailed co-existence scenarios can be further discussed in WG. The detailed scenarios do not need to be captured in the WID.

E-UTRAN HBS requirements can be considered as baseline when define NR HBS requirements. We are also interested in studying whether any requirements can be relaxed for NR HBS for the sake of cost reduction.

Regarding the bands, from CMCC perspective, we consider TDD n41 as example band.

**mmWave multi-band BS**

Please proponent respond the comments from other companies and provide more justifications.

**Feedback Form 33:**

**1 – Ericsson France S.A.S**

One response to Huawei comment "For mmWave multi-band BS, the implementation could be single active component supporting multiple bands, or multi bands are supported by separate RF chains but within the same module, which is similar as that for FR1 MB BS. ". For the latter case of multi-bands supported by separate RF chains, according to the definition for FR1 this is then not a multi-band basestation: (From 38.104)

**multi-band connector**: *Antenna Connector* of *BS type 1-C* or *TAB connector* of *BS type 1-H* associated with a transmitter or receiver that is characterized by the ability to process two or more carriers in common active RF components simultaneously, where at least one carrier is configured at a different *operating band* than the other carrier(s) and where this different *operating band* is not a *sub-band* or *superseding-band* of another supported *operating band*

**multi-band RIB:** *operating band* specific RIB associated with a transmitter or receiver that is characterized by the ability to process two or more carriers in common active RF components simultaneously, where at least one carrier is configured at a different *operating band* than the other carrier(s) and where this different *operating band* is not a *sub-band* or *superseding-band* of another supported *operating band*

So the multi-band requirements would apply for cases where the bands are processed through common RF components. As mentioned before, it may not be urgent to cover 28+39GHz in common RF in Rel-18 timescale, although it could be decided in the context of an overall prioritization of RAN4 workload.

**2 – Huawei Technologies France**

Thanks Ericsson for the clarification. It seems the MB requirements for sub-6GHz do not exclude the implementation of multi chain for multi-bands. But that could be further clarified in RAN4. And we also bring a discussion paper for the upcoming RAN4 meeting.

As for the deployment scenario, actually FR2 inter-band CA was introduced from Rel-16, and the band combinations are already captured in the specification, i.e. CA*n257-n259, CA*n258-n260 and CA_n260-n261. And band combinations are continuously discussed in Rel-17. As we explained, the spectrum may not be acquired at the same time and the capacity is increased gradually for the deployment. A mmWave MB-BS would be suitable for the deployment evolvement as well as the cost reduction for operators.

Regarding the workload, we think the BS topics are equally important as those for UE side for the industry. And based on the proposals, we see more less BS topics are under discussion. So we don't think the work load would be an issue for the BS RF session in RAN4.

3UK commented to support WID on mmWave MB-BS WI. 3UK do have licenses for 42GHz and 28GHz spectrum

**Others**

Ericsson proposed the following working area with some short justifications

- Investigate and if possible simplify declaration.

Please provide the feedback and comments on the proposal.

**Feedback Form 34:**

**1 – ZTE Corporation**

More clarifications and motivations might be needed, why some declaration parameters might be not needed anymore.

**2 – Ericsson France S.A.S**

We appreciate that this is a rather late proposal and will discuss offline with interested companies what/whether simplifications may be identified. If there is consensus that some simplifications can be made, then a means to achieve this in Rel-18 should be found, but actually we do not intend to propose any longer study.

**3 – Ericsson France S.A.S**

Possible simplifications include: Removal of declaration of both beam centre and beam peak directions (was originally introduced in case beams have ripple, but now with AAS experience maybe not needed), beamwidth (not relevant to requirement applicability and testing), redirection of OTA sensitivity range (implies RET on AAS).

**4 – Huawei Technologies France**

It's a bit late to see such a new proposal for BS topic. We would like to better understand the motivation with more discussion.

**5 – Nokia Japan**

At this moment, we are not sure for instance, how much simplification do we get in the end if these declarations are anyway not used.

It would be great if Ericsson could provide more details with justifications. Then, we can further discuss this topic in the next RAN.

4.3.2.2 Summary for intermediate round

**Objectives which seems more acceptable**

Ericsson provided more detailed explanation on co-existence study. CMCC commented that those co-existence scenarios can be done in WI phase and make clear that the example band should be n41.

**mmWave multi-band BS**

3UK commented to support WID on mmWave MB-BS WI. 3UK do have licenses for 42GHz and 28GHz spectrum.

Ericsson provided the responses and Huawei also provided responses further. It seemed that during this meeting the group cannot reach consensus on this working area. Moderator suggests to further discuss it in future meeting.

**Others**

Regarding Ericsson's proposal to simplify declaration, three companies provided the feedback and needed more time to understand the motivation and proposed simplifications. Moderator suggests to further discuss it in future meeting.

### 4.3.3 Final round

#### 4.3.3.1 Proposals and comments collection

**Objectives which seems more acceptable**

Based on the feedback, the moderator would like to suggest the following objectives for discussion in the final round.

- **Proposal #6-1: for BS RF requirement evolution, the following objectives can be considered:**
  - Home base station (HBS) (RAN4)
    - Example band is n41
    - Specify RF requirements for BS
      - Identify the scenario and conduct co-existence study for defining the BS requirements
    - Specify conformance testing requirements
    - No new demodulation performance requirement is needed

Please provide your comments in table below.

**Feedback Form 35:**

| |
|---|
| **1 – Ericsson France S.A.S**<br>For co-existence study, it would be useful to discuss further on what kind of simulation campaigns are needed (or whether other lighter methods of assessing co-existence are feasible in this case), and what the scenarios are. This can be discussed/checked more offline and in future rounds. Agree that the details can be done during the WI, just good to understand the overall scope and workload. |

**2 – CATT**

It is found that there is no BS RF general evolution area, but there are general evolution area for UE RF, RRM and demod. we think it would be beneficial to have 2 areas for BS side, one is new items and one is leftovers from R17. we can try to complete as much as possbilt in Rel-17, but not sure we can always managed to do so. Maybe this comment is a little late, but i think it is better for work organization.

#### 4.3.3.2 Summary for final round

Ericsson commented on the objective for co-existence study. The intention is to know how to conduct the co-existence study and on what scenarios in order to evaluate the workload. CATT suggested to keep Rel-17 leftover issues as the working areas. There was no discussion on it during this email thread. But as respond before, the moderator will list the proposals from companies in the summary section.

Based on the feedback, the moderator would like to add a note for proposal #6-1 to address Ericsson's comment.

- **Proposal #6-1: for BS RF requirement evolution, the following objectives can be considered:**
  - Home base station (HBS) (RAN4)
    - Example band is n41
    - Specify RF requirements for BS
      - Identify the scenario and conduct co-existence study for defining the BS requirements
    - Specify conformance testing requirements
    - No new demodulation performance requirement is needed

NOTE: Further discuss on what kind of simulation campaigns are needed and what the scenarios are in the future meetings before Rel-18 RAN4 package approval.

## 4.4 EMC enhancement

### 4.4.1 Initial round

#### 4.4.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***Test enhancement and EMC enhancement, with following areas***
  - *EMC enhancement for both UE and BS*

The comments, questions, and responses in the August pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- EMC enhancements
  - Potential justifications:
    - (Refer to RP-211825)
  - Potential objectives:
    - UE EMC enhancement
    - BS EMC enhancement
      (Refer to RP-211825)
  - Leading working group:
    - RAN4
  - SI or WI:
    - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, and whether it should be SI or WI.

**Feedback Form 36:**

| |
|---|
| **1 – China Telecommunications**<br>We support the EMC WI, which was already postponed from Rel-17. |
| **2 – Nokia Japan**<br>This should be handled if there are available TUs after approving WI/SI for other areas. |
| **3 – Samsung Electronics Co.**<br>This is one of proposals dropped in Rel-17. We are supportive on the proposal under the condition that limited meeting effort should be assigned on EMC. |
| **4 – China Unicom**<br>The scopes of EMC enhancements are very clear and stable. We support this WI in Rel-18. |
| **5 – Huawei Technologies France**<br>In general, we are supportive for the EMC work in Rel-18. A package BS WI could be considered if needed, and EMC can be one of the part in the WI together with other possible aspects. |

**6 – Ericsson LM**

We support the EMC WI. The WID has been stable even for Rel-17. The amount of effort required to complete the WI is limited in terms of required TU. However, we fully agree that EMC like other items are part of Rel-18 package.

#### 4.4.1.2 Summary for initial round

Six companies provided comments. The justification and scope in the draft WID RP-211825 seems acceptable.

Given that situation, moderator would like to suggest stopping the discussion for this topic in this email discussion. In the future, the moderator will recommend putting it into Rel-18 RAN4 package and discuss together with other potential RAN4 items with stable contents.

### 4.4.2 Intermediate round

There is no need of intermediate round and final round for this topic.

### 4.4.3 Final round

## 4.5 OTA testing enhancement

### 4.5.1 Initial round

#### 4.5.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***Test enhancement and EMC enhancement, with following areas***
  - *OTA testing enhancement*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- OTA testing enhancements
  - Potential justifications:

        - Address the industry need for more advanced UE testing in environments that are closer to field operation
            - Faster changes in signal directions and/or fast channel variation
            - Current RRM/beam management tests are very simplistic with most 2 signals coming from different directions and long dwell time
            - Need to verify multi-panel UE performance.
        - Power classes targeting at FWA devices in FR2 have been introduced from Rel-15 (PC1, more recently PC5), and RF and RRM requirements were defined, however, there is no testing methodology in 3GPP.
    - Potential objectives which need more discussions
        - Dynamic OTA and 4DL OTA testing for FR2/FR2-2
        - Testing framework for FR2 FWA devices (PC1/PC5 in FR2)
        - FR2 OTA testing for UEs with multi-panel reception
    - Leading working group:
        - RAN4
    - SI or WI:
        - SI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 37:**

**1 – China Telecommunications**

We support the dynamic OTA testing. With the purpose of guaranteeing FR2 UE performance/requirements in mobility and rotation status, we see the benefit of this study.

For 4DL OTA testing for FR2/FR2-2 and FR2 OTA testing for UEs with multi-panel reception, maybe they can be discussed together with the requirements for FR2 multi-Rx chain DL reception? In general we are supportive of this work.

**2 – Nokia Japan**

We support to enhance OTA testing method. At this stage, we would likely not need to include FR2-2 in order to limit the scope of the SI. This study should focus on addressing issues real deployments in real market and standardization. Additionally, it would need to ensure better testing of UE core requirements for UE with single and multi-panel/beam reception. The latter means that due to lack of clear testing availability, requirements for example for multi-panels have been put on hold. However, more clarification on the objectives is necessary. For instance, multi-panel reception is not clear enough since it is simultaneous multi-panel reception at an instance or multi-panel reception by switching panels. Additionally, it also needs to discuss multi-Rx/beam reception in a generic manner. We should discuss if simultaneous multi-panel transmission or multi-panel transmission by switching panel is included or not.

The objectives should be revisited based on the latest Rel-17 status and Rel-18 WI including relevant aspects.

**3 – MediaTek Inc.**

- Dynamic OTA testing: Supportive, but prefer to be limited in FR2-1. Whether to include FR2-2 can be further discussed, though we do not see the urgency.
- FR2 4layer: Need core requirements first

**4 – QUALCOMM JAPAN LLC.**

We see the need for these testing enhancements and RAN4 needs to take on this work to deliver solutions for the industry. For the dynamic OTA, a SI was already proposed in the last release so the contents should be relatively stable. Since the proposal was already on the table for a long time, it would be useful to get comments as early as possible. The proposal only had FR2-1 in mind so we would have no problem to limit to this frequency range.

For the FR2 FWA, this is needed to enable the testing of these devices such that commercialization at scale becomes possible. This work will leverage the Rel.15 OTA testing work by checking which assumptions used in deriving the test methodology have to be modified to enable a larger quite zone(>15cm) and larger radiating arrays. The work should be straightforward.

For the OTA testing with multi-panel, this is needed to enable testing of features introduced in FeMIMO in Rel.17 and also the 4L FR2 OTA. Without a testing solution, these advanced features will be difficult to deploy in practice. We believe this could go in parallel with the requirements definition.

Based on the experience so far, it takes a very long time from the start of an OTA study in RAN4 until testing solutions become availabel(test equipment is developed and produced by TE vendor) so starting as early is possible is highly desirable. This observation is valid for all the proposals here.

**5 – Samsung Electronics Co.**

<u>Dynamic OTA testing</u>

We prefer to first study the test methodology instead of introducing new requirement in initial phase.

<u>FR2 OTA testing for UEs with multi-panel reception and 4DL layer for FR2-1,2-2</u>

This pending on whether core requirements will be introduced in Rel-18.

We are open to have a basket OTA test enhancement SI with all objectives.

**6 – Intel Corporation (UK) Ltd**

- FR2 OTA testing for UEs with multi-panel reception
  - We support the proposal. OTA test methods for enhanced UEs with multi-panel reception capabilities shall be studied to ensure proper testing of the high end FR2 devices. The objectives shall be adjusted subject to discussion on the scope of respective work under section 5.5
- Testing framework for FR2 FWA devices (PC1/PC5 in FR2)
  - We support the proposal. The current test methods are focused on handheld PC3 devices. Further extension of test methodology for FR2 PC1/PC5 devices and also PC3 devices with different form factors can be beneficial to ensure a consistent framework for mmWave device testing.
- Dynamic OTA testing
  - We are ok with the studies
- We also support the idea to have a basket SI on FR2 OTA enhancements

**7 – SAICT**

In general, we are interested in the study of the enhanced OTA test methods. For dynamic OTA, we should focus on the test methodology, and consider the progress of Rel-17 MIMO OTA WI to decide whether to introduce new requirements. At present, the FR2 MIMO OTA requirements for the R17 phase have not yet been formulated.

In addition, we also prefer to focus on the FR2-1 first to make the scope reasonable.

**8 – Huawei Technologies France**

For dynamic OTA test, we still think that it has high relation with the current 'static' MIMO OTA test methodology, the validation principle and metric for MPAC chamber is still unclear and not standardized. The corresponding test parameter is private implemented, which has big difference among different vendors. Before we have substantial progress on 'static' FR2 MIMO OTA test methodology, we don't see the possibility to study dynamic OTA that do not have any prerequisite knowledge. Also we think that the targets by dynamic OTA tests has already been covered by existing tests and existing methodology adopted by the industry.

**9 – Apple AB**

l Dynamic OTA and 4DL OTA testing for FR2/FR2-2

In the existing tests, UE beam management performance and 2AoA have been supported. We need to understand the extra info/requirements we look for. Also it is unclear why 4DL for FR2 need to be considered since all requirements are based on the assumption of up to 2 DL MIMO layers.

l FR2 OTA testing for UEs with multi-panel reception

This can be discussed after RAN4 start working on multi-panel reception requirements.

**10 – Verizon UK Ltd**

We support the dynamic OTA for FR2 and support the OTA testing with multi-panel for 4L FR2

#### 4.5.1.2 Summary for initial round

Ten companies provided the comments. Eight companies are supportive to the work. Huawei and Apple were not convinced for dynamic OTA testing and testing with multi-panel reception and 4DL for FR2.

### 4.5.2 Intermediate round

#### 4.5.2.1 Proposals and comments collection

Concerns from Huawei and Apple need be addressed. Please proponent provide the responses.

Based on the feedback and comments, the moderator would like to suggest discussing on the following potential objectives.

- Potential objectives which need more discussions
  - Dynamic OTA testing method for FR2-1
    - No intention to introduce the new RAN4 requirements in Rel-18

        - Take the test method and outcome in Rel-17 MIMO OTA WI into account
    - Testing framework for FR2 FWA devices (PC1/PC5 in FR2)
    - FR2 OTA testing for UEs with multi-panel reception and 4DL layer for FR2-1
        - Depend on the status of other Rel-18 RAN4-led items proposal where core requirements will be specified
        - Decide whether simultaneous multi-panel reception or multi-panel reception with switching between panels should be considered

Please proponent respond the comments from other companies. Please companies comment on the moderator's proposal.

**Feedback Form 38:**

**1 – China Telecommunications**

Ok with the objective for dynamic OTA.

For multi-panel reception, regarding the "**simultaneous** multi-panel reception" or "multi-panel reception with **switching between panels**", we understand the objective was updated based on the comment by Nokia in the initial round. In our understanding, to align with the objectives for the core requirements for 4-layer DL, at least "**simultaneous** multi-panel reception" should be kept.

**2 – Apple AB**

We still don't see much additional info dynamic OTA can provide on top of existing multiple-AoA and beam management tests. Clarification is needed.

The other proposals from the moderator look reasonable to us.

**3 – QUALCOMM JAPAN LLC.**

Response to Huawei's comments:

Regarding the relation with Rel-17 MIMO OTA WI, test methodology for 'static' MIMO OTA has been completed in Rel-16 MIMO OTA SI. The current Rel-17 WI on MIMO OTA are focusing the 'static' requirements development. The dynamic OTA SI is to study the dynamic test methodology, not to define any new requirements. Therefore, the progress for the current Rel-17 WI on MIMO is should not have any impact on the new Rel-18 dynamic OTA SI.

Regarding the targets, the current FR2 OTA testing is static, i.e., either fixing the test direction during the test or giving enough beam dwell time with multiple test directions, so the UE beam management has not been really verified in 3GPP. We are looking forward the 3GPP solution to test the real UE performance. Proprietary approach from industry will increase the test cost as we already stated mutliple times.

We believe the current testing does not address even some relatively basic scenario like UE rotation and maintaining the connection.

Response to Apple's comments:

Regarding the difference between existing tests, please refer to our response to Huawei. In addition, as we clarified, no additional requirements will be defined in this dynamic OTA SI. The aim is to develop a new test methodology.

Regarding DL 4L and multi-panel, multi-panel is needed for DL 4L. We expect multiple probes (e.g., MPAC) will be used for both multi-panel and dynamic OTA. Considering the forward compatibility, we'd like to include multi-panel in dynamic OTA SI.

In general, we are OK with proposals from moderator. For the third bullet, test method has been completed in Rel-16 MIMO OTA SI. And the Rel-17 WI is to specify the MIMO OTA requirements that will have no impact on the Rel-18 dynamic OTA.

We already commented a few times that there won't be any new requirements defined. After developing the test methodology, the most that could be done is introduce some tests based on the existing core requirements.

Any proposal to modify the RRM core requirements would have nothing to do with this SI, would have to come from some observed need for enhancements(e.g. some proof that UEs meeting current requirements have very poor field performance in certain scenarios).

Regarding simultaneous vs. non-simultaneous multi-panel reception, our understanding is that the test setup would be very similar or the same since even with non-simultaneous, the switching is fast enough not to allow re-positioning of the DUT or probes in the chamber. The only thing that might differ is the level of interaction/interference between the signals coming from different probes. For this, there could be different ways of handling it. The best would be anyway to have a full solution supporting simultaneous also so that we have forward compatibility.

The fact that multi-panel will happen sooner or late is quite clear so the study for testing should be started right away. it takes a long time from the start of developing a test method until it becomes available for conformance testing. Lack of testing should not delay(to the extent possible) deployment of features. Also, looking at testing early might provide inputs to the requirements development.

**4 – Intel Corporation (UK) Ltd**

- We are fine with moderator summary.
- Dynamic OTA testing: we agree with no intention to introduce requirements and ok to focus on FR2-1
- Testing framework for FWA: we are ok with the proposal but prefer not to preclude additional form factor devices. In addition for this objective we prefer to further discuss FR2-2 subject to Rel-17 progress,
- Multi-panel and 4DL layers: we agree that the objective needs to be considered in case corresponding requirements are decided to be introduced. Agree with Qualcomm that test methods development takes time and lack of test methods can delay the adoption of multi-panel devices.

**5 – Nokia Japan**

At this moment, we can live with the proposed objectives due to limited time, but the objectives should be further refined in the next RAN. For instance, it is hard to understand what we want to specifically achieve with dynamic OTA testing…

**6 – Huawei Technologies France**

For dynamic OTA testing, we are not convined that the current Rel-17 MIMO OTA has no impact on the Rel-18 proposal. As for Proprietary approach for the industry, if the tests are already there, what's the benefit for additional 3GPP test methods? It's just a burden for the measurement.

For FWA testing framework, not sure why the existing test methods cannot be applied.

#### 4.5.2.2 Summary for intermediate round

Six companies provided comments in this round.

Apple and Huawei were not convinced for dynamic OTA testing yet, although the proponents clarified the motivations. The concerns from Apple and Huawei were still whether there is benefit of new testing method given that there exist multi-AoA and beam management tests, and whether Rel-17 MIMO OTA work will impact the dynamic OTA testing work. Nokia can accept the bullets and would like to further understand what can be achieved by using dynamic OTA testing. Huawei questioned why the existing test method cannot be used for FWA testing framework. China Telecom commented to keep simultaneous transmissions for FR2 multi-panel reception testing. Intel wanted to discuss FR2-2 for FWA testing.

### 4.5.3 Final round

#### 4.5.3.1 Proposals and comments collection

Based on the feedback from companies, the moderator would like to suggest the following objectives for discussions in final round. Given the comment on FWA testing framework, the moderator puts the second big bullet in [].

- **Proposal #7-1: for OTA testing, the following objectives can be considered with understanding that some bullets need more discussions.**
  - Dynamic OTA testing method for FR2-1
    - No intention to introduce the new RAN4 requirements in Rel-18
    - Take the test method and outcome in Rel-17 MIMO OTA WI into account

undefined NOTE: to agree on the objectives for dynamic OTA testing method, further discussions on the benefit of dynamic OTA testing method compared to the existing multi-AoA tests and beam management tests are needed.

NOTE: to stabilize the objectives, further discussion on whether Rel-17 MIMO OTA will impact the work for dynamic OTA testing is needed

  - [Testing framework for FR2 FWA devices (PC1/PC5 in FR2)]
  - FR2 OTA testing for UEs with multi-panel reception and 4DL layer for FR2-1
    - Depend on the status of other Rel-18 RAN4-led items proposal where core requirements will be specified
    - Decide whether simultaneous multi-panel reception or multi-panel reception with switching between panels should be considered

Please the proponent respond to comments from companies if needed, and please other companies comment on the moderator's proposal.

**Feedback Form 39:**

**1 – Nokia Japan**

We are basically OK with the proposal, but we don't agree with adding [ ] to a bullet of "Testing framework for FR2 FWA devices (PC1/PC5 in FR2)". In addition, multi-panel reception handling shall be consistent with corresponding requirements discussion in another WI if that is included in Rel-18. Hence, we propose a following bullet is replaced with our alternative.

"Decide whether simultaneous multi-panel reception or multi-panel reception with switching between panels should be considered"

Should be replaced with

"How to handle multi-panel reception, i.e., assuming simultaneous multi-panel reception and/or multi-panel reception with switching between panels is decided depending on objectives to specify relevant core requirements in another WI"

**2 – QUALCOMM JAPAN LLC.**

We do not agree with the notes since we already provided enough explanations/clarifications to those questions. The simplest example of a test that doesn't exist today is UE rotation. the current 2AoA tests do not ensure that UE can appropriately switch Rx beams without interruptions to follow the strongest received signal.

It would be good if the companies arguing that there might be impact from the Rel.17 MIMO OTA work could provide some concrete examples. So far the comments only stated "concerns/we are not convinced" without any real substance.

Regarding the proprietary testing, we did not say these already exist. what we are saying is that if 3GPP does not do anything in this area, there will be proprietary implementations/tests that would lead to increased costs.

For FWA, we already clarified that the current conditions for PC3 OTA testing(quite zone size of 15cm, radiating surface size, far field distance, etc) are not suitable for FWA form factors. The test methodology is not directly reusable so a test methodology has to be developed.

Regarding simultaneous vs. non-simultaneous multi-panel reception, as we commented already, we do not think this will lead to a major change in the test setup/methodology.

**3 – Intel Corporation (UK) Ltd**

For **Testing framework for FWA** and other FR2 devices, in our understanding the existing FR2 framework is applicable to PC3 devices with a focus on handheld devices. The test grid and quiet zone assumptions depend on UE antenna array assumptions and form factor. So, certain modifications are required to enable testing of other devices type. In our understanding current test methods do not cover other device types and certain work in RAN4 and/or RAN5 is required.

**4 – Huawei Technologies France**

For dynamic OTA testing, we think the issues in the Notes are important to be further considered, thus the notes should be kept.

Regarding FWA test issue, currently quite zone size of 30cm, 40cm and 50cm are already agreed by RAN5. The measurement framework is available, which can be extended to FWA UE. We don't think it should be a RAN4 topic.

#### 4.5.3.2 Summary for final round

Nokia, Qualcomm proposed to remove the [ ] on FWA testing. Intel also commented that the test method for PC3 cannot be directly applied to FWA. But Huawei commented that RAN5 has already agreed multiple quiet zone sizes and the test method for FWA should not be RAN4 topic. The moderator would like to keep [ ] for further discussion.

For dynamic OTA testing, Qualcomm proposed to remove note, while Huawei would like to keep it. In the moderator view, other companies also had the comment and so the note seems need to be kept to move forward.

Nokia proposed the modification for multi-plan reception test.

Based on the feedback, the moderator modified.

- **Proposal #7-1: for OTA testing, the following objectives can be considered with understanding that some bullets need more discussions.**
  - Dynamic OTA testing method for FR2-1
    - No intention to introduce the new RAN4 requirements in Rel-18
    - Take the test method and outcome in Rel-17 MIMO OTA WI into account

undefined NOTE: to agree on the objectives for dynamic OTA testing method, further discussions on the benefit of dynamic OTA testing method compared to the existing multi-AoA tests and beam management tests are needed.

NOTE: to stabilize the objectives, further discussion on whether Rel-17 MIMO OTA will impact the work for dynamic OTA testing is needed

  - [Testing framework for FR2 FWA devices (PC1/PC5 in FR2)]
  - FR2 OTA testing for UEs with multi-panel reception and 4DL layer for FR2-1
    - Depend on the status of other Rel-18 RAN4-led items proposal where core requirements will be specified
    - ~~Decide whether simultaneous multi-panel reception or multi-panel reception with switching between panels should be considered~~
    - How to handle the multi-panel reception, i.e., assuming simultaneous multi-panel reception and/or multi-panel reception with switching between panels is decided depending on objectives to specify relevant core requirements in another potential WI proposal

## 4.6 ATG

### 4.6.1 Initial round

#### 4.6.1.1 Proposals and comments collection

**Previous discussion**

- ***Evolution of requirements across RF, RRM and demodulation, with the following example areas***
  - *Support of intra-band non-collocated EN-DC/NR-CA deployment (including FR, RRM and demodulation performance requirements)*
  - ***ATG (air-to-ground network)***
  - *[Co-channel HAPS]*
  - *Requirement for FR2 multi-Rx chain DL reception including 4-layer DL MIMO (including RF, RRM and demodulation requirements and OTA test methods)*
  - *[FR2 HST enhancement (including CA FR2, multi-panel simultaneous operation, high velocity supporting up to 500km/h)*
  - *NOTE: further prioritization for above items are needed in future meeting.*

The comments, questions, and responses in the August pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- ATG
  - Potential justifications: (Refer to RP-211985)
    - There are several regional commercial or trial in-flight networks based on hybrid techniques of ATG and satellite communication, such as Gogo's commercial network in USA, Inmarsat's commercial network in Europe, and CMCC's trial network in China. Regarding the hybrid network, satellite link focus on providing every-where connectivity (e.g., when cross the sea), while ATG link focus on providing high-quality data services for all service available areas (e.g., inland and coastline area).
    - Considering that ATG has the advantage of high throughput, low propagation delay, and low cost application, some operators and the aircraft industry have a strong request for the deployment of ATG, and it is urgent to start the standardization of ATG, especially for RAN4 requirements which is very important for the coexistence of ATG and IMT
    - The existing Rel-17 NTN WI does not specify the RF requirements of ATG, in order to avoid confusion and overloading of the NTN WI and the low dependency between RAN1-3 work and RAN4 work for ATG, it is proposed that the ATG RAN4 work is performed within the context of this ATG WI. The proposal to split off RAN4 work is exceptional for the NTN work due to the large and complex scope of covering quite different types of system and low dependency on RAN1-3
  - Potential objectives:
    - Core part: Specify features to core specifications of RF requirements for coexistence between ATG and IMT terrestrial network [RAN4]
    - Perf part: Identify and specify RRM/Demod requirements for ATG, taking into account the decisions/outcome of Rel-17 NTN work item.
      (Refer to RP-211985)
  - Leading working group:
    - RAN4
  - SI or WI:
    - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 40:**

**1 – China Telecommunications**

We also have domestic commercial and trial ATG deployments, and we support the ATG WI in Rel-18. Moreover, the scope has been well discussed in previous RAN meetings, and is very stable.

**2 – Ericsson France S.A.S**

Ericsson: ATG has been proposed since Rel-17 and the WI proposal is stable

**3 – LG Electronics Deutschland**

We support ATG to be included in Rel-18

**4 – China Mobile Com. Corporation**

ATG was proposed as a Rel-17 RAN4 WI from 2019. The WI scope is already quite stable after at least 4 rounds of email discussions tasked by RAN. Due to the high work load in Rel-17 RAN4, this WI proposal was postponed. Considering the clear and urgent commercial demand, ATG should be specified in Rel-18.

**5 – Nokia Japan**

RP-211985 is very helpful and our comments are objectives captured in it.

And we think it would be appreciated if the objectives are further clarified to understand what to do and to estimate workload.

For instance, there is a text saying that "Identify the FR1 potential band(s) to be used as example for ATG". Clarification on potential bands is highly appreciated in advance since based on the number of bands, the required TU number must be different. For instance, if the potential bands are 900 MHz and 4GHz, the required ACS/ACLR etc may be different. It means co-existence study should be done individually.

Another example is "Determine whether conducted, OTA or both types of requirement are required for both the BS and UE". If RAN4 concluded that OTA requirements for UE would be necessary, the amount of work must be huge since this is FR1 discussion and we only have very limited number of OTA requirement that took significant time to complete. And we would need a dedicated WI for OTA for FR1 as well.

Overall, required TU may change drastically according to the outcomes during the WI. Hence, we need to estimate the requited TU number in a conservative way to if it is not clarified. Hence, clarification is very appreciated.

**6 – MediaTek Inc.**

The scope is already very stable. We do not have a concern.

**7 – ZTE Wistron Telecom AB**

Considering the huge commercial demands and interests of ATG, and even some commercial trials have been conducted, its standardization is already far behind. Even with stable objectives, it was still precluded in Rel-17, however, we cannot afford to defer it again in Rel-18.

**8 – QUALCOMM JAPAN LLC.**

For ATG, we believe it would be useful to understand what can be reused from NTN to better estimate the amount of work. We understand this might be a bit difficult now but at least some high level guidance would be useful.

Also, will this work have any impact on other WGs?

**9 – Samsung Electronics Co.**

This is one of the proposals dropped in previous Rel-17 discussion. The proposal and objectives are clear and stable enough.

Our understanding, this is a pure RAN4 WI based on existing NR physical layer and L2/L3 design including specific features introduced under Rel-17 NTN WI.

There are several potential proposals which may be required co-existence study in RAN4 e.g.

l Home BS (RAN4 led)

l ATG (RAN4 led)

l NTN (Ka Band) (RAN2 led)

l Duplex evaluation (RAN1 led)

l HAPS

The co-existence study always time consuming and simulation resource consuming, we need to consider how to control the overall workload from co-existence effort aspect.

One question for clarification: What's the candidate frequency for ATG deployment, FR1 only or including both FR1 and FR2? Do we need to consider some specific frequency range as example band as starting point?

**10 – China Unicom**

The scope of ATG is very clear and stable. We are supportive to start this work in Rel-18.

**11 – Intel Corporation (UK) Ltd**

Recommend using objectives in RP-211985 as baseline.

#### 4.6.1.2 Summary for initial round

Ten companies provided the feedback. Most companies thought the existing WID are stable.

Nokia and Samsung commented on the frequency band to be investigated. Nokia also commented on whether OTA testing should be considered. Qualcomm commented that the group should know what requirements for NTN can be reused and whether it will impact the other WGs. Samsung commented on the workload issue for co-existence study considering quite a number of items need co-existence study.

### 4.6.2 Intermediate round

#### 4.6.2.1 Proposals and comments collection

The following questions and comments need further discussion in the intermediate round.

- What frequency range (FR1, FR2 or FR1 and FR2) and what bands need be considered in the proposed WID?
- Is OTA type of requirements should be introduced for BS and UE in FR1?

- What kind of requirements defined for NTN can be reused for ATG? Or we can simply put the objectives like ”reuse the existing NTN requirements as much as possible?
- Will this work have any impact on other WGs.

Please proponent(s) respond to those questions and comments. Please other companies provide further feedback.

**Feedback Form 41:**

**1 – China Telecommunications**

For the frequency band, we support to consider band n1 and n78 considering our deployment needs.

We don’t think this WI has other WG impact, excepting some potential regular work on the signaling part.

**2 – China Mobile Com. Corporation**

**What frequency range (FR1, FR2 or FR1 and FR2) and what bands need be considered in the proposed WID?**

The scope of ATG had already been discussed for almost two years, the scope is focused on FR1 (RWS-210338). Regarding the example band, from CMCC perspective, the band is n79. Considering different operators may have different interests on the bands, we prefer to identify the bands in WI phase based on more inputs.

**Is OTA type of requirements should be introduced for BS and UE in FR1?**

For BS OTA requirements, we prefer to determine whether OTA requirements are needed or not, this is the regular approach as other WIs. For UE OTA requirements, we did not propose in our WID (RWS-210338) to specify OTA requirements for UE.

**What kind of requirements defined for NTN can be reused for ATG? Or we can simply put the objectives like ”resue the existing NTN requirements as much as possible?**

ATG is different from NTN on co-existence scenario and the operating bands. Before the study and the co-existence simulation, we cannot conclude to reuse any NTN requirements.

**Will this work have any impact on other WGs.**

There is no impact on other WGs.

**3 – ZTE Corporation**

**What frequency range (FR1, FR2 or FR1 and FR2) and what bands need be considered in the proposed WID?**

Similar view as CMCC, this should be up to operators’ request and based on existing feedback from interested operators, FR1 could be starting point.

**Is OTA type of requirements should be introduced for BS and UE in FR1?**

Both BS type 1-C/1-H/1-O could be defined, we don’t see much difficulties to specify it.

**What kind of requirements defined for NTN can be reused for ATG? Or we can simply put the objectives like ”resue the existing NTN requirements as much as possible?**

Similar view as CMCC, this topic is different from NTN topic. we could further discuss it in the normative phase of this WID.

**Will this work have any impact on other WGs.**

We also don't see the impacts on other WGs;

**4 – Intel Corporation (UK) Ltd**

- Applicable FR: WI can be limited to FR1
- Type of requirements: Only conducted requirements shall be considered for UEs in Rel-17 scope. Conducted/OTA requirements can be considered for BS.
- Reusing NTN requirements: Overall we prefer to minimize requirements changes comparing to NTN and non-NTN designs for ATG. Same time it can be challenging to include a detailed list in WID. Therefore, we suggest keeping it up to WG-level discussion and provided recommendation to "strive to minimize changes comparing to Rel-17 requirements"
- WG impact: We do not expect impact on other WGs

#### 4.6.2.2 Summary for intermediate round

Four companies provided the responses to the questions. The answers seems clear that the work focuses on FR1 and the example band is n1, n78 and n79, only considers the OTA requirements for BS (the corresponding FR1 OTA tests have been specified for BS), may strive to minimize the work considering reusing the NTN requirements but companies cannot decide which requirements can be reused.

### 4.6.3 Final round

#### 4.6.3.1 Proposals and comments collection

Based on the feedback, the moderator would like to suggest the following objectives for discussions in the final round:

- **Proposal #8-1: for ATG, the following objectives can be considered**
  - Core part: Specify features to core specifications of RF requirements for coexistence between ATG and IMT terrestrial network [RAN4]
    - Example bands include n1, n78 and n79.
    - Consider BS type 1-C/1-H/1-O and specify the requirements
    - Consider conductive requirements for UE
  - Perf part: Identify and specify RRM/Demod requirements for ATG, taking into account the decisions/outcome of Rel-17 NTN work item. [RAN4]
  - For the whole WI, strive to minimize changes compared to Rel-17 requirements

NOTE: for more detailed information please refer to RP-211985

Please provide your comments in table below. □

**Feedback Form 42:**

**1 – QUALCOMM JAPAN LLC.**

Strive to minimize changes is too general of a statement, it could also mean nothing can be re-used. In our understanding, the actual work scope could change a lot depending on how much can be reused. The last bullet should be replaced with some list of requirements that can be reused and what exactly is needed. If this is not possible, then there should be an initial phase to identify what can be reused and what has to be newly specified.

**2 – Ericsson France S.A.S**

The objectives in RP-211985 have been discussed since Rel-17 scoping. These conclusions are OK, but in our view the objectives in RP-211985 should be kept as a basis and updated with some conclusions here on example bands, both OTA & conducted for BS and conducted for UE. ”Strive to minimize changes to Rel-17” does not clarify whether it means changes compared to NTN (Satellite) or compared to TN. It is of course good to maintain as much commonality as possible though (presumably with TN ?).

**3 – ZTE Corporation**

Regarding QC’s comments, we think that it’s better to discuss the detailed requirements in WG level just similar as other WIDs.

**4 – China Mobile Com. Corporation**

Regarding Qualcomm’s comments, as we commented in the intermediate round, ATG scenario is different from NTN, before the study and analysis, we cannot draw conclusion on the list of requirements that can be reused. This should be discussed in WG level. We don’t see any ambiguity on the current wording.

**5 – China Mobile Com. Corporation**

Dear all,

I list the objectives in RP-211985 that have been discussed since Rel-17 scoping and update some bullets regarding example bands and OTA/conducted requirements based on moderators’ summary.

I want to highlight that the objectives in RP-211985 already captures ”identify key characteristics where it is absolutely necessary to differentiate ATG BS and UE from ground based BS and UE, and aim to reuse existing requirements for BS and UE where possible”. **We think the following objectives can be considered as baseline for further discussion.**

==========

Specify features to core specifications of RF requirements for coexistence between ATG and IMT terrestrial network [RAN4]

- Identify key characteristics where it is absolutely necessary to differentiate ATG BS and UEs from ground based BS and UEs
  - Aim to reuse existing requirements for BS and UE where possible.
- ~~Study and specify the framework how ATG core requirements are defined.~~
- ~~This includes identifying whether the requirements are captured within the existing specifications or new specifications are created.~~
- ~~Determine whether conducted, OTA or both types of requirement are required for both the BS and UE~~
- Example bands include n1, n78 and n79.
- Consider BS type 1-C/1-H/1-O and specify the requirements, Consider conductive requirements for UE

- Consider conductive requirements for UE
- ~~Identify the FR1 potential band(s) to be used as example for ATG~~
- Perform FR1 co-existence evaluation for ATG network (e.g. ACLR, ACS)
- Specify new UE/BS type(s) for ATG network if necessary
- Taking into account identified differences between ATG and ground based systems
- Specify RF requirements for ATG UE/BS
- Considering the results of co-existence simulations in terms of impact on emissions and RX requirements, cell sizes and link budgets, technology capabilities, likely BS and UE architectures and other relevant aspects.
- Specify test procedures for ATG BS conformance testing
- ~~Determine at an early phase whether conducted, OTA or both types of testing are needed~~

Indentify and specify RRM/Demod requirements for ATG, taking into account the decisions/outcome of Rel-17 NTN work item.

- RRM core requirements for ATG UE. [RAN4]
  - Considering the different nature of ATG UEs and their view of the network, increased cell sizes and other relevant aspects.
- RRM performance requirements and test cases for ATG UE type. [RAN4]
- Demodulation performance requirements and test cases for ATG UE/BS. [RAN4]

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**6 – China Mobile Com. Corporation**

Dear all

I list the objectives in RP-211985 that have been discussed since Rel-17 scoping and update some bullets regarding example bands and OTA/conducted requirements based on moderators' summary.

I want to highlight that the objectives in RP-211985 already captures "identify key characteristics where it is absolutely necessary to differentiate ATG BS and UE from ground based BS and UE, and aim to reuse existing requirements for BS and UE where possible". We think the following objectives can be considered as baseline for further discussion.

==========

Specify features to core specifications of RF requirements for coexistence between ATG and IMT terrestrial network [RAN4]

- Identify key characteristics where it is absolutely necessary to differentiate ATG BS and UEs from ground based BS and UEs
  - Aim to reuse existing requirements for BS and UE where possible.
- ~~Study and specify the framework how ATG core requirements are defined.~~
- ~~This includes identifying whether the requirements are captured within the existing specifications or new specifications are created.~~
- ~~Determine whether conducted, OTA or both types of requirement are required for both the BS and UE~~
- Example bands include n1, n78 and n79.
- Consider BS type 1-C/1-H/1-O and specify the requirements, Consider conductive requirements for UE

- Consider conductive requirements for UE
- ~~Identify the FR1 potential band(s) to be used as example for ATG~~
- Perform FR1 co-existence evaluation for ATG network (e.g. ACLR, ACS)
- Specify new UE/BS type(s) for ATG network if necessary
- Taking into account identified differences between ATG and ground based systems
- Specify RF requirements for ATG UE/BS
- Considering the results of co-existence simulations in terms of impact on emissions and RX requirements, cell sizes and link budgets, technology capabilities, likely BS and UE architectures and other relevant aspects.
- Specify test procedures for ATG BS conformance testing
- ~~Determine at an early phase whether conducted, OTA or both types of testing are needed~~

Indentify and specify RRM/Demod requirements for ATG, taking into account the decisions/outcome of Rel-17 NTN work item.

- RRM core requirements for ATG UE. [RAN4]
  - Considering the different nature of ATG UEs and their view of the network, increased cell sizes and other relevant aspects.
- RRM performance requirements and test cases for ATG UE type. [RAN4]
- Demodulation performance requirements and test cases for ATG UE/BS. [RAN4]

#### 4.6.3.2 Summary for final round

Qualcomm commented that either the requirements to be reused should be identified before approval of WID or the initial stage to identify the requirements to be reused should be conducted in WI. Ericsson commented that the draft WID needs be updated to capture the tentative agreed objective and asked a question whether the new ATG requirements should be changed compared to NTN or TN. In the moderator view, both NTN and TN requirements can be reused.

Based on the feedback from proponents and comments from companies, the moderator modified the proposal #8-1.

**Proposal #8-1: for ATG, the following objectives can be considered**

- Specify features to core specifications of RF requirements for coexistence between ATG and IMT terrestrial network [RAN4]
  - Core part: Specify core requirements for coexistence between ATG and IMT terrestrial network [RAN4]
    - Example bands include n1, n78 and n79.
    - Perform FR1 co-existence evaluation for ATG network (e.g. ACLR, ACS)
    - Identify key characteristics where it is necessary to differentiate ATG BS and UEs from ground based BS and UEs
      - Aim to reuse existing requirements for BS and UE where possible.
    - Specify RF requirements for ATG UE/BS

        - Considering the results of co-existence simulations in terms of impact on emissions and RX requirements, cell sizes and link budgets, technology capabilities, likely BS and UE architectures and other relevant aspects.
        - Taking into account identified differences between ATG and ground based systems
        - Consider BS type 1-C/1-H/1-O and specify the requirements
        - Consider conductive requirements for UE
    - Specify RRM core requirements for ATG UE
        - Taking into account identified differences between ATG and ground based systems
        - Considering the different nature of ATG UEs and their view of the network, increased cell sizes and other relevant aspects
    - Specify new UE/BS type(s) for ATG network if necessary
  - Perf part: Identify and specify RRM/demodulation performance requirements for ATG, taking into account the decisions/outcome of Rel-17 NTN work item. [RAN4]
    - Specify test procedures for ATG BS conformance testing
    - RRM performance requirements and test cases for ATG UE type. [RAN4]
    - Demodulation performance requirements and test cases for ATG UE/BS. [RAN4]

NOTE: further refinement of objectives would be needed in the future meeting.

## 4.7 Co-channel HAPS

### 4.7.1 Initial round

#### 4.7.1.1 Proposals and comments collection

**Previous discussion**

- ***Evolution of requirements across RF, RRM and demodulation, with the following example areas***
  - *Support of intra-band non-collocated EN-DC/NR-CA deployment (including FR, RRM and demodulation performance requirements)*
  - *ATG (air-to-ground network)*
  - ***[Co-channel HAPS]***
  - *Requirement for FR2 multi-Rx chain DL reception including 4-layer DL MIMO (including RF, RRM and demodulation requirements and OTA test methods)*
  - *[FR2 HST enhancement (including CA FR2, multi-panel simultaneous operation, high velocity supporting up to 500km/h)*
  - *NOTE: further prioritization for above items are needed in future meeting.*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedbacks in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- Co-channel HAPS
  - Potential justifications:
    - TBD
  - Potential objectives:
    - TBD
  - Leading working group:
    - RAN4
  - SI or WI:
    - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 43:**

| |
|---|
| **1 – Ericsson France S.A.S**<br>Ericsson: It is not apparent why RAN4 needs to study co-channel and which RAN4 requirements the study outcome would impact. |
| **2 – T-Mobile USA Inc.**<br>Our understanding is that HAPs falls under the terrestrial licensing, so we think that HAPS should be treated separately from satellite NTN. We think that studying co-channel HAPS could be useful for operators considering HAPs for coverage enhancements or emergency situations. |
| **3 – KDDI Corporation**<br>Now NTN email discussion has the same topic, this should be discussed in NTN email. |
| **4 – Samsung Electronics Co.**<br>In previous email discussion, HAPS was handled under NTN email thread. Any difference compared to previous discussion on this co-channel HAPS proposal? What's the detailed objectives, and expected output for this proposal?<br><br>We are open to discuss this proposal with further clarifications from proponents. |
| **5 – China Unicom**<br>*In Rel-17 HAPS coexistence study, only adjacent channel case between HAPS and TN was considered, co-channel case between HAPS and TN need to be considered in Rel-18. Several operators show very strong interests in HAPS in Rel-18 RAN discussions, and HAPS can be deployed to provide services in various scenarios, e.g. pedestrian in remote area, wide area IoT connectivity.*<br>*A RAN4 related work focus on the evaluation on co-channel interference issue between HAPS and TN.*<br>*It is proposed the following bullets for RAN4 discussion:* |

- *Evaluate Co-channel interference issue between HAPS and TN;*
- *Identify RF requirements for coexistence between HAPS and IMT terrestrial network*
  - *Identify the FR1 potential band(s) to be used as example for HAPS, and FR2 bands can also be considered as example band if needed*
  - *Co-existence evaluation for HAPS network (e.g. ACLR, ACS)*
  - *Identify UE/BS requirements for HAPS network if necessary*

**6 – Intel Corporation (UK) Ltd**

Discussion on HAPS scenario is taking place in the email thread RAN94e-R18Prep-13 (NTN) and we recommend continue discussion in that thread.

**7 – ZTE Wistron Telecom AB**

It seems not so clear on demands for co-channel HAPS. And as other companies comment, this topic could be treated with the same thread as NTN.

#### 4.7.1.2 Summary for initial round

T-Mobile USA showed the interest on the co-channel co-existence. But most companies commented that this topic should be treated in the other email thread.

Moderator suggests to suspend the discussion on this topic in this email thread this week. Let companies continue discussing the topic in RAN94e-R18Prep-13 (NTN).

### 4.7.2 Intermediate round

No intermediate round is needed for this topic in this email discussion.

### 4.7.3 Final round

# 5 Non-spectrum related: RRM & demodulation centric

## 5.1 RRM requirements enhancement

### 5.1.1 Initial round

#### 5.1.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***RRM requirement focus enhancement***

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- RRM requirements enhancement
  - Potential justifications:
    - TBD
  - Potential objectives which need more discussions:
    - FR2 RRM enhancements (RAN4, RAN2)
      - Enhancement RF beam measurement requirements to allow UE to measure a subset of the configured resources
      - Define FR2-FR2 DAPS requirements
      - SCell activation enhancement in FR2
      - Enhancement type 2 BWP switching in FR2
      - RRM for different Rx beam sets in FR2
      - Network controlled gaps for UE Rx beam switching
      - FR2 delay reduction enhancements
    - General RRM requirement enhancement and leftovers (RAN4, RAN2)
      - UL frame boundary offset reporting
      - FR1-FR1 NR DC RRM requirements
      - Enhancement for CSI-RS based L3 measurement
      - HO with PSCell for new scenarios
      - TCI switching enhancement
      - CMTC
      - RLM enhancements
    - Measurement gap related enhancement and leftover (RAN4, RAN2)
      - NeedForGap
      - Per-FR gap
      - Inter-RAT NR measurement without gaps
      - Measurement gap sharing enhancement
  - Leading working group:
    - RAN4, secondary RAN2
  - SI or WI:
    - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 44:**

**1 – China Telecommunications**

We support the further enhancement for RRM area in Rel-18.

We are interested in the following proposals:

» NeedForGap

» HO with PSCell for new scenarios

» Inter-RAT NR measurement without gaps

» FR2-FR2 DAPS requirements (also discussed in Mobility Enhancements thread)

» FR2 beam measurement enhancement

**2 – LG Electronics Deutschland**

FR2 RRM enhancement is an important topic for the commercialization of FR2 in the market. For this, FR2 beam management enhancement and operation should be considered first. We have interests in the enhancement of Rx beam measurement including independent Rx beam set per MO. For leftovers, we would like to discuss after checking the progress of Rel-17.

**3 – China Mobile Com. Corporation**

In general, we hope RRM enhancements in Rel-18 can focus on the essential features (e.g. features that will be deployed, issues found in network) instead of enhancements for corner cases.

From CMCC perspective, we consider the following topics as high priority:

- NeedForGap: feature is introduced in Rel-16 already, and this is a very useful feature to reduce the gap overhead. Support to specify the requirements in Rel-18
- FR1-FR1 NR DC RRM requirements: this is the leftover issue, RAN4 needs to fix the missing requirements.
- HO with PSCell for new scenarios: the new scenarios are all practical deployment including SA-NEDC, SA-NR DC, LTE-ENDC, and the work for extension to new scenarios are very small.
- Inter-RAT NR measurement without gaps: inter frequency without gap is already supported in Rel-17, extension to inter-RAT is very straightforward.

**4 – NTT DOCOMO INC.**

As mentioned in previous discussion, the topic discussed in Rel-18 should be essential feature. From this perspective, we are interested in following topics:

- FR2 RRM enhancements
  - SCell activation enhancement in FR2
  - RRM for different Rx beam sets inFR2
  - FR2 delay reduction enhancements
- General RRM requirement enhancement and leftovers
  - HO with PSCell for new scenario
  - TCI switching enhancement

- RLM enhancements
- Measurement gap related enhancement and leftover
  - Per-FR gap

**5 – Nokia Japan**

We support some of the proposed topics. We suggest that RAN4 focus on aspects which can improve the UE and system performance except for topics which can be addressed by network configurations.

In addition, in general we see that there is a clear need for down scoping the number of topics as the currently proposed list of topics is extensive. Some of the topics we see as being more appropriate for SI instead of WI. We would also think that instead of one big WI including many potentially not related objectives – it would be better to have more dedicated WIs. E.g. the current discussion setup already lists the topics in 3 distinct bullets which could be used as guide for separate WI's.

**Comments on each topic**

- **Enhancement RF beam measurement requirements to allow UE to measure a subset of the configured resources: Neutral**
  This enhancement may be handled through nerwork configuration.
- **FR2-FR2 DAPS requirements: Negative.**
  This was discussed earlier when current DAPS requirements were developed. At that time it was recognised that for FR2-FR2 DAPS it would be complex due to assumptions on UE Rx limitation. Hence, we are not supportive towards general DAPS requirements. If RAN4 should work on this, the scope should be limited to UEs which can operate with independent multibeam Rx (including intra-frequency). This is also listed under 5.5 discussion.
- **SCell activation enhancement in FR2: Positive.**
  This can reduce SCell (and PSCell) activation delays in FR2 (SCell activation enhancement in FR2) as reduction of the delays in general can benefit both UE and system.
- **Enhancement type 2 BWP switching in FR2: Negative.**
  The proposals are not clear and would need more detailed work scope description
- **RRM for different Rx beam sets in FR2: Negative.**
  The proposals are not clear and would need more detailed work scope description.
- **Network controlled gaps for UE Rx beam switching. Neutral.**
  This would likely need a study first. There are aspects which should be studied firstin order to progress the specification work.
- **FR2 delay reduction enhancements: Negative.**
  In general the proposals are vague and it is difficult to analyse what is suggested in details and potential work scope. We would be fine with delay reduction but it depends on the cost.
- **General RRM requirement enhancement and leftovers (RAN4, RAN2):**
- **UL frame boundary offset reporting: Negative.**
  Scope and work description is vague and it is not possible to analyse what work we would agree to. More information would be appreciated.
- **FR1-FR1 NR DC RRM : Positive.**
  Very limited number of RRM requirements like MRTD/MTTD has been specified for FR1-FR1 NR DC despite the fact that FR1-FR1 NR DC is a realistic deployment scneario. We expext the amount of work would be limited as RF and RAN2 work has already been finalized.

- **CSI-RS for L3 measurement: Neutral.**
  Our view is that the current requirements already limit the configuration based on limiting the UE requirements to apply only when the configuration is time limited.
- **HO with PSCell for new scenarios: Positive.**
- **TCI switching enhancements: Neutral.**
  We are not against improvement work related to TCI switching enahncements,but this switch delay is conditional based on network behaviour like network configuration.
- **CMTC: Neutral.**
  Same reasoning as Enhancements to CSI-RS based L3 comments
- **RLM enhancement: Positive (conditional).**
  We support work on RLM enhancement, however only the part addressing introducing the 2nd BLER level. We are negative on the topic addressing unifying the RLM and BFD/CBD procedure.
- **Measurement gap related enhancement and leftover (RAN4, RAN2):**
  Measurement gap handling in NR has become complex. Hence, we support improvement which can lead to reduced complexity of measurement gaps.
- **NeedForGap: Positive.**
  It can bring benefits but scope should be limited and aligned to what has been done for NCSG in Rel-17.
- **Per-FR gap: Negative.**
  We see less benefits from Per-FR gap. The benefits from the proposed enhancements are not clear and need more discussion and justification.
- **Inter-RAT NR measurement without gaps: Positive.**
  We see the potential benefits in reducing need for measurement gaps.
- **Measurement gap sharing enhancement: Negative.**
  We do not see much real benefit. Current granularity for MG sharing ratio is sufficient. The benefits from the proposal enhancements is not clear and need more justification.

**6 – MediaTek Inc.**

We are interested in

- Enhancement type 2 BWP switching in FR2
- UL frame boundary offset reporting: the intention is to reduce the uncertainty of interruption starting points, such as SRS switch or Tx switching. It also help to resolve the uncertainty of UE UL transmission after gap.
- CMTC
- Per-BC indication for per-FR gap capability

As a rapporteur of Rel-17 MG enh WI, we also anticipate some potential Rel-18 candidate objectives for further MG enh, e.g., Joint requirements for pre-configured MG, concurrent MG and NCSG. Another direction is to further consider the requirement for new gaps introduced by MU-SIM

To our understanding, all gapless-related proposals could already covered in current NCSG discussions in Rel-17 MG enh. Companies can check.

**7 – QUALCOMM JAPAN LLC.**

There are a lot of proposals but we would like to see some strong justifications to pursue these objectives. While many are leftovers, the actual performance gains are small or questionable.

The FR2 related enhancements do not seem to bring any significant gains or some are already possible to implement.

FR1-FR1 DC RRM requirements should be finalized such that the entire feature is implementable/deployable.

For the gap related, what is the per-FR gap objective related to? requirements for need for gap is one area that could be pursued.

**8 – Samsung Electronics Co.**

In general, we are supportive to take some optimization and enhancement on RRM areas based on urgent demand from market on new deployment scenarios and/or the critical issues identified by commercial NW deployment. Meanwhile, current proposed scope seems quite huge and impractical to endorse all of them in Rel-18 considering Rel-17 experience; down-scoping on these proposals expected to control the overall load into a reasonable range.

As other companies commented, the proposal "FR2-FR2 DAPS" seems also proposed in another potential RAN2 led WI "mobility enhancement". We agree this objective majorly related to RAN4, better to avoid overlapped objective in two parallel WIs.

**9 – Intel Corporation (UK) Ltd**

- In our view it is preferable to start the discussion on candidate objectives so that RAN4 has a stable set of clear objectives with proper justification. For Rel-17 leftovers – a set of candidate topics can be further refined after Nov and Jan RAN4 meetings.
- It may be difficult to converge on the set of topics. We suggest making categorization as a part of this email discussion. For categorization we suggest at least
  - ***FR2 enhancements***
  - ***General RRM requirements enhancements/leftovers***
  - ***Measurement Gap related enhancements***
  - ***FR2 HST enhancements***
- FR2 RRM enhancement
  - In our view Enhancement type 2 BWP switch in FR2 and SCell activation enhancement in FR2 can be grouped under umbrella of FR2 delay reduction enhancements,
    - *FR2 delay reduction enhancements*
      - *Measurement delay reduction by assuming reduced number of Rx beams*
      - *SCell activation enhancement in FR2*
      - *Enhancement type 2 BWP switch in FR2*
  - From our point of view the following FR2 enhancements can be prioritized
    - *FR2 delay reduction enhancements*
      - *Measurement delay reduction by assuming reduced number of Rx beams*
      - *SCell activation enhancement in FR2*
      - *Enhancement type 2 BWP switch in FR2*

        - *Network controlled gaps for UE Rx beam switching*
        - *Define FR2-FR2 DAPS requirements*
    - The proposed objective "FR2-2 enhancements: Leftover deployment scenarios in Rel-17 (e.g., FR2-2 NR-DC and FR2-1 - FR2-2 NR CA/DC)" is missing and we suggest adding it to the list
- For general RRM requirements enhancements we prioritize the following
    - *FR1 + FR1 NR-DC RRM requirements*
    - *CMTC*
    - *RLM enhancements*
    - *TCI state switch enhancements*
- Regarding UL frame boundary reporting, specific objectives are not clear currently – so we suggest the proponent to clarify more on the scope of this proposal
- For MG related enhancements we suggest to structure as follows.
    - *Measurement Gap related enhancements*
        - *NeedForGap requirements*
        - *Per-FR gap UE capability enhancement*
        - *Measurement gap sharing enhancements*
- We also think that it would be proper to list HST RRM enhancements as a separate topic so that the discussion can take place jointly with other objectives

**10 – vivo Communication Technology**

Firstly, we support further RRM enhancements in Rel-18 as there are important leftovers from Rel-16 and there will be Rel-17 leftovers worth continuing in Rel-18.

One general aspect would be it is better that Rel-16 leftovers and Rel-17 leftovers can be considered together to decide what should be selected for further enhancements in Rel-18. Otherwise, it can be the case that Rel-17 leftovers only get the chance for further enhancement in Rel-19, like what it is now for Rel-16 leftovers.

For the potential objectives list in the email, we would like to ask clarification whether the potential objectives submitted to RAN#93e meeting should also be added. In our view, it should not preclude any potential objectives at this stage.

Thus, we would like to formulate our proposals on further RRM enhancements in Rel-18 as in RP-212020 and RP-212021.

l RRM requirements enhancement for NR-U operation [RAN4]

l Idle/Inactive Mode CA/DC Measurements (EMR)

l Direct SCell activation

l DAPS handover

l Conditional handover

l Conditional PSCell Change

l Multiple SCell activation

l BWP switching on multiple CCs

l Uplink spatial relation switch delay

l CSI-RS based L3 measurement

l L1-SINR measurements for reporting

l Pathloss reference signal switching delay

l CGI reading

l [HO with PSCell]

l CSI-RS based RLM for NR-U

l CSI-RS based link recovery for NR-U

l CSI-RS based L1-RSRP measurements and reporting

l RRM requirements for NR-U Scenario E

For FR2 RRM enhancements, we would like to add SRS carrier based switching for FR2 Inter-band as one additional potential objective.

l FR2 RRM enhancements (RAN4, RAN2)

l SRS carrier based switching for FR2 Inter-band

**11 – Huawei Technologies France**

Regarding RRM requirements, we support to at least define some newly objectives in FR2 RRM enhancements. FR2 operation provides ultra-high throughput and ultra-low latency and we expect it to be more widely deployed in Rel-18 time frame compared to earlier releases. However current FR2 related RRM requirements may not be able to fully realize the potential of FR2 operation, e.g., latency is long, requirements are not complete, etc.

Herein we would like to provide justification on some enhancement of FR2 RRM enhancement we proposed.

- Enhance FR2 beam measurement requirements to allow UE to measure a subset of the configured resources
  - UE BM is subject to the UE measurement capability, which is limited. Network either configures limited BM resources which results in frequent reconfiguration of BM resources; or NW configures more resources over UE capability which may results in no valid report to the NW and waste of UE power. Allowing UE to measure a subset of the configured resources can lead to better power efficiency and more reliable measurement performance.

- Define FR2-FR2 DAPS requirements
  - UE who supports independent beam management (IBM) for two bands in FR2 can Tx/Rx from different directions at the same time. Therefore it may be feasible to introduce FR2-FR2 DAPS HO for inter-band scenario. Of course the UE capability (whether depends on IBM) are open to be further discussed.

- SCell activation enhancement in FR2
  - Large activation delay in FR2 was caused by the assumption that UE needs to receive the TCI indication from NW for PDCCH, PDSCH and CSI-RS for CSI, and for unknown case UE needs to perform L1-RSRP measurement and reporting. Therefore further reduce the SCell activation delay in FR2 need to be enhanced.

- Enhancement type 2 BWP switch in FR2
  - Currently there are two types of BWP switching delay based on UE capability. The switching delay for type 2 UE is rather large for FR2 or FR2-2. The enhancement is expected.

The above are examples for FR2 RRM enhancement, we are open to other FR2 enhancements.

For general RRM requirement enhancement and leftovers, from our view CMTC may be useful for UE monitoring CSI-RS resources. For network, more flexible configuration can be supported regarding where UE would perform measurement.

**12 – ZTE Wistron Telecom AB**

We notice that there are still some ”old leftovers” at this moment, even though some are essential. We don’t think it is a good practice that when discussing a new release, there is a long list of new enhancement/optimization proposals but accompanied with many ”leftovers”. We think that the efforts should be assigned properly so that ”leftovers” can be completed in time with the highest priority. And if there is still some TU available, it can be assigned to these sufficiently justified as essential /significant enhancements, or urgent demands.

**13 – Apple AB**

In general, many bullets to be discussed are described in very high level. This may result in different understanding from different companies, and that makes the discussion even more challenging. It is suggested the proponents at least provide some details in a few sub bullets for each proposal.

For time being, it is still beneficial to categorize for the high-level topics as (1) R17 drop off topics (2) newly identified topics in R17 (3) Newly identified topics in R18; Such practice will help to balance the work among in-field issues, leftover issues from early release(s), and new enhancement.

(1) Regarding general RRM requirement enhancement and leftovers, we support following topics:

- TCI switching enhancement

In order to shorten the TCI switching delay, RAN4 needs to further discuss if UE behavior can be enhanced to receive DL data during the time gap of Tfirst-SSB in Rel-18 or if any other reference signal could be used to speed up the switching delay.

- FR1+FR1 NR-DC RRM

This was a fundamental scenario introduced in R16, it would be necessary to specify full set of RRM requirements for FR1+FR1 NR-DC in R18 FeRRM WI.

- CGI reading requirement for NR-U cell

CGI reading feature is an important functionality especially on unlicensed carrier, and it would be worthwhile to discuss the corresponding CGI reading requirement with CCA in REL-18.

- CMTC

So far the timing limitation for CSI-RS L3 measurement is specified as a requirement applicability in RAN4, but it’s not a real systematic solution for network and UE to configure and perform L3 CSI-RS measurement, respectively. So it’s desirable to introduce clear timing window for L3 CSI-RS measurement, like SMTC for SSB based L3 measurement.

- HO with PSCell for new scenarios

The following scenarios are missing in R17 WI:

- HO with PSCell from NR SA to NE-DC
- HO with PSCell from NR SA to NR-DC
- HO with PSCell from LTE SA to EN-DC

(2) Regarding measurement gap related enhancement and leftover, we support following topics:

- RRM requirement with NeedForGap

NeedForGap is an important functionality for both UE and network to save throughput loss due to overuse of the MG. But this scope may be removed if R17 NCSG scope in MG enhancement WI can cover it (more conclusion from RAN4 group meeting is needed).

- Inter-RAT NR measurement without gaps

(3) In the list of this section, some proposals from last RANP meeting are missing. We have high interests to include those newly identified topics in R18:

- Harmonized RLM/BM

There are lots of commonality between RLM and BM, and in order to simplify the link evaluation procedure and reduce the UE complexity and procedure delay, RAN4 may investigate and introduce a harmonized link monitoring/recovery mechanism to unify the RLM and BFD/CBD within single UE procedure.

- RRM enhancement for large CC number

In Rel-15, Rel-16 and Rel-17, the serving CC number for RRM is specified as below, however in TS38.101-1/2/3 the allowed serving cell could be more than RRM requirement, e.g., 10 NR CCs in DC*1A-3A-5A-7A-7A*n78C-n257M. With larger number of serving CC, it would result into huge long measurement/detection delay to degrade mobility performance based on CSSF factor without MG. It would be desirable to investigate and introduce a RRM enhancement mechanism for the measurement delay when large number of serving CCs are used.

- allowInterruption for deactivated SCell measurements

RAN4 to investigate and introduce allowInterruption mechanism for the NR deactivated SCell measurement to save UE power consumption when measCycleSCell<640ms. This mechanism is missing in NR but it has been used in LTE from old release.

- CSI-RS based CFRA in RRM requirement

The CSI-RS based CFRA is a fundamental functionality from R15 but its requirement is missing for handover and PSCell addition requirement in RRM. We propose RAN4 to investigate and specify additional RRM requirement when CSI-RS based CFRA is used:for handover and for PSCell addition.

(4) Regarding the topics in FR2 RRM enhancements,

- Define FR2-FR2 DAPS requirements:

  This scope shall be decided after we have concrete conclusion on UE multiple panel capability

- Enhancement type 2 BWP switching in FR2

We have both type 1 and type2 BWP switching delay already, we don't see strong justification to introduce a new specific type for FR2.

- Network controlled gaps for UE Rx beam switching

We think the Rx beam sweeping or switching shall be based on UE implementation. And this topic is also relevant to the discussion in CBM related topic and we may need more conclusion from those discussions.

- FR2 delay reduction enhancements

Need more justification and scope clarification. We would like to understand more on what kind of the reduction we want to specify, and which UE capability is needed to support this enhancement, e.g., multiple panel.

**14 – Ericsson LM**

We suggest following list of objectives for RRM enhancement in Rel-18:

- NeedForGap
  - Define the NeedForGap requirement for UE based on RAN2 signalling
  - Broaden the use case for NeedForGap at least to inter-RAT (currently in R16, only apply for SA
  - Introduce gapless measurement for DSS (DSS LTE cell should be in the same frequency with NR)
- Fast and gapless SCell activation
  - Define fast SCell activation based on SSB and TRS instead of SMTC
  - Define gap-less SCell activation (currently in R16, there are potential several interruptions for multiple SCell activation)
- TCI state switching enhancements
  - In Rel-15, TCI states are updated per CC – one serving cell at a time. But it is very common that TCI states for different CCs need to be updated at the same time. In R15, there is an uncertainty time before UE finishes TCI state switch. UE and NW should have the same understanding on the TCI state.
- Multiple gaps for Multi-USIM
- Fast RRC connection re-establishment
  - In Rel-15, RRC re-establishment time is too long, especially, for advance features like URLLC or XR.
  - Define candidate cell lists, NW should guarantee that the candidate cells can get UEs context by the backhaul.
  - UE should perform re-establishment to the cell in candidate lists without cell search and measurements.
  - Possibly reuse RRC re-establishment from NB-IoT enhancement in R17 e.g. early cell search before RLF.
- Remaining issues related to measurement gap enhancement (Rel-17 leftovers)
  - Combination of two or more MG enhancement features introduced in Rel-17

        - Define concurrent gaps with NCSG
        - Define concurrent gaps with pre-Configured gap
    - Enhanced pre-configured gaps
        - Pre-configured gaps, triggered by other than BWP switch
    - Dynamic activation and switching of the measurement gap pattern for different applications

**15 – Verizon UK Ltd**

We support general objectives of FR2 RRM, the left-over general requirement, and measurement gap enhancement.

5.1.1.2 Summary for initial round

Fifteen companies provided the feedback The moderator provided summary for each working area.

**FR2 RRM enhancements (RAN4, RAN2)**

- Enhancement RF beam measurement requirements, e.g., allow UE to measure a subset of the configured resources
    - Positive: China Telecom, Huawei
    - Negative
- Define FR2-FR2 DAPS requirements
    - Positive: China Telecom, Intel, Huawei,
    - Negative: Nokia,
- SCell activation enhancement in FR2
    - Positive: NTT DOCOMO, Huawei
    - Negative
- Enhancement type 2 BWP switching in FR2
    - Positive: Mediatek, Intel, Huawei,
    - Negative: Nokia
- RRM for different Rx beam sets in FR2
    - Positive: LGE, NTT DOCOMO
    - Negative: Nokia
- Network controlled gaps for UE Rx beam switching
    - Positive: Intel
    - Negative: Apple
- FR2 delay reduction enhancements

    - Positive: NTT DOCOMO, Nokia, Intel
    - Negative
- Others (intel): Leftover deployment scenario in Rel-17 (FR2-2 NR-DC and FR2-1-FR2-2 NR CA/DC)

**General RRM requirement enhancement and leftovers (RAN4, RAN2)**

- UL frame boundary offset reporting
    - Positive: Mediatek,
    - Negative: Nokia, Intel (clarify the scope)
- FR1-FR1 NR DC RRM requirements
    - Positive: CMCC, Nokia, Qualcomm, Intel, Apple, CATT
    - Negative
- Enhancement for CSI-RS based L3 measurement
    - Positive: CATT
    - Negative
- HO with PSCell for new scenarios
    - Positive: China Telecom, CMCC, NTT DOCOMO, Nokia, Apple, CATT
    - Negative
- TCI switching enhancement
    - Positive: NTT DOCOMO, Intel, Apple, Ericsson, CATT
    - Negative
- CMTC
    - Positive: Mediatek, Intel, Huawei, Apple
    - Negative
- RLM enhancements
    - Positive: NTT DOCOMO, Nokia, Intel, CATT
    - Negative

**Measurement gap related enhancement and leftover (RAN4, RAN2)**

- NeedForGap
    - Positive: China Telecom, CMCC, Nokia, Qualcomm, Intel, Apple, Ericsson, CATT
    - Negative

- Per-FR gap
  - Positive: NTT DOCOMO, Mediatek, Intel, CATT
  - Negative: Nokia
- Inter-RAT NR measurement without gaps
  - Positive: China Telecom, CMCC, Nokia, Apple, CATT
  - Negative
- Measurement gap sharing enhancement
  - Positive: Intel
  - Negative: Nokia

**Others**

- Joint requirements for pre-configured MG (Mediatek, CATT)
- Cocurrent MG and NCSG (Mediatek, Ericsson, CATT)
- New gaps for MUSIM (Mediatek, Ericsson)
- HST RRM enhancement (Intel)
- CGI reading requirement for NR-U cell (Apple, Vivo)
- Harmonized RLM/BM (Apple)
- RRM enhancement for large CC number (Apple)
- Allow interruption for deactived SCell measurements (Apple)
- CSI-RS based CFRA in RRM requirement (Apple)
- Fast and gapless Scell activation (Ericsson)
- Fast RRC connection re-establishment (Ericsson)
- Enhance pre-configured gaps (Ericsson)
- Dynamic activation and switching of the measurement gap pattern for different applications (Ericsson)
- RRM enhancement for NR-U (Vivo)

### 5.1.2 Intermediate round

#### 5.1.2.1 Proposals and comments collection

The list of RRM enhancement is huge and the list is not stable and keeps growing. The moderator felt that it is very difficult to identify the common ground to move forward. It is suggested to have some high level discussions.

According to previous discussion and feedback, the moderator propose to agree on the following high level working areas:

- Potential objectives which need more discussion:
  - FR2 RRM enhancements (RAN4, RAN2)
  - General RRM requirement enhancement and leftover (RAN4, RAN2)
  - Measurement gap related enhancement and leftover (RAN4, RAN2)

Please provide your feedback and comments.

**Feedback Form 45:**

**1 – China Telecommunications**

Ok with the high-level working area proposed by moderator.

For the detailed objective, while more concrete proposals and prioritization are needed later, maybe the current list summarized by moderator can be used for information for future discussion.

**2 – Apple AB**

We are fine with the proposed work areas.

Same as we commented in the first round. Many bullets to be discussed are described in very high level. This may result in different understanding from different companies, and that makes the discussion quite challenging. It is suggested the proponents at least provide some details in a few sub bullets for each proposal or at least add a reference to the corresponding tdocs.

It seems following Apple's proposals for R18 RRM enhancement are missing in the summary, and we propose to add them into the summary for discussion.

- Harmonized RLM/BM

There are lots of commonality between RLM and BM, and in order to simplify the link evaluation procedure and reduce the UE complexity and procedure delay, RAN4 may investigate and introduce a harmonized link monitoring/recovery mechanism to unify the RLM and BFD/CBD within single UE procedure.

- RRM enhancement for large CC number

In Rel-15, Rel-16 and Rel-17, the serving CC number for RRM is specified as below, however in TS38.101-1/2/3 the allowed serving cell could be more than RRM requirement, e.g., 10 NR CCs in DC*1A-3A-5A-7A-7A*n78C-n257M. With larger number of serving CC, it would result into huge long measurement/detection delay to degrade mobility performance based on CSSF factor without MG. It would be desirable to investigate and introduce a RRM enhancement mechanism for the measurement delay when large number of serving CCs are used.

- allowInterruption for deactivated SCell measurements

RAN4 to investigate and introduce allowInterruption mechanism for the NR deactivated SCell measurement to save UE power consumption when measCycleSCell<640ms. This mechanism is missing in NR but it has been used in LTE from old release.

- CSI-RS based CFRA in RRM requirement

The CSI-RS based CFRA is a fundamental functionality from R15 but its requirement is missing for handover and PSCell addition requirement in RRM. We propose RAN4 to investigate and specify additional RRM requirement when CSI-RS based CFRA is used:for handover and for PSCell addition.

**3 – QUALCOMM JAPAN LLC.**

First of all we have concerns about simply counting numbers on positive vs. negative without much discussion on technical details or actual commercial relevance. We should just avoid a beauty contest between which proposal gathers more support among vendors.

We are negative on some of the items above even though we haven't listed them.

The listed objective are very generic, what is the plan going forward with this?

**4 – LG Electronics Deutschland**

We are fine with the three main categories for high-level discussion.

**FR2 RRM enhancement** is an important topic for FR2 commercialization, especially, Rx beam related RRM and delay issues.

**For general RRM requirement enhancement**, finalizing FR1 deployment based issues are the highest priority such as FR1+FR1 NR DC.

**For the leftover issues**, further discussions are needed depending on Rel-17 progress.

**5 – ZTE Corporation**

The proposed working area might be a bit high level, we would like to have more concrete discussions in the coming RAN-P meeting. In addition, the reasonable prioritization rule should be also been clarified later on.

**6 – Intel Corporation (UK) Ltd**

- We agree with the proposed areas and agree that further discussion on benefits/urgency of different proposals shall take place.
- We feel the same way with Nokia that it is necessary to have separate work items with shaped focus among the proposed areas. Otherwise the management of the scope and progress of the item is difficult.
- Another comment is that RAN4 does not exclude other areas or other topics than the ones listed, and we also suggest considering one HST related RRM topic to be included in R18 since HST is very important in terms of market demand. We think that it would be proper to list the below objectives as a topic so that the discussion can take place jointly with other objectives. We could consider the below objectives:
  - *Specify applicable RRM requirements for non-HST UE-s in HST FR2 network*
    - *Introduce, if necessary, UE capability signaling to ensure clear alignment between UE and network knowledge on applicable RRM requirements to different types of UE-s*
- Regarding gap-less topics, we support needForGap and inter-RAT measurements without gap. We don't think they can be fit into R17 NCSG and they need to be included in R18 since the objectives missing are mainly about RRM requirements for UE with gap-less measurement capability.
- Regarding joint requirements for pre-configured gap, multiple concurrent gap and NCSG, we need to review the R17 progress later to see whether we should add them into R18 as leftovers in the MG enhancements area. If anything is not done in R17, we support to consider them in the R18 scope of MG enhancements area.

**7 – CATT**

We are fine with the high-level working areas proposed by moderator.

But for the detailed objectives, the current topic list can be information for further discussion since there can be some more potential topics (such as per-FR gap support for positioning, joint discussion of R17 gap enhancement feature) based on RAN#93e meeting input and RAN4 discussion. And more detailed justifications for some topics are needed.

On the other hand, we also have concerns on the selection of so many topics, maybe we can categorize them into different parts of discussion based on the high-level working area and split them into different work items.

**8 – Nokia Japan**

We are OK with proposal by moderator. Also, we believe that to facilitate further progress and discussion, it would be necessary for proponents to clarify more detailed the proposed scope of a proposal. Additionally, we should have a down scoped list of concrete candidate topics to be discussed and stop further expansion of the list of proposals.

The supporting companies of a topic should provide more detailed scope and objectives for their preferred topics in the next RAN. Otherwise, we would see the same situation in the next RAN.

Based on the first round we provide further input:

**FR2 RRM enhancements (RAN4, RAN2):**

FR2 delay reduction enhancements: Postive. This topic seems to be supported by multiple companies. This can be included as a candidate where objectives could be discussed in further detials.

SCell activation enhancement in FR2: Positive. Supported by multiple companies and objectives could be discussed on more details.

Enhancement RF beam measurement requirements: Neutral due to unclear scope. However, based on the further clarification in 1st round we are not against discussing this topic but we would like more detailed information about the scope of the potential work.

Define FR2-FR2 DAPS requirements: Negative on the general scope of introducing requirements without considering a more limited scope addressing UE which support independent beam management. It should be further discussed if this includes also intra-frequency operation.

Enhancement type 2 BWP switching in FR2, RRM for different Rx beam sets in FR2, Network controlled gaps for UE Rx beam switching and Other: Negative. Regarding these topics the scope and objectives are unclear.

**General RRM requirement enhancement and leftovers (RAN4, RAN2)**

FR1-FR1 NR DC RRM requirements and HO with PSCell for new scenarios. Positive. These two topics received good support in first round and the further detailed objectives can be discussed

For the rest of the proposals in this group got less support.

**Measurement gap related enhancement and leftover (RAN4, RAN2)**

NeedForGap. Positive. This topic received support from many companies and further discussion on the objectives could progress.

Rest of the topics in this group got less support.

**9 – Ericsson LM**

High level areas look fine. But we should at least include objectives related to missing requirements for quite fundamental features:

- NeedForGaps (signaling since R16. Avoiding / minimizing use of gaps will be major benefit since gaps are used even for intra-frequency measurements)
- TCI switching enhancement (currently not possible on multiple CCs at the same time, which is major limitation)

**10 – Huawei Technologies France**

We are fine with the high level working areas suggested by the moderator. As it seems difficult to agree on or to exclude any detailed objective, and we suggest that proponents to further elaborate their proposals in the next RAN, and companies can also make more concrete comments e.g. on the proposals from this meeting, as well as their views on the prioritization.

**11 – NTT DOCOMO INC.**

We are fine with proposed high-level area, and agree with that the scope and benefit of each topic should be clarified to make progress. At least following topics are clear what is the benefit and make NW more efficient.

- SCell activation enhancement in FR2: The main motivation to use FR2 is throughput enhancement, thus CA should be efficiently used.
- RRM for different Rx beam sets in FR2: UE is assumed to use Rx beam and the Rx beam management is directly related to comfortable connection. This topic could enhance Rx beam management.
- FR2 delay reduction enhancements: In order to keep high throughput and keep connection, delay reduction could be useful.
- HO with PSCell for new scenarios: HO with PSCell is an important technique to keep high throughput under DC environment, thus various scenarios should be covered as much as possible.
- TCI switching enhancement: TCI switching delay and interruption should be reduced and it should be immediately switched to keep comfortable NW connection both FR1 and FR2.

For the details for each working areas, it is better for companies to come back in the future RAN plenary or email discussion with the concrete papers on them.

#### 5.1.2.2 Summary for intermediate round

Eleven companies provided the feedback. It seemed that most companies are OK with high level working areas for RRM enhancement topic. Intel proposed to list HST RRM as the high level working area. But the proposal ”Specify applicable RRM requirements for non-HST UEs in HST FR2 network” is specific and not general enough.

Most companies shared the views on how to move forward. But because the list of proposals is quite long and more information for each proposal is needed, it seems unrealistic to try to agree on some objectives although they were extensively discussed like NeedForGap. To be fair the moderator suggests that the proponents should provide more details on the motivation, commercial use case, benefit and specification impact for each proposed objective in the next RAN plenary. Based on those details, companies can further discuss which objectives should be taken into account for Rel-18 RRM enhancement.

Moderator: To Qualcomm, the intention counting numbers of companies who are positive or negative is to help companies quickly understanding the situation and identifying the potential objectives which most companies share the common interests to facilitate the further discussion, and is not to decide which objectives should be captured in Rel-18. As you said, the benefit and commercial opportunity should be evaluated and considered for each proposal. The plan is to agree on the general directions for RRM enhancement, the categorize each proposal into those directions, and then discuss the proposals belong to the same categories together.

To Apple, Intel, the summary of initial round has already captured your proposal under ”Others”.

### 5.1.3 Final round

#### 5.1.3.1 Proposals and comments collection

Based on the feedback from companies, the moderator would like to endorse the high level working areas for RRM enhancement topics and encourage companies to provide more details on motivation, benefits and specification impacts for each proposal.

- **Proposal #9-1: for RRM requirements enhancement topic, the following high level working areas can be endorsed**
  - FR2 RRM enhancements (RAN4, RAN2)
  - General RRM requirement enhancement and leftovers (RAN4, RAN2)
  - Measurement gap related enhancement and leftover (RAN4, RAN2)
- **Proposal #9-2: companies are encouraged to provide more details on the motivation, benefit and specification impacts for each proposed objective for RRM requirement enhancement in RAN#94-e.**

Please provide your comments in table below. □

**Feedback Form 46:**

| |
|---|
| **1 – Nokia Japan**<br>We support both proposals by moderator. It looks reasonable at this moment considering the remaining time of this e-mail discussion. We can further discuss how to handle RRM enhancement topics based on the proposals in the future meetings |
| **2 – Apple AB**<br>Thanks for the big efforts from the moderator and we also support both proposals.<br>It may be due to the unclarity of our previous comments. We would like to further clarify our views on some of the proposals.<br>− Define FR2-FR2 DAPS requirements<br>○ Positive: China Telecom, Intel, Huawei, ~~Apple~~<br>○ Negative: Nokia,<br>− Enhancement type 2 BWP switching in FR2 |

○ Positive: Mediatek, Intel, Huawei, ~~Apple~~

○ Negative: Nokia, Apple

− Network controlled gaps for UE Rx beam switching

○ Positive: Intel, ~~Apple~~

○ Negative: Apple

− FR2 delay reduction enhancements

○ Positive: NTT DOCOMO, Nokia, Intel, ~~Apple~~

○ Negative

**3 – MediaTek Inc.**

We are in general fine with moderator's suggestion.

Regarding leftover items, we assume by default RAN2 should not be involved unless some capabilities are agreed during RAN4 requirement discussions.

**4 – NTT DOCOMO INC.**

We are fine with moderator's final proposals.

**5 – LG Electronics Deutschland**

We are fine with the moderator proposal. Detailed objectives of each high-level topics can be discussed in the coming RAN#94. We need to downscope the currently proposed objectives and the methodology to do that is not clear for us as of now. We hope this methodology can also be further discussed.

**6 – Ericsson LM**

We are fine with the moderator proposals. We can discuss the objectives at RAN#94-e.

**7 – vivo Communication Technology**

We are fine with moderator's high level working areas with the understanding that RRM enhancements for NR-U falls into working area 2 – General RRM requirement enhancement and leftovers, although we prefer to have a separated working area on RRM enhancements for NR-U.

It seems that one issue on how to take potential Rel-17 leftovers into consideration, as we commented in the 1st round, is not addressed. It would be good if there is high level guidance.

In the 1st round summary, vivo's proposals on RRM enhancements for NR-U and NR were not captured. We think it should be captured in the 1st round summary as the potential candidate objectives. At current stage, we don't think prioritization/down-selection could be made.

Thus, we would like to further clarify our proposals for RRM enhancements for NR and NR-U.

RRM enhancements for NR-U:

• List of potential objectives can be found in 1st round feedback.

RRM enhancements for NR:

Enhancement on TCI state switch

• Temporary RS as for fast SCell activation may be enhanced to reduce TCI state switch delay under certain conditions.

FR1+FR1 NR-DC

SRS carrier-based switching for FR2 Inter-band

**8 – ZTE Corporation**

We are also fine with the moderator proposals and could further discuss its detailed objectives in the coming RAN#94e meeting.

**9 – Intel Corporation (UK) Ltd**

We agree with moderator proposals and open to further discuss based on identified high-level areas

**10 – CATT**

We support moderator's proposals. At the same time, as our views on detailed objectives were not reflected in the previous round, we would like to show our interests on the following topics:

**General RRM requirement enhancement and leftovers (RAN4, RAN2)**

- -FR1-FR1 NR DC RRM requirements
- -Enhancement for CSI-RS based L3 measurement including CMTC
- -HO with PSCell for new scenarios
- -TCI switching enhancement
- -RLM enhancements

**Measurement gap related enhancement and leftover (RAN4, RAN2)**

- -NeedForGap
- -Per-FR gap
- -Inter-RAT NR measurement without gaps
- -Joint requirements for pre-configured MG Cocurrent MG and NCSG

**11 – Huawei Technologies France**

We support both proposals from moderator. As it seems difficult to agree on detailed objective during this meeting, we suggest that proponents to further elaborate their proposals in the next RAN.

5.1.3.2 Summary for final round

Apple, CATT and Vivo had comments on previous intermediate round summary. The moderator updated the summary to capture the comments. Mediatek commented on the impacted work group. It seems that most companies can accept the proposals from the moderator.

Based on the feedback, the moderator modified the proposals to capture the comment.

- **Proposal #9-1: for RRM requirements enhancement topic, the following high level working areas can be endorsed**
  - FR2 RRM enhancements ~~(RAN4, RAN2)~~
  - General RRM requirement enhancement and leftover ~~(RAN4, RAN2)~~
  - Measurement gap related enhancement and leftover ~~(RAN4, RAN2)~~

- **Proposal #9-2: companies are encouraged to provide more details on the motivation, benefit and specification impacts for each proposed objective for RRM requirement enhancement in RAN#94-e.**

## 5.2 Demodulation requirements evolution

### 5.2.1 Initial round

#### 5.2.1.1 Proposals and comments collection

**Previous discussion**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***Demodulation focus requirement evolution***
  - *UE advanced receiver*
  - *Other leftovers*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- Demodulation requirements evolution
  - Potential justifications:
    - TBD
  - Potential objectives which need more discussion:
    - UE advanced receiver (RAN4)
      - Soft IC to cancel inter-stream interference in SU-MIMO scenario
      - Enhanced DL receivers for multi-DCI multi-TRP scenario
      - Advanced receiver to cancel inter-user interference for MU-MIMO
      - Inter-cell CSI-RS(TRS)/SSB interference mitigation
      - E-MMSE-IRC under uneven interference (including time selective inter-cell interference)
      - Enhancement of CRS-IC
    - BS advanced receiver (RAN4)
      - MMSE-IRC for inter-cell interference
    - Other leftovers
      - eMIMO: two UE rate matching CRS patterns in multi-DCI Tx scheme
  - Leading working group:
    - RAN4, secondary RAN2 and/or RAN1

- SI or WI:
  - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 47:**

**1 – China Telecommunications**

We support the further enhancement for demod area in Rel-18.

We are interested in the following proposals:

1) UE advanced receiver

- Soft IC to cancel inter-stream interference in SU-MIMO scenario.
  Regarding the complexity, we agree that the total number of iterations is not increased, if limiting the number of iterations for each LDPC decoding.

- Inter-cell CSI-RS(TRS)/SSB interference mitigation.
  In Rel-17 discussion for inter-cell interference IRC, chipset/UE companies have concerns on configuring SSB in the same time/frequency location for neighboring/interfering cells, to avoid performance degradation due to time/frequency tracking error.
  However, configuring SSB in the same time/frequency location for neighboring cells is a typical scenario. From this perspective, further enhancement on inter-cell CSI-RS(TRS)/SSB interference mitigation is beneficial for time/frequency tracking and thus PDSCH/PDCCH performance.

- Advanced receiver to cancel inter-user interference for MU-MIMO
  In Rel-17, only MMSE-IRC receiver is used for MU-MIMO scenario. As MU-MIMO is largely used for NR, further enhancement on receiver is beneficial.
  E-IRC, R-ML, SL-IC can be used as the candidate receivers for Rel-18. E-IRC only requires additional channel estimation for the co-scheduled UE(s) in the same cell, and R-ML has been used for SU-MIMO scenario.

- E-MMSE-IRC under uneven interference (including time selective inter-cell interference)
  We don't support to consider the scenario with different SCSs in different cells in the same carrier, since it is not likely to happen in the real network in the near future.
  We can consider the scenario with non-slot based transmission and aligned SCS among cells. One aspect is that: if DMRS based MMSE-IRC cannot work well (or even worse than MMSE) in this scenario, do we need to specify requirements to ensure that the UE should fallback to MMSE receiver but not use MMSE-IRC.

2) BS advanced receiver

- MMSE-IRC for inter-cell interference
  BS IRC was defined for LTE. Difficult to discuss further BS receiver enhancement if IRC requirement is still absent in Rel-18.

We have proposed the following objective in RAN #93e:

MMSE-IRC receiver for inter-cell and intra-cell MU-MIMO in CA scenario. Single carrier requirements have been defined in Rel-17, and it is straightforward to extend the requirements to CA scenario.

In addition, we also support ATP if it is not proposed in Rel-17. The feasibility of ATP with link adaptation has been concluded in Rel-17, and we should start the normative phase. We can discuss whether ATP WI is a RAN5-led WI?

**2 – Ericsson France S.A.S**

**Feedback Form**

Ericsson: Regarding the list of UE advanced receivers, the list is too large for a reasonable workload. In our understanding, TRS and SSB mitigation is not important as the interference will not have a large system impact. For IRC under uneven interference, this could be downprioritized since it can be expected that networks are synchronized, and it is not clear that in the Rel-18 timeframe there will be a substantial use of different slot length between different cells to the extent that overall capacity could be hit. "Enhancement of CRS-IC" should be elaborated further, but in general the Rel-17 work should take care of CRS-IC. The first three bullets may be more interesting; the potential gains should be studied first.

Proposal: Study the benefits for the first 3 bullets, remove the second 3.

For BS MMSE-IRC, it can be done but since BS in general do this already it is not obvious that it is a useful use of 3GPP time.

**3 – China Mobile Com. Corporation**

In general, we support to further enhance demodulation requirements in Rel-18.

Among all the listed advanced receivers, we consider following can be studied as high priority:

- Soft IC to cancel inter-stream interference in SU-MIMO scenario
- Advanced receiver to cancel inter-user interference for MU-MIMO
- Inter-cell CSI-RS(TRS)/SSB interference mitigation

**4 – NTT DOCOMO INC.**

Generally we are fine with moderator's proposal. We are interested in following topics about UE advanced receiver.

- Soft IC to cancel inter-stream interference in SU-MIMO scenario
- Inter-cell CSI-RS(TRS)/SSB interference mitigation

**5 – MediaTek Inc.**

The current scope is extremely big. Some downscoping is needed.

- Soft IC in SU-MIMO: we have strong concern on the UE complexity, performance benefit and HARQ reporting time budget.
- Inter-cell CSI-RS(TRS)/SSB: Neutral. Some study is needed to understand how much gain this can provide. As we know, TRS and SSB are not like CRS which is transmitted in every sub-frame.
- Enhancement of CRS-IC: Need to wait for the current RAN4 discussion

- E-MMSE-IRC under uneven interference (non-slot based): In our view, this is targeting the scenarios where the interference is from the URLLC traffic from netighboring cells. UE definitely needs assistance information from network to now the interference resource allocation. However, even for the same cell, gNB can only provide pre-emption indication several slots after URLLC data transmitted. Can a neighboring gNB provide UE the same information even faster than pre-emption indication?
- Others: Some study on the system benefit is needed.

**6 – Nokia Japan**

- **Concerning UE advanced receivers:**
  We are generally negative towards "**Soft IC to cancel inter-stream interference in SU-MIMO scenario**", as it seems to cover minor implementation details, that most implementations of the non-enhanced requirements are likely already including.
- In the case of "**Advanced receiver to cancel inter-user interference for MU-MIMO**", we have concerns on the testing framework for MU scenarios. Especially in the context of inter-user interference, the current test setup will not suffice.
  Additionally, the maximum scope of the required/allowable network assistance should be set. What RAN1/2 framework would be used for achieving "knowledge on co-scheduled UE presence/modulation"?
- In "**Inter-cell CSI-RS(TRS)/SSB interference mitigation**" the target scenario of "SSB and TRS in neighboring cells are configured in the same time and frequency location respectively" seems quite contrived to us. Such situations might be avoided with careful scheduling and the impact should be low (even in the worst case) as SSB/TRS are not covering a substantial part of the resource grid.
- "**E-MMSE-IRC under uneven inte[r]ference (including time selective inter-cell interference)**": Some contributions ask that "necessary network assistance signalling can be defined to simplify the UE receiver design", without stating the scope of the signaling required. Without more detail, it is not possible to judge the feasibility, advantages, disadvantages, and overall gains to be had.
- "**Enhancement of CRS-IC**E" is too broad of an objective. Before we can agree to this objective the scope needs to be defined.
- **Concerning BS advanced receivers**:
  We don't see the need to specify requirement for the particular receiver implementation of "MMSE-IRC".
  If requirements for scenarios with inter-cell interference are expected to be markedly different from the requirements without interference, then requirements can be studied without mandating the receiver implementation.
  The questions of test setup feasibility for this case also needs to be considered.
- **Concerning other leftovers:**
  Nokia does not have a preference to specify the demodulation performance for the case of two UE rate matching CRS patterns in multi-DCI Tx scheme. It can be discussed, if sufficient companies express a preference for it.

**7 – QUALCOMM JAPAN LLC.**

In this area also there are a lot of proposals, we need to better understand the actual gains for these new features. We believe some are addressing corner cases (for example scenarios with uneven interference) that are irrelevant in commercial deployments. Also, the tradeoffs between complexity and performance gains need to be well understood.

The only area that could potentially show useful gains is the advanced receiver for MU-MIMO.

**8 – Samsung Electronics Co.**

We are supportive to take some enhancement on receiver baseband area based on urgent market demand and critical issues identified by commercial deployment.

For BS receiver side:

We are ok for MMSE-IRC. This is one of proposal dropped in Rel-17 and in UE side, Rel-17 already include MMSE-IRC receiver requirements. Same logic as UE side, we assume the requirements will be only defined for FR1 considering narrow beamforming in FR2 can avoid dominate inter-cell interference case.

For UE receiver side:

As we commented above, current scope seems unrealistic and we should respect the workload and focus on critical issues.

l Soft IC to cancel inter-stream interference in SU-MIMO scenario

l Advanced receiver to cancel inter-user interference for MU-MIMO

l Enhanced DL receivers for multi-DCI multi-TRP scenario

Study phase seems required to evaluate the performance gain, candidate receiver assumption, and UE complexity aspect. We should make decision after initial study phase based on all above aspect other than purely based on performance gain.

l Inter-cell CSI-RS(TRS)/SSB interference mitigation

We can understand network may allocate overlapping TRS/SSB in the same resources. The question what's the performance impact on PDSCH demodulation even with this allocation? Typically, UE rely on TRS/SSB for coarse timing/frequency, and residual time/frequency error can be compensated by DMRS on PDSCH and CE. Usually time/frequency tracking performance is robust compared to decoding. And SSB decoding performance is robust enough compared to PDSCH.

Furthermore network can also avoid the overlapping between adjacent cells, and dominant interference cells by scheduling.

l E-MMSE-IRC under uneven inteference (including time selective inter-cell interference)

Study phase seems also required for this proposal to identify the possible scenario and candidate solutions.

Not sure whether RAN1 /RAN2 also need to be involved if some solutions required RAN1 action.

l CRS-IC

This is pending on Rel-17 ongoing discussion.

One general question for clarification, what's the expected starting time for this WI?

I assume this WI can be target to be approved in March 2022 RAN-P together with other RAN4 proposals meanwhile the actual starting time pending on Rel-17 performance part progress. And we may also need to consider leaving some room to reconsider the scope on some left over issues after Rel-17 performance part finalized.

**9 – China Unicom**

In general, we support to further enhance demodulation requirements in Rel-18. Particularly, we are interested in UE and BS advanced receiver characteristics.

**10 – Intel Corporation (UK) Ltd**

- Advanced UE and BS interference mitigation receivers are critical to ensure robust and improved UE/BS performance under practical deployment scenarios. More justifications on the particular RX structures were provided as a part of September email discussion.
- Prioritization: The list of potential objectives for further discussion looks fine for us. To make the further down selection, we can use the similar procedure as we used for Rel-17 scope discussion, i.e. companies can provide their views on topics priority and we can select the topics which are supported by most of the companies. From our side, the following topics have the the highest priority:
  - UE receivers
    - E-MMSE-IRC under uneven interference (including time selective inter-cell interference)
    - Advanced receiver to cancel inter-user interference for MU-MIMO
    - CRS-IC receivers for DSS (if CRS-IC reference receiver is not defined in Rel-17)
    - Soft IC to cancel inter-stream interference in SU-MIMO scenario
  - BS receivers
    - MMSE-IRC for inter-cell interference
- Lead WG:
  - As for secondary leading working group, we think that we can include at least RAN2 for most of considered UE topics in case we need to define UE capability signalling or Network assistance signalling.
  - RAN1 can be involved for "UE Advanced receiver to cancel inter-user interference for MU-MIMO", because the rather similar scenario and receiver algorithms were considered in Rel-14 LTE MuST WI and new DCI Format was introduced to inform target UE about co-scheduled UE PDSCH parameters.
- SI/WI: There is no need to have a SI and all objectives can be a part of WI. Similar to Rel-17 Enhanced Demodulation requirements, we can consider 2 stage approach (study stage and requirements definition stage) for some of the topics if feasibility analysis is required.

**11 – Huawei Technologies France**

UE advanced receiver (RAN4)

- **Advanced receiver to cancel inter-user interference for MU-MIMO**

  MU-MIMO is a very typical scenario in the real network. The performance requirements of MMSE-IRC for MU-MIMO was agreed to be defined in Rel-17. The E-MMSE-IRC and R-ML receivers to cancel inter-user interference can be used to achieve better performance in fading and spatially correlated channels compared to MMSE-IRC. We support the investigation of E-MMSE-IRC and R-ML candidate receivers for MU-MIMO scenario.

  Regarding R-ML receiver, which was specified for SU-MIMO scenario in Rel-15, the network assistant signalling may be needed to indicate the target user the existence of interference as well as transmission parameters to save the effort of blind detection and simplify UE receiver design in MU-MIMO scenario, we prefer to focus on E-MMSE-IRC without assistant signalling firstly.

- **Soft IC to cancel inter-stream interference in SU-MIMO scenario**

  In the previous discussion, most companies agreed that the typical use case for Soft IC is to address the performance degradation problem caused by the imbalanced SNRs between multiple layers for one CW since one CW will be mapped to multiple layers not larger than 4 for NR. In this use case the CWIC cannot be used. The main concern from companies is the implementation complexity and performance gain. In RP-212486, we shared our evaluation results by using the receiver with the complexity comparable to R-ML and achieved around 1.5dB performance gain over R-ML by using soft-IC receiver under the low correlation channel for higher modulation order of 64QAM and 256QAM. If companies still have concerns, maybe a study phase to evaluate the performance gain of soft IC over R-ML could be conducted.

- **Inter-cell CSI-RS(TRS)/SSB interference mitigation**

  According to the guidance of Rel-18 discussion, the technique to address the issues in real network or improve the performance for typical scenarios should have the higher priority. Based on the discussion related to CSI-RS/SSB configuration in the ongoing Rel-17 MMSE-IRC work, companies agreed that CSI-RS/SSB colliding configurations are very typical in the real network.

  TRS/SSB is used for timing and frequency tracking. The accurate time-frequency tracking is important to ensure good performance. However, there would be serious interference from TRS/SSB of neighbour cells in the real network due to the colliding TRS/SSB configurations. So it would be beneficial to investigate the performance gain for TRS/SSB interference mitigation (IM) to improve UE robustness. Based on our initial evaluations, we observed up to 1.8dB for 64QAM and 2.1dB for 256QAM performance gain with SSB-IM, 3.2dB performance gain for 64QAM with TRS-IM under the low network load compared to without IM receiver in RP-212486.

- **E-MMSE-IRC under uneven interference (including time selective inter-cell interference)**

  MMSE-IRC for uneven interference is set to lower priority in Rel-17.

  The non-slot based transmission, especially for toB service, is regarded as an important feature for NR. For it, the flexible starting symbol S and symbol length L can be configured. Besides, considering the different configurations of SCS and DMRS, it would be difficult for UE to assume evenly distributed interference. In some cases, IRC receiver will use DMRS to estimate the interference from the neighbour cells. For those cases, maybe not all the interference layers can be observed by DMRS. So the potential combinations would be very complex. Thus the typical scenario should be investigated. It is beneficial to study how to efficiently cancel the uneven interference from the interference cells, where the spatial characteristics of interferences are uneven within a slot. Without any similar receiver for LTE, the thorough study of a practical interference profile is needed. Considering the long candidate receiver list for Rel-18, it is better to setup a SI to do full investigation.

- **Enhanced DL receivers for multi-DCI multi-TRP scenario**

  We should align the understanding for this scenario on whether PDSCH corresponding to multi-DCI multi-TRP are overlapping or non-overlapping, what the baseline receiver is for performance comparison, and what the enhanced DL receivers should be considered.

  Based on our understanding, the enhanced DL receiver refers to CWIC, which is used to do the inter-layer interference between two CW. Soft IC can be used for inter-layer cancellation within one or two CW, we do not observe the necessity to additionally introduce CW-IC just for one specific deployment scenario. Except for CW-IC, we are wondering if any other enhanced DL receivers should be considered compared to the MMSE-IRC used for Rel-17 m-DCI m-TRP performance requirements.

- **Enhancement of CRS-IC**

  Based on the evaluation results, LLR weighting is agreed to be used baseline for LTE-NR spectrum overlapping scenario in Rel-17. The good performance can be achieved by using it. And most UE vendors didn't think that it is necessary to introduce CRS-IC for Rel-17. So what are the additional

justifications to introduce enhanced CRS-IC in Rel-18? What are the enhancements compared to CRS-IM discussed in Rel-17. Companies have serious concerns on the complexity and performance gain for CRS-IC compared to LLR weighting. Considering that LTE-NR coexistence scenario is transient, we do not observe too much benefit to do enhancements for CRS-IC in Rel-18.

- **BS advanced receiver (RAN4) (MMSE-IRC for inter-cell interference)**
  BS is different from UE. The UE needs to pass the certification before it goes to the market. So the relative comprehensive test cases need to be defined to ensure the UE complies with the specification and UE from different vendors can correctly communicate with BS from different BS vendors. But all BSs need to pass strict field testing before operators decide to deploy it. So there is no much meaning to define performance requirements for all possible aspects comparing with UE. Also considering several UE candidate receivers are for investigation in Rel-18 and the limited TU, it is much beneficial to focus on improvement for UE advanced receiver.

Other leftovers

- **eMIMO: two UE rate matching CRS patterns in multi-DCI Tx scheme**
  Based on our understanding, this has been evaluated in Rel-17 CRS-IM WI, and there is no need to do further investigation to define specific requirement for it. Otherwise, we want to know what is the difference between the evaluated ”Scheme #3: Rel-16 CRS-RM for 2 interference cells” conducted in Rel-17 CRS-IM and this proposal?

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**12 – VODAFONE Group Plc**

R18 will be the 4th release of NR specifications and over the 5 years since completion of Rel 15, UE processing capabilities have improved. We believe that this can be leveraged to support enhanced demodulation requirements in Rel-18.

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**13 – ZTE Wistron Telecom AB**

- UE advanced receiver (RAN4)
  - Soft IC to cancel inter-stream interference in SU-MIMO scenario
    If a UE is equipped with only one LDPC decoder, soft IC does not introduce a big additional processing delay since code blocks have to be decoded in a sequential way. However, if a UE is equipped with two parallel LDPC decoders, the extra delay introduced by soft IC is not negligible. Clarification might be needed to indicate that the target UE type is single-LDPC-decoder-equipped, if this objective is agreed.
  - Advanced receiver to cancel inter-user interference for MU-MIMO
    With optimized UE pairing at the scheduler and the use of MMSE-IRC receiver, the headroom for improvement could be limited, thus we doubt it is worthy of spending efforts on inter-user interference cancellation for MU-MIMO at this stage.
  - Inter-cell CSI-RS(TRS)/SSB interference mitigation:
    Compared with LTE, NR has provided much more flexibility to avoid SSBs conflicting in frequency domain among adjacent cells. Unless it turns out to be inevitable in real networks (which of course already means a huge waste of standardization efforts on designing such flexibility), we don’t think we need to add this into the TODO list.
  - E-MMSE-IRC under uneven interference (including time selective inter-cell interference)
    We share similar view that uneven interference may be a corner case.
  - Enhancement of CRS-IC
    Unclear on what is the enhancement of CRS-IC.

- BS advanced receiver (RAN4)
    - MMSE-IRC for inter-cell interference:
      We believe MMSE-IRC being widely in use though there is no requirements defined at BS side yet. Ok to introduce in Rel-18.

**14 – Apple AB**

The list of topics is very extensive for UE advanced receiver/ demod enahncements. RAN4 should prioritize topics that have benefit in the real network and aim to solve problems experienced in the field rather than define requirements just because a gain is observed but is not a widely applicable scenario. Also, we need to take into account performance benefit over UE processing complexity and discuss the required assistance upfront for any advanced receiver processing.

On UE Demod Enhancements:

– Soft IC to cancel inter-stream interference in SU-MIMO scenario : Negative - Need to study performance benefit vs UE complexity.

– Enhanced DL receivers for multi-DCI multi-TRP scenario: Neutral -We need to understand if it is a widely deployed use case before looking into defining requirements.

– Advanced receiver to cancel inter-user interference for MU-MIMO: Need to discuss the required assistance information for advanced processing. The target deployment scenarios need to be discussed and established.

– Inter-cell CSI-RS(TRS)/SSB interference mitigation: Negative – Unlike CRS CSI-RS and SSB configuration in NR is very flexible. The network can always configure to avoid inter-cell interference. The benefits of such mitigation might be limited to corner cases.

– E-MMSE-IRC under uneven interference (including time selective inter-cell interference) – The scope of this should be first discussed, there were many topics included under this item and how practical and useful all are is not clear. Also, any advanced receiver processing would likely need network assistance. Some potential solutions may also involve RAN1 design update and should be considered as well.

– Enhancement of CRS-IC – CRS_IM is being discussed in R17, we would like to understand what the enhancement is targeting in R18. We would like to understand how relevant would any enhancement in R18 be when NR networks are more prevalent by the time R18 capable UEs and networks are in the field.

Other leftovers

– eMIMO: two UE rate matching CRS patterns in multi-DCI Tx scheme: Negative – No real benefit of introducing the requirement to verify that 2 CRS RM patterns can be handled by the UE.

Leading working group: RAN4 and depending on the scope RAN2 and RAN1 for UE capability signaling, NWA signaling, any RAN1 design enhancements

#### 5.2.1.2 Summary for initial round

Fourteen companies provided the feedback. The moderator would like to provide the summary for each working areas. In moderator view, there seems no clear consensus.

**SoftIC**

China Telecom, Ericsson, CMCC, NTT DOCOMO, Intel, and Huawei supported it. Samsung were OK to have study first.

Mediatek expressed the strong concern on the complexity, performance benefit and HARQ reporting time budget. Nokia and Apple were negative. ZTE would like to clarify that single LDPC-decoder is equipped.

**Enhanced DL receivers for multi-DCI multi-TPR**

Ericsson supported it. Samsung were OK to have study first.

Huawei commented on reference receiver to be used.

**Advanced receiver for MU-MIMO**

China Telecom, Ericsson, CMCC, Qualcomm, Intel and Huawei supported. Samsung were OK to have study first. Apple commented that the assistance signaling needs be discussed.

Nokia expressed the concerns on testing framework for MU-MIMO and network assistance signaling. ZTE doubted the gain compared to MMSE-IRC.

**Inter-cell CSI-RS/SSB IM**

China Telecom, CMCC, NTT DOCOMO, and Huawei supported it.

Ericsson commented that TRS/SSB mitigation is not important since the interference won't have large system impact. Nokia commented that the overlapping TRS/SSB scenario can be avoided by implementation. Samsung were not convinced and thought the timing/frequency tracking performance is robust enough. ZTE and Apple did not see the need to introduce such requirements considering the flexibility of network deployment.

**E-MMSE-IRC under uneven interference**

China Telecom (not considering different SCS cases), Intel supported it

Ericsson preferred to down-prioritize the work because the cells are synchronized and in Rel-18 it is not clear whether cells will use different slot length. Mediatek questioned whether a neighbor gNB can provide UE necessary indication. Nokia commented that it is unclear on network assistance signaling part. Qualcomm and ZTE thought it addressed the corner case. Samsung commented that it was unclear if RAN1/2 need be involved.

**Enhanced CRS-IC**

Intel supported it for DSS scenario.

Ericsson commented that it should be done in Rel-17. Mediatek and Samsung commented that they need wait for current RAN4 discussion. Nokia commented that the scope is too broad. Huawei did not think it should be done in Rel-18.

**BS advanced receiver (MMSE-IRC)**

China Telecom, Samsung, and ZTE supported it.

Ericsson commented that BS can do it already and there is no need to spend time in 3GPP for it. Nokia and Huawei did not see the need to specify the requirement.

**Other leftover (eMIMO two UE rate matching CRS patterns in multi-DCI Tx scheme)**

China Telecom support ATP for defining the corresponding RAN4 requirements.

China Telecom proposed to extend MMSE-IRC receiver for inter-cell and intra-cell MU-MIMO to CA case.

Nokia, Huawei and Apple did not prefer to defining the requirements for eMIMO two UE rate matching CRS patterns.

### 5.2.2 Intermediate round

#### 5.2.2.1 Proposals and comments collection

There is no clear consensus on the working area for demodulation performance enhancement topic. For some working areas, the study may be needed and companies are open. For some working areas, it seems that companies were quite negative. To facilitate the discussion in the future, the moderator suggested to drop some working areas in Rel-18:

- It is proposed to drop a number of working areas
  - E-MMSE-IRC under uneven interference
  - Enhanced CRS-IC
  - eMIMO two UE rate matching CRS patterns

Please provide your comments on the above proposal.

**Feedback Form 48:**

| |
|---|
| **1 – China Telecommunications**<br>In general we are Ok with moderator's suggestions to drop some of the proposals.<br>But we'd like to clarify if we drop "**Enhanced** CRS-IC", can we still consider **CRS-IC** if it is not introduced in Rel-17?<br>Ok to drop the other bullets. |
| **2 – Apple AB**<br>The proposals are OK for us. More detailed scopes are subject to further discussion. |
| **3 – QUALCOMM JAPAN LLC.**<br>We supporting dropping those items to reduce the scope of the discussion to more relevant proposals. |
| **4 – Intel Corporation (UK) Ltd**<br>We are fine to drop "eMIMO two UE rate matching CRS patterns" topic.<br>For "Enhanced CRS-IC", we can keep discussion of this topic on hold for now and decide based on progress of Rel-17 CRS-IM requirements discussion. In case CRS-IC will be deprioritized in Rel-17, we think that |

it will be rather straightforward to define such requirements in Rel-18 based on analysis and agreements from Rel-17 without big impact on RAN4 workload.

For "E-MMSE-IRC under uneven interference", we think that this an important topic. MMSE-IRC requirements for such scenario are already in the scope of Rel-17 with the second priority. Taking into account NR flexibility for PDSCH mapping, we think that this can be a rather typical scenario. We are fine to focus on scenarios with aligned SCS among neighboring cells.

**5 – Nokia Japan**

We agree to drop at least the listed topics and would like to discuss which topics among the rest should be included in Rel-18 and clear objectives for them in the next RAN.

**6 – Huawei Technologies France**

We agree with moderator's suggestion to drop the above three items from the Rel-18 work scope discussion considering that so many candidate receiver are in queue that can be used to address more practical scenario.

For the rest of working areas, please proponents respond the comments and questions. Please other companies provide the further feedback for constructive proposals on how to move forward.

**Feedback Form 49:**

**1 – China Telecommunications**

**Soft IC:**

Regarding the HARQ processing time commented by MTK, if needed we can discuss it in a potential study phase.

Regarding the single LDPC-decoder commented by ZTE, we wonder is it for the same CB? If it is for the same CB, our understanding is yes, it is done in a sequential way.

**Advanced receiver for MU-MIMO:**

Regarding the testing framework for MU-MIMO commented by Nokia, we already have a testing framework when defining the MMSE-IRC requirements for MU-MIMO in Rel-17. We don't see a issue for it.

Regarding the network assistance commented by Nokia, it depends on the reference receiver. If E-MMSE-IRC is considered, it would not be an issue. If R-ML or soft-IC is considered, we need to discuss how to obtain the modulation order of the co-scheduled UE.

Regarding the performance gain commented by ZTE, for E-IRC the gain comes from the more accurate estimation of the interference covariance, and additional gain can be obtained for R-ML and soft-IC.

In general, with more and more UEs connected to NR cells instead of LTE cell, we see the benefits of doing enhancement for MU-MIMO scenario.

**Inter-cell CSI-RS/SSB IM:**

For TRS configuration, in Rel-17 discussion on inter-cell IRC, it has been agreed that the TRS configuration are aligned / overlapped among cells, to reflect the practical deployment.

For SSB configuration, it is also the common understanding from network vendors and operators that the SSB configuration should be aligned among cells to match the practical deployment. But chipset and UE

vendors want to configure non-overlapping SSB configurations among cells to avoid impact on time/frequency tracking.

Another thing we see is that the TRS density is much more sparse compared to CRS density for LTE.

**BS advanced receiver (MMSE-IRC):**

BS MMSE-IRC is beneficial for uplink coverage and overall performance, and we see in general that the UL performance improvement draw more attention in NR compared to LTE era.

Companies commented IRC has already implemented in the BS, but how could we know its performance in different typical scenarios without the requirement.

Another thing is that if IRC does not worth 3GPP work since it has already been implemented, can we consider other further BS enhancements in 3GPP without IRC requirements?

**ATP**

As commented in the initial round, we support defining the corresponding RAN4 requirements for ATP. But we are not sure whether this work should be considered separately as a RAN5-led WI?

**MMSE-IRC receiver for inter-cell and intra-cell MU-MIMO to CA case**

It is just to extend the baseline IRC receiver to CA case.

**2 – QUALCOMM JAPAN LLC.**

Please see below further comments from our side on the proposals:

- Soft-IC: from the studies we performed, we have only seen gains of most 0.6dB with a Soft-IC receiver. this does not justify the added UE complexity in our view, would be better to focus the energy in areas with higher return.
- Enhanced receiver for multi-DCI mTRP: As per our understanding, this scenario is not deployed. So, RAN4 should not consider enhancements for such scenarios at this point.
- Advanced receiver for MU-MIMO: We are ok with E-MMSE-IRC receiver but not R-ML receiver since that will also require knowledge of modulation of co-scheduled UEs (that will either need blind modulation detection or NW assistance via DCI). This means either very high complexity UE or complexity on the network side
- TRS/SSB-IC: We don't expect much perf impact due to this and it is very difficult to quantify also. In fact, during Rel-17 Demod Enh WI, companies ran simulations for Inter-cell Interference scenario to see the impact of serving cell TRS colliding with interfering cell TRS/data v/s being interference free and companies did not observe any performance difference.

**3 – Ericsson France S.A.S**

- Soft IC to cancel inter-stream interference in SU-MIMO scenario
- Advanced receiver to cancel inter-user interference for MU-MIMO

These two proposals are likely to be fairly generically applicable, but the complexity and benefits of the receivers have not been elaborated. A Study could make sense.

- Enhanced DL receivers for multi-DCI multi-TRP scenario

This is a more specialized scenario than the general one; again a study is needed. Considering that the first two are more general in benefits, if prioritizing this could have a lower priority.

- Inter-cell CSI-RS(TRS)/SSB interference mitigation

We don't expect benefit on average PDSCH throughput. Compared to LTE CRS these signals are much less frequent. In our view, the earlier proposal above are related to more general, consistent interference and may be more useful to spend effort on.

**4 – Intel Corporation (UK) Ltd**

We think that for most of considered scenarios with RX processing enhancements study stage will be required to confirm the performance benefits and ensure a reasonable complexity before definition of requirements (i.e. similar to Rel-17 procedure)

**Soft IC**

Our understanding that single LDPC-decoder per iteration should be considered. However, we need to further discuss the all details of receive processing in the study stage of this topic in case it will be included in the Rel-18 scope.

**Enhanced DL receivers for multi-DCI multi-TPR**

We think that we can focus on scenario with overlapping PDSCH allocation. As for receiver type, we can consider CW-IC and Soft IC and, based on discussion, decide whether any differentiation is needed. Based on our understanding, there is no big Rx processing difference of these two receivers and probably we can discuss the details during study stage in case this topic will be included in the Rel-18 scope.

**Advanced receiver for MU-MIMO**

Based on our analysis from RAN4#100 meeting (R4-2113120), performance benefits of E-MMSE-IRC can be observed in certain typical scenarios. As for performance benefits of R-ML receiver for MU-MIMO, we think that it was proven in the Rel-14 LTE MuST work item and we can check whether similar observations are also valid for NR.

As for testing framework for MU-MIMO, we think that this topic will be discussed for Rel-17 MMSE-IRC MU-MIMO requirements and similar procedure can be used for Rel-18 MU-MIMO requirements.

**BS advanced receiver (MMSE-IRC)**

Similar to MMSE-IRC UE requirements, we think that it is very important to verify that BS supports MMSE-IRC processing. Current requirements are defined for AWGN conditions and don't allow to verify whether BS is able or not to apply MMSE-IRC processing. Therefore, definition of requirements in scenarios with inter-cell interference are required. No study stage is required.

**5 – Nokia Japan**

Given that the available time is limited this week after receiving some clarification on each of the topics by the respective proponents, we propose to discuss these area's necessity of the inclusion of Rel-18 package and/or the detail objectives in the next RAN Plenary and beyond based on the feedbacks.

**6 – Huawei Technologies France**

**UE advanced receiver**

- **Advanced receiver to cancel inter-user interference for MU-MIMO**

We support to consider E-MMSE-IRC for the inter-user interference cancellation for MU-MIMO considering that MIMO is a very typical scenario for NR, related enhancements are beneficial to improve UE performance.

- **Soft IC to cancel inter-stream interference in SU-MIMO scenario**

For concerns raised by other companies during first round discussion, our considerations are:

@MediaTek, Apple and Samsung: As we elaborated in our contribution RP-212486, the complexity can be controlled by reusing the multi-CC processing capability to improve the performance of single CC; the processing delay can be controlled by keeping the same iteration number of LDPC decoder as RML, only additional MIMO detector, interleaver/de-interleaver, scrambler/de-scrambler are needed, but simpler detector can be used to utilize the prior information of the LDPC decoder. Around 1.5dB performance gain can be achieved by using soft-IC receiver under the low correlation channel for higher modulation order of 64QAM and 256QAM, no any negative performance gain compared with RML in various scenarios.

But anyway it is fine for us to have a study phase to investigate the related aspects, such the performance gain, the specific receiver assumptions and complexity.

@Nokia: It is unreasonable to judge a kind of advanced receiver from the implementation details that are minor or big, we should focus on whether it can solve a real critical issue (inter-stream interference in one CW) and bring a certain performance gain.

@ZTE: We did not fully understand your question that UE with two parallel LDPC-decoders will have extra delay introduced by Soft IC. As per our understanding, if the two parallel LDPC decoders are used for two CC, they should be separate; If two parallel LDPC decoder are used for single CC, it should be faster than single LDPC decoder.

- **Inter-cell CSI-RS(TRS)/SSB interference mitigation**

Several companies think the scenario that neighboring cells are configured with colliding TRS/SSB in the real network is not typical, they think that can be avoided by scheduling. But based on the current NR real network configurations and discussion about TRS/SSB configuration for ongoing Rel-17 MMSE-IRC for inter-cell interference, we can know that TRS/SSB in the neighboring cell are configured in the same time and frequency are very typical, vendors or operator can double check this from the NR real network.

TRS/SSB are used for time-frequency tracking, accurate time-frequency tracking is important to ensue good performance. Usually SSB is used for coarse time-frequency tracking, if no good coarse time-frequency tracking, there will be larger residual time-frequency error that will be impose heavy burden for the following accurate time-frequency tracking, and then impact the PDSCH performance. TRS is used for accurate time-frequency tracking during the connect state, inaccurate time-frequency tracking will have serious impact on channel estimation for PDSCH. We don't think that DM-RS for PDSCH is assumed to be used for residual time-frequency tracking by default as per 3GPP specification, especially the issues for PRB bundling size 2 or 4 for timing tracking, DM-RS 1+0 for frequency tracking, and DM-RS 1+1 with interval of 7 symbols for very limited frequency tracking.

Because TRS are transmitted with certain periodicity and not in every subframe for CRS, it is more important to have TRS/SSB as less interference as possible to achieve accurate time-frequency tracking. Especially in certain conditions, such as the network load is light and higher modulation order is scheduler. If companies have concerns on the performance gain, it is fine for us to have a study phase to evaluate the related performance gain. For SSB-IM, we observed SSB only is transmitted by some network, then SSB is used for time-frequency tracking for all the time. Or SSB is used for time-frequency tracking before TRS is transmitted, such random access procedure. So SSB-IM can bring performance improvement for PDSCH by accurate time-frequency tracking.

- **Enhanced DL receivers for multi-DCI multi-TRP scenario**

We would like to suggest to drop "Enhanced DL receivers for multi-DCI multi-TRP" working area considering that it just targets for very specific scenario multi-DCI scheduled multi-TRP, also only demodulation performance requirements for non-overlapping PDSCH resource allocation for m-DCI based m-TRP are

defined in Rel-17, further clarifications about the enhanced receiver and targeted scenario as we commented in the initial round are needed.

**BS advanced receiver (RAN4)**

- **MMSE-IRC for inter-cell interference**

Usually the performance requirements defined by 3GPP are used to ensure the BS implement the related functions and corresponding performance. But MMSE-IRC for inter-cell interference should have been implemented in real network and strict field trial is usually conducted before operator deploy the BS. We do not think that it is necessary to define related performance requirement in the specification and ask BS to do additional unnecessary duplication testing in lab compared to the field trial.

**Others**

- **ATP WI**

Although ATP SI is completed with the feasibility to define related performance requirements, we still have concerns on the benefits to define the performance requirements, considering different network may have different configurations and target for different scenarios, operators have different requirements for different scenarios and service, how to define a set of requirements with many fixed test configurations to cate for all operator's request? We do not think that it is feasible and beneficial. Considering so many other urgent and real network request features to be introduced for Rel-18, we suggest to focus on those higher priority work and down priority of this ATP.

- **Extend MMSE-IRC receiver for inter-cell and intra-cell MU-MIMO to CA cases**

Considering so many other urgent and real network request features to be introduced for Rel-18, like those candidate UE advance receivers that are used to solve critical and real issues in the network, we suggest to focus on those higher priority work of UE advanced receiver for single CC.

#### 5.2.2.2 Summary for intermediate round

Most companies supported to drop three working area, i.e., E-MMSE-IRC under uneven interference, Enhanced CRS-IC, eMIMO two UE rate matching CRS patterns. China Telecom and Intel proposed to put CRS-IC on hold. Intel proposed to further considering E-MMSE-IRC under uneven interference.

Based on the feedback from initial round, it seems that most companies did not favor E-MMSE-IRC under uneven interference. To speed up the discussion, the moderator suggests to drop E-MMSE-IRC under uneven interference, enhanced CRS-IC and eMIMO two UE rate matching CRS patterns. The moderator wonders if the group can agree on the proposal.

For the other topics, enough information is shared for each proposal and many good feedback is also provided. The moderator observes the common interests for MU-MIMO advance receiver from companies. For the other proposals, the moderator encourages companies to provide more simulation results and analysis on UE implementation complexity, and come back with good papers in RAN#94-e for further discussion.

### 5.2.3 Final round

#### 5.2.3.1 Proposals and comments collection

Based on the comments and feedback from companies, moderator would like to propose

- **Proposal #10-1: for the demodulation requirements evolution topic, it is proposed to de-prioritize the following working areas**

- E-MMSE-IRC under uneven interference
- Enhanced CRS-IC
  - Depending on the progress of Rel-17. CRS-IC could be further discussed in Rel-18 RAN4 package if it is not introduced in Rel-17
- eMIMO two UE rate matching CRS patterns

– **Proposal #10-2: for the demodulation requirements evolution topic, the following objectives can be considered**

- UE advanced receiver (RAN4)
  - Evaluate and specify advanced receiver to cancel inter-user interference for MU-MIMO
    - FFS on reference receiver
    - Study the performance gain before specify the requirements

– **Proposal #10-3: for the demodulation requirements evolution topic, companies are encouraged to provide more simulation results and analysis related UE implementation complexity for each proposal in RAN#94-e.**

Please provide your comments in table below.

**Feedback Form 50:**

| |
|---|
| **1 – China Telecommunications**<br>We are fine with moderator's proposal as the starting point for future discussion. |
| **2 – Nokia Japan**<br>For **#10-1**, we support proposal #10-1, though it's better to make sure that the three areas dropped not to expand the discussion further in the next meetings.<br>For **#10-2**, as we commented in the initial round, the current test setup in the context of inter-user interference will not suffice. Additionally, the maximum scope of the required/allowable network assistance is not clear, so what RAN1/2 framework would be used for achieving "knowledge on co-scheduled UE presence/modulation" is not clear as well. Hence, the last bullet point of "Study the performance gain before specify the requirements" should be replaced with "Study the performance gain, testability, required signalling overhead, as well as impact on other WGs before specify the requirements"<br>For **#10-3**, as commented on #10-2, the detail of network assistance mechanism and its impact on other WGs should be also provided. Hence, our alternative is as follows.<br>"for the demodulation requirements evolution topic, companies are encouraged to provide more simulation results, analysis related UE implementation complexity, **required level of network assistance frameworks and their impact on other WGs** for each proposal in RAN#94-e." |
| **3 – MediaTek Inc.**<br>On 10-2, we think Nokia's comment is valid. Subjected to be RAN4 discussion outcome, we may want to introduce some assistance information like modulation or # of layers of the co-scheduled UE. The current proposal seems to prohibit this possibility? |
| **4 – QUALCOMM JAPAN LLC.**<br>We agree with proposal #10-1. |

Of #10-2, we agree with Nokia that there are dependencies on assistance data so the proposed change is useful.

**5 – VODAFONE Group Plc**

We are fine with the moderator's proposals as a starting point for future discussion.

**6 – Intel Corporation (UK) Ltd**

**Proposal #10-1**

We prefer to keep E-MMSE-IRC under uneven interference for further discussion. In the past we've shown the performance benefits of such receiver for scenario where we have misalignment of serving and interference cells PDSCH duration configurations. Also, such scenario is already included in the Rel-17 scope (but with MMSE-IRC receiver) and if we will not have time to complete it within Rel-17 timeframe, then we suggest to continue discussion in Rel-18. Companies can bring more justifications as a part of proposed discussion under proposal 10-3.

**Proposal #10-2**

We support consider UE advanced receiver for MU-MIMO as one of potential Rel-18 topic. Same time, as we commented in the initial round, we need to have more discussion on whether RAN1 should be involved in the discussion on this topic.

**Proposal #10-3**

Agree.

5.2.3.2 Summary for final round

Although companies supported to remove three working areas proposed by #10-1, Intel still preferred to keep MMSE-IRC under uneven interference and provided some justification. Since at the current stage, the group is not supposed to do prioritization in general (The reason to propose to drop some proposals for this demodulation topic is that there are too many proposals).So the moderator would like to keep MMSE-IRC under uneven interference for the time being.

Nokia provided modification to clarify the dependency on assistant signaling to other working group.

Based on the feedback, the moderator modified the proposals.

- **Proposal #10-1: for the demodulation requirements evolution topic, it is proposed to de-prioritize the following working areas**
  - ~~E-MMSE-IRC under uneven interference~~
  - Enhanced CRS-IC
    - Depending on the progress of Rel-17. CRS-IC could be further discussed in Rel-18 RAN4 package if it is not introduced in Rel-17
  - eMIMO two UE rate matching CRS patterns
- **Proposal #10-2: for the demodulation requirements evolution topic, the following objectives can be considered**
  - UE advanced receiver (RAN4)
    - Evaluate and specify advanced receiver to cancel inter-user interference for MU-MIMO

- FFS on reference receiver
- Study the performance gain, testability, required signaling overhead, as well as impact on other WGs before specify the requirements

- **Proposal #10-3: for the demodulation requirements evolution topic, companies are encouraged to provide more simulation results and analysis related UE implementation complexity, required level of network assistant frameworks and their impact on other WGs for each proposal in RAN#94-e.**

## 5.3 Support of intra-band non-collocated EN-DC/NR-CA deployment

### 5.3.1 Initial round

#### 5.3.1.1 Proposals and comments collection

**Previous discussion in general for topics across RF, RRM and demodulations**

The proposed conclusion in September pre-RAN email discussions for this area (RP-211667) is as follows.

- ***Evolution of requirements across RF, RRM and demodulation, with the following example areas***
  - ***Support of intra-band non-collocated EN-DC/NR-CA deployment (including FR, RRM and demodulation performance requirements)***
  - *ATG (air-to-ground network)*
  - *[Co-channel HAPS]*
  - *Requirement for FR2 multi-Rx chain DL reception including 4-layer DL MIMO (including RF, RRM and demodulation requirements and OTA test methods)*
  - *[FR2 HST enhancement (including CA FR2, multi-panel simultaneous operation, high velocity supporting up to 500km/h)*
  - *NOTE: further prioritization for above items are needed in future meeting.*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- Support of intra-band non-collocated EN-DC/NR-CA deployment
  - Potential justifications:
    - Due to different co-existence conditions, Tx antenna co-location is not always available
    - For some operators, 3 blocks in C-band were allocated at different time, which makes Tx antenna co-location cost-inefficient sometimes infeasible
      (Refer to RP-212098)
  - Potential objectives: (Refer to RP-212098)

- Support of non-co-located scenario for FR1 intra-band non-contiguous EN-DC/NR-CA
- RRM part
  - Study and, if feasible, define requirements for UE other than FG 2-19 Type 2 operation in non-collocated deployment for FR1 intra-band non-contiguous NR-CA/EN-DC
  - Define requirements applicable to UEs capable of FG 2-19 Type 2
- Demod part
  - Define PDSCH Requirements for non-collocated scenario for intra-band non-contiguous EN-DC and NR-CA

- Leading working group:
  - RAN4
- SI or WI:
  - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 51:**

**1 – LG Uplus**

In general we support the proposed potential justification and objectives from moderator. Thanks for that. However it seems that the RF part is not mentioned while it is in the title, "***Support of intra-band non-collocated EN-DC/NR-CA deployment (including FR(maybe typo, so it should be RF), RRM and demodulation performance requirements)*** ". So I would like to suggest following which is from RP-211579 when we discussed it for Rel-17 addition at RAN 92e :

RF part

· *Feasibility of UE RF architecture to support both DL and UL operation*

· *Feasible value of the power imbalance*

**2 – LG Electronics Deutschland**

RAN4 needs to study how much power imbalance will be needed to support non-collocated intra-band CA/DC operation. RAN4 should inform demodulation session of the agreed max. allowed power imbalance level for their work. Also, RAN4 needs to study which of the other RF requirements would need to be addressed to support this feature. In summary, we think there should be an explicit RF requirement listed as one of the objectives.

**3 – KDDI Corporation**

We are fine with proposed justification and objectives.

**4 – SoftBank Corp.**

Thanks moderator for the proposal. As a proponent, we fully support it.

**5 – NTT DOCOMO INC.**

We are supportive of moderator's proposal and fine with LG Uplus and LGE comments. If RF requirements are explicitly needed, it is better to be clarified.

**6 – Nokia Japan**

Currently, only co-located requirements are specified for FR1 intra-band non-contiguous EN-DC / NR-CA. We would be positive towards supporting scenarios like non-co-located scenarios.

However, the listed below objectives would need clarification and clear scope would be listed. It needs to be clarified in the scope which UE Type is included in the WI. E.g. Type 2 UE means that the UE shall be capable of inter band requirements even if intra band CA/DC is used. Hence, it clearly says that non-co-located deployment capable.

- Study and, if feasible, define requirements for UE **other than** FG 2-19 Type 2 operation in non-co-located deployment for FR1 intra-band non-contiguous NR-CA/EN-DC
- Define requirements applicable to UEs capable of FG 2-19 Type 2

Alternative could be as follows. But it can be further made specific later.

Specify RRM requirements for UE that indicates *interBandMRDC-WithOverlapDL-Bands-r16*.

**7 – MediaTek Inc.**

We support this work, but have a similar view as LGE that the RF session needs to be involved. The RF architecture should be the fundamental part to agree first before proceeding RRM and Demod discussions.

**8 – QUALCOMM JAPAN LLC.**

For the non-collocated deployments, some discussion on the baseline assumptions in terms of MRTD and power imbalance would be useful. AS was commented already, implementation for this is quite difficult. Our understanding is that the current architecture for NC CA with a common LNA is the baseline assumption

**9 – Samsung Electronics Co.**

We support to consider study phase to identify the parameters for this deployment, delta related to existing requirements and feasibility from implementation.

For objective, one suggestion: to avoid confusion, replace "FG 2-19 Type 2" with exactly definition.

**10 – Intel Corporation (UK) Ltd**

Different coexistence conditions apply for different part of the same frequency band, so collocated Tx is not always available even for intra-band EN-DC and CA. RAN concluded MRTD/MTTD are not specified in Rel-16 or Rel-17. RRM requirements are missing for type 2 UE (2-19) implementation when it supports intra-band NC MR-DC with the same assumption that it handles MRTD > 3us.

The following refined objectives are suggested to clarify differentiation of UE capabilities:

- *Enable FR1 intra-band non-contiguous EN-DC/NR-CA for non-co-located scenario*
  - *Define requirements for UEs supporting DL operation in non-co-located deployment for FR1 intra-band non-contiguous NR-CA/EN-DC*

        - *Power imbalance requirements between the two carriers*
        - *MRTD and MTTD requirements*
        - *Define requirements for UEs capable of Rel-16 FG 2-19 Type 2*
    - *Study and, if feasible, define requirements for UEs supporting DL and UL operation in non-co-located deployment for FR1 intra-band non-contiguous NR-CA/EN-DC*
        - *Power imbalance requirements between the two carriers*
        - *MRTD and MTTD requirements*
- *Define PDSCH requirements for non-colocated scenario for intra-band non-contiguous EN-DC and NR-CA based on the applicable MRTD and power imbalance values*

**11 – Huawei Technologies France**

We support to have WI in Rel-18 to address the issue in real deployment scenario.

**12 – Apple AB**

As many operators are requesting to support from the perspective of commercial deployment, it is reasonable for RAN4 to study it. However, due to the potentially large MRTD, the impact on UE should be carefully studied first. The feasibility to support such scenario should be decided after the study.

#### 5.3.1.2 Summary for initial round

Twelve companies provided feedback. All the companies can accept this working area. LGU+, LGE, and Mediatek commented that UE RF architecture, power imbalance need be studied. In addition, Qualcomm and Intel commented that MRTD/MTTD need be specified. Apple commented that impact of larger MRTD on UEs needs be studied first. Nokia and Samsung commented that ”FG2-19 Type 2” needs be replaced by other terms.

### 5.3.2 Intermediate round

#### 5.3.2.1 Proposals and comments collection

Based on the feedback and comments from companies, the moderator would like to suggest the following potential objectives for further discussion. In the initial summary, only part of the objectives were copied and some information was missing.

- Potential objectives: (copied from RP-212098 with modification for FG 2-19 Type 2 operation)
    - Support of non-co-located scenario for FR1 intra-band non-contiguous EN-DC/NR-CA
    - RRM part
        - Study and if feasible, define requirements for UE which is not capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way to support inter-band CA, i.e., UE not indicating interBandMRDC-WithOverlapDL-Bands-r16
            - Study the following aspects
                - Feasibility of UE RF architecture to support both DL and UL operation
                - Feasible value of the power imbalance
                - Feasible value of MRTD and MTTD in non-collocated deployment

        - Define MRTD and MTTD requirements
            - NOTE: MTTD requirements are subject to the decision whether UL Tx is needed for both (or all) carriers
    - Define requirements for UE which is capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way as to support inter-band CA, i.e., UE indicating interBandMRDC-WithOverlapDL-Bands-r16.
        - First investigate the applicable MRTD and power imbalance level, considering the network deployment scenario and UE implementation feasibility.
            - Specify MRTD and Requirements for FR1 intra-band non-contiguous EN-DC applied for non-co-located scenario (including power imbalance limitation)
            - Specify MRTD Requirements for FR1 intra-band non-contiguous NR-CA applied for non-co-located scenario (including power imbalance limitation)
- Demodulation part
    - Specify PDSCH requirements for non-collocated scenarios for intra-band non-contiguous EN-DC and NR-CA
        - Define PDSCH demodulation performance requirement based on the applicable MRTD and power imbalance values.
            - Power imbalance between the carriers is limited to [X]dB
        - [Work is limited to CA/EN-DC for EN-DC/NR-CA for bands 42, n77/n78]

Please provide your comments in below table.

**Feedback Form 52:**

| |
|---|
| **1 – Apple AB**<br>it seems our comments haven't been reflected. It is more appropriate to start this work as SI. It is not OK for us to directly conclude "Support of non-co-located scenario for FR1 intra-band non-contiguous EN-DC/NR-CA" without such study. |
| **2 – QUALCOMM JAPAN LLC.**<br>We understand there was a clear proposal (with a use case and a band) for the 2nd big bullet but we do not necessarily see the use case for the first big bullet. What are the target bands for this ? |
| **3 – SoftBank Corp.**<br>To: Apple<br>In our understanding, all the scope start from study based on the current moderator's proposal. Thus, we understand that this is a wording issue of the very 1st main bullet. Then, we are fine to rephrase it to "**Study and if feasible,** support of non-co-located scenario for FR1 intra-band non-contiguous EN-DC/NR-CA".<br>To: Qualcomm<br>The bands we are interested are 42 and n77/n78. The UE described in the 1st big bullet aims at the use of full-rank MIMO. Meanwhile, The UE described in the 2nd big bullet aims at e.g. the large power imbalance at the sacrifice of MIMO capability. We think both are important from our deployment scenario point of view. The feasibility can be discussed during the study phase. |

**4 – LG Electronics Deutschland**

Currently RF objectives are embedded in RRM part. As we mentioned in the initial round, separate RF objectives would be better

**5 – KDDI Corporation**

In general we are fine with the proposed objrctives, we are also fine with the rewording from softbank mentioned above.

**6 – LG Uplus**

We are fine with the proposed objectives and also fine with the modification proposed by SoftBank. For information, our interested bands are n77/n78 which include band 42(3400-3600MHz). Like LGE mentioned, just curious that the RF parts are not explicitly specified but embeded in RRM. Is it better to list it explicitly?

**7 – Intel Corporation (UK) Ltd**

We are overall fine with the proposed objectives and suggest to make some clarifications on RRM (and RF) scope

- *Core part*
  - *Study and if feasible, define requirements for UEs supporting DL and UL operation in non-co-located deployment for FR1 intra-band non-contiguous EN-DC and NR-CA*
    - *Study feasibility of UE RF architecture to support both DL and UL operation [RF]*
    - *Study and if necessary, define*
      - *Feasible value of the power imbalance [RF]*
      - *Feasible value of MRTD and MTTD in non-collocated deployment [RRM]*
      - *NOTE: MTTD requirements are subject to the decision whether UL Tx is needed for both (or all) carriers*
    - *Note: requirements are applicable for UEs not capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way to support inter-band CA, i.e., UE not indicating interBandMRDC-WithOverlapDL-Bands-r16*
  - *Define requirements for UEs supporting DL operation in non-co-located deployment for FR1 intra-band non-contiguous EN-DC and NR-CA*
    - *Identify feasible MRTD and power imbalance level, considering the network deployment scenario and UE implementation feasibility [RF, RRM].*
    - *Note: requirements are applicable for UE capable of supporting DL intra-band non-contiguous NR-CA and EN-DC in the same way as to support inter-band CA, i.e., UE indicating interBandMRDC-WithOverlapDL-Bands-r16.*

**8 – Nokia Japan**

Regarding UE RF related objectives, discussion on power imbalance between carriers has been on-going in RAN4. Hence, the final objectives should reflect the outcome of Rel-17 discussion (Perhaps, we may not need to include UE RF objectives). The achievable power imbalance conditions will be captured for UE demodulation as moderator suggested.

**9 – NTT DOCOMO INC.**

We are fine with moderator's proposal and also fine with the modification proposed by SoftBank.

#### 5.3.2.2 Summary for intermediate round

Nine companies provided the feedback. Apple proposed the work as a SI. Softbank responded and offered the change of the first main bullet. Qualcomm commented if the study and requirements are needed for UE not indicating *interBandMRDC-WithOverlapDL-Bands-r16*. Softbank provided the responses. For the concerning bands, Softbank and LGU+ proposed 42 and n77/n78.

Moderator: to Apple, since there are two kinds of UE capabilities, for UE who indicates support of *interBandMRDC-WithOverlapDL-Bands-r16*, there seems no shared LNA issue. Thus it seems reasonable to have a WI to specify the corresponding requirements. For UE who does not indicate that capability, the study is needed. If one item covers both UE capabilities, it seems that a WI with study phase would be a good choice. Anyway whether to specify the requirements or not for UE who does not indicate the *interBandMRDC-WithOverlapDL-Bands-r16* capability depends on the conclusion of study.

### 5.3.3 Final round

#### 5.3.3.1 Proposals and comments collection

Based on the comments and feedback, the moderator would like to propose the following bullet for discussions in the final round.

- **Proposal #11-1: for support of intra-band non-collocated EN-DC/NR-CA deployment, the following objectives can be considered:**
  - Study and if feasible, support non-co-located scenario for FR1 intra-band non-contiguous EN-DC/NR-CA
    - Work is limited to CA/EN-DC for EN-DC/NR-CA for bands 42, n77/n78
  - Core part
    - Study and if feasible, define requirements for UE which is not capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way to support inter-band CA, i.e., UE not indicating interBandMRDC-WithOverlapDL-Bands-r16
      - Study feasibility of UE RF architecture to support both DL and UL operation [RF]
      - Study and if necessary, define
        - Feasible value of the power imbalance [RF]
        - Feasible value of MRTD and MTTD in non-collocated deployment [RRM]
        - NOTE: MTTD requirements are subject to the decision whether UL Tx is needed for both (or all) carriers
    - Define requirements for UE which is capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way as to support inter-band CA, i.e., UE indicating interBandMRDC-WithOverlapDL-Bands-r16.
      - Identify feasible MRTD and power imbalance level, considering the network deployment scenario and UE implementation feasibility [RF, RRM]
  - Performance part [Demodulation]

- Specify PDSCH demodulation requirements for non-collocated scenarios for intra-band non-contiguous EN-DC and NR-CA
  - Define PDSCH demodulation performance requirement based on the applicable MRTD and power imbalance values.
    - Power imbalance between the carriers is limited to [X]dB

undefined NOTE: Power imbalance may be specified as the condition in the demodulation performance requirements

Please provide your comments in table below.

**Feedback Form 53:**

| |
|---|
| **1 – Nokia Japan**<br>We believe this should be included in Rel-18 and also support the proposal as a starting point. And we believe that the details on the objectives for WID should be further discussed in the next RAN. |
| **2 – LG Electronics Deutschland**<br>We support this proposal and agree with Nokia that further update of the objectives is necessary. |
| **3 – KDDI Corporation**<br>We are fine with moderator's proposal. |
| **4 – NTT DOCOMO INC.**<br>We support the moderator's proposal. |
| **5 – SoftBank Corp.**<br>We support the moderator's proposal. Thanks everyone for the constructive discussions! |
| **6 – LG Uplus**<br>We support the proposal from moderator. (Thanks so much for leading) |
| **7 – Intel Corporation (UK) Ltd**<br>We support the proposal. Further fine-tuning of objectives wording may be required at a later stage. |
| **8 – TELECOM ITALIA S.p.A.**<br>ok with the moderator's proposal |

5.3.3.2 Summary for final round

The proposed objectives are acceptable to the group.

- **Proposal #11-1: for support of intra-band non-collocated EN-DC/NR-CA deployment, the following objectives can be considered:**

- Study and if feasible, support non-co-located scenario for FR1 intra-band non-contiguous EN-DC/NR-CA
    - Work is limited to CA/EN-DC for EN-DC/NR-CA for bands 42, n77/n78
- Core part
    - Study and if feasible, define requirements for UE which is not capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way to support inter-band CA, i.e., UE not indicating interBandMRDC-WithOverlapDL-Bands-r16
        - Study feasibility of UE RF architecture to support both DL and UL operation [RF]
        - Study and if necessary, define
            - Feasible value of the power imbalance [RF]
            - Feasible value of MRTD and MTTD in non-collocated deployment [RRM]
            - NOTE: MTTD requirements are subject to the decision whether UL Tx is needed for both (or all) carriers
    - Define requirements for UE which is capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way as to support inter-band CA, i.e., UE indicating interBandMRDC-WithOverlapDL-Bands-r16.
        - Identify feasible MRTD and power imbalance level, considering the network deployment scenario and UE implementation feasibility [RF, RRM]
- Performance part [Demodulation]
    - Specify PDSCH demodulation requirements for non-collocated scenarios for intra-band non-contiguous EN-DC and NR-CA
        - Define PDSCH demodulation performance requirement based on the applicable MRTD and power imbalance values.
            - Power imbalance between the carriers is limited to [X]dB

undefined NOTE: Power imbalance may be specified as the condition in the demodulation performance requirements

## 5.4 FR2 HST enhancement

### 5.4.1 Initial round

#### 5.4.1.1 Proposals and comments collection

**Previous discussion**

- **Evolution of requirements across RF, RRM and demodulation, with the following example areas**
    - *Support of intra-band non-collocated EN-DC/NR-CA deployment (including FR, RRM and demodulation performance requirements)*
    - *ATG (air-to-ground network)*
    - *[Co-channel HAPS]*
    - *Requirement for FR2 multi-Rx chain DL reception including 4-layer DL MIMO (including RF, RRM and demodulation requirements and OTA test methods)*
    - ***FR2 HST enhancement (including CA FR2, multi-panel simultaneous operation, high velocity supporting up to 500km/h)***

- *NOTE: further prioritization for above items are needed in future meeting.*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- FR2 HST enhancement
  - Potential justifications:
    - Limited study was provided on the tunnel scenario due to the limited Rel-17 effort and relative prioritization
    - The intra-band carrier aggregation (CA) operation and the feasibility of supporting high-speed-train velocity of up to a maximum of 500km/h are also of interests to operators, which is not yet covered in Rel-17 work item scope.
    - It is of importance to introduce the support of simultaneous reception with maximum 2 active panels at the train roof-mounted FR2 high power devices in the bi-directional RRH deployment scenario.
    - In Rel-17 work item, the larger autonomous timing adjust step $T_q$ is specified for FR2 HST UE, and the RAN4-based solutions for the uplink timing issue are focused, while other solutions involving other RAN working groups are not fully studied.
      (Refer to RP-212115)
  - Potential objectives:
    - Core part:
      - Study and specify the requirements for the following deployment scenario [RAN4]:
        - Focused on train roof-mounted high power devices with target applicable carrier frequency up to 30GHz;
        - Study on reference tunnel deployment scenario for FR2 HST and specify the channel model and corresponding core requirements;
        - Specify the requirements for intra-band carrier aggregation (CA) scenario;
        - Specify the requirements to support the scenario with mixed near-to-track (i.e., Scenario-A with Ds = 700m and Dmin = 10m) and far-from-track (i.e., Scenario-B with Ds = 700m and Dmin = 150m) RRH deployment;
        - Study the feasibility of supporting HST velocity of up to a maximum of 500km/h, with carrier frequency up to 30GHz.
      - Specify the requirement for multi-panel operation for train roof-mounted FR2 high power devices [RAN4]:
        - Maximum 2 active panels supporting the multi-panel simultaneous reception.
      - Specify the new uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays from different TRPs to UE [RAN1, RAN4].
    - Perf part:
      - Specify the RRM performance requirements of measurement accuracy if identified.
      - Specify the RRM test cases related to new core requirements.
      - Specify the UE demodulation and BS demodulation requirements.

- Leading working group:
  - RAN4
- SI or WI:
  - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 54:**

**1 – China Telecommunications**

We support FR2 HST enhancement in Rel-18, and support the proposed objectives above.

Rel-17 is the first release for FR2 HST requirements, and it is beneficial to cover more scenarios and higher velocity in Rel-18.

We also have a small comment on the responsible WG for following objective. We suggest to list RAN4 first, since RAN4 will discuss the needed enhancement on timing adjustment mechanism, and then RAN1 can update the specification accordingly based on RAN4 recommendation.

- Specify the new uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays from different TRPs to UE **[RAN4, RAN1]**.

**2 – Ericsson France S.A.S**

Ericsson: The tunnel scenario will clearly be similar to Scenario A RRM wise (i.e. the BS is visible within 1 UE beam/panel) and demodulation wise it is very unlikely that the propagation model will differ so substantially to the single tap model that performance will differ substantially, so we do not think this needs really to be studied.

Regarding mixing Scenario A and Scenario B: Currently in Rel-17 it seems like demodulation wise the performance is the same in both scenarios. For RRM, more RX beams are needed for scenario B. For a mixed case, presumably the worst case in respect to the number of RRM beams would need to be considered, which implies 6 beams. We do not think there is a need to develop any additional requirements for the mixed case.

The CA scenario could be useful to consider

Extending to 500km/h could be done; however when prioritizing the overall workload for demodulation we think this should not be high priority as the urgent need in the Rel-18 timeframe is not obvious.

Regarding 2 panel operation; this can already be achieved by operating each panel of the train mounted equipment as an individual UE in uni-directional. We can support to specify 2 panel operation for consistency though.

Regarding the time adjustment scenario, if the time adjustment in Rel-17 works then it is not obvious what needs to be improved; we think the need can be clarified after completion of the Rel-17 work.

Proposal: Consider CA objective and 2 panel operation. Possibly consider higher speeds depending on overall workload in demodulation, but further clarification requested on whether this is critical in Rel-18 timescale.

**3 – China Mobile Com. Corporation**

We support to enhance FR2 HST requirements in Rel-18 including:

- 500km/h support for FR2 HST
- intra-band carrier aggregation scenario, e.g. n258
- mixed near-to-track scenario (also depends on the conclusion in Rel-17)
- 2 active panel operation

**4 – Nokia Japan**

We support enhancing FR2 HST. At is quite natural to have a possibility to utilize CA as well. Further clarification on the objectives is needed based on the progress of the Rel-17 WI, at least for the following items:
Requirements to support the scenario with mixed near-to-track and New uplink timing adjustment mechanism

Multi-panel operation would require the design of a new UE testing setup. It could be beneficial to consider this issue on a general level and not only in application to HST FR2 scenario.

**5 – QUALCOMM JAPAN LLC.**

We need to better understand the motivation for this work. At least for now, there are no FR2 HST deployments and we are not aware of any deployments happening anytime soon. The work should be based on some critical commercial needs.

**6 – Samsung Electronics Co.**

We are supportive for the proposal and objectives as refer to our t-doc RP-212115/2114 for motivation and justifications.

For tunnel scenario: This is one non-covered scenario from Rel-17 which due to RAN4 TU limitation and prioritization. We would like to take some study for this scenario to identify the proper parameters of deployment and any impact on RAN4 requirements which not covered by Rel-17 requirements.

For test issue of Multi-panel operation: Following previous approach in RAN4, requirements and test issues can be decoupled and handled separately. In this WI, we can focus on introducing corresponding core and performance requirements. Test issue can be handled in another SI which we see relevant proposal under item 4.5.

For Specify the new uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays from different TRPs to UE, we are ok to first discuss in RAN4 and then send recommendations to RAN1 as China Telecom suggested.

For 500 km/h, in rel-17 there are some demand from EU and Chinese operators. We would like to further evaluate the possibility to increase the supporting velocity.

**7 – China Unicom**

We support to work on enhancing FR2 HST in Rel-18, and fine with proposed objectives.

A clarification question: Whether or not to specify band-specific (e.g. n258) requirements in this WI?

**8 – Intel Corporation (UK) Ltd**

Certain down-selection of objectives should be considered. The following objectives can be prioritized:

- Requirements for intra-band carrier aggregation (CA) scenario
- Supporting HST velocity of up to a maximum of 500km/h
- Requirement for multi-panel operation

For multi-panel operation scenario, we believe that further alignment with objectives in 5.5 shall be considered and the multi-panel reception can be considered in 5.5.

**9 – Verizon UK Ltd**

We support the proposal as referring to both t-doc RP-212115/2114 for Rel-18. And, we are fine with proposed objectives.

**10 – Huawei Technologies France**

Generally we support to do some enhancements for FR2 HST in Rel-18, but for the potential objectives, we have the following considerations:

We support to study the following items:

- Study on reference tunnel deployment scenario
- Study the feasibility of supporting HST velocity of up to a maximum of 500km/h, with carrier frequency up to 30GHz.
- Specify the requirement for maximum 2 active panels for multi-panel reception for train roof-mounted FR2 high power devices
- Specify the new uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays from different TRPs to UE

RAN4 RRM is targeting for UE specific implementation method to solve the larger UL TA issue in Rel-17 FR2 HST, it is beneficial to investigate other possible ways that can involve both UE and BS to solve the large UL TA if possible.

We have concerns on the following items:

- Specify the requirements for intra-band carrier aggregation (CA) scenario: considering the larger channel bandwidth for FR2, we do not think that there would be urgent market requests even in the near future for FR2 HST CA. Since there are many other aspects to be studied, this objective can be with the low priority from our point of view.
- Specify the requirements to support the scenario with mixed near-to-track (i.e., Scenario-A with Ds = 700m and Dmin = 10m) and far-from-track (i.e., Scenario-B with Ds = 700m and Dmin = 150m) RRH deployment: we do not think it is necessary to specify the requirements for scenario with mixed Scenario A and Scenario B. Rel-17 FR2 HST is under study to define unified or separate requirements for Scenario A and Scenario B with target to ensure that UE can meet the requirements for both scenarios.

| |
|---|
| **11 – ZTE Wistron Telecom AB**<br>We are fine to continue FR2 HST enhancement in Rel-18 if TU permits. However, the listed objectives look a bit too ambitious for the Rel-18 time frame, and in our views, higher priority should be cast to:<br>(1) Missing pieces: for example, tunnel scenario, 500km/h<br>(2) Essential enhancement: for example, intra-band CA |
| **12 – Apple AB**<br>Is this proposal limited to CPE or generalized to all types of UE? It is OK to limit it to CPE as R17. Otherwise, a study is needed. |

5.4.1.2 Summary for initial round

Twelve companies provided the feedback. For the scenarios to be specified, companies had different views.

**Tunnel scenario**

Samsung, Huawei, ZTE supported it.

Ericsson thought the existing requirements can cover it and do not need study.

**CA sceanrio**

Samsung, Ericsson, CMCC, Intel, and ZTE supported it. China Unicom questioned if band specific (e.g. n258) requirements will be specified.

Huawei commented that it seemed not urgent market request.

**Mixed scenario A and B:**

Samsung, CMCC supported it.

Ericsson and Huawei thought there is no need to define requirement for it. Nokia commented that further clarification on objectives is needed based on the progress of Rel-17.

**Up to 500km/h for up to 30GHz**

Samsung, CMCC, Intel, Huawei, ZTE supported it.

Ericsson thought it could be with low priority.

**Multi-panel operation**

Samsung, Ericsson, CMCC, Intel, Huawei supported it.

Nokia commented that further clarification on objectives is needed based on the progress of Rel-17 and preferred to consider it on a general level rather only for HST.

**New uplink timing adjustment mechanism**

Samsung, Huawei supported it.

Ericsson thought whether it is needed depend on completion of Rel-17.

**UE type**

Apple commented that WI should be limited to CPE as Rel-17.

### 5.4.2 Intermediate round

#### 5.4.2.1 Proposals and comments collection

Based on the comments and feedback, the moderator would like to suggest further discussing which scenarios should be considered.

Please the proponents provide the response to the comments and questions from companies. Please other companies provide constructive suggestions on how to proceed.

**Feedback Form 55:**

**1 – China Telecommunications**

**Tunnel scenario**

We think it is a very typical scenario for HST while not addressed in Rel-17.

**CA scenario**

At least intra-band carrier aggregation scenario should be considered as commented by CMCC. And in general we can consider band agnostic requirements for a certain range of frequency.

**Multi-panel operation**

Only one active antenna panel is considered in Rel-17. The multi-panel requirements for HST and non-HST are different and should be discussed separately.

**New uplink timing adjustment mechanism**

We support it considering the large propagation delays from different TRPs to UE, and also considering the Ts / Tc value is very small in FR2.

**UE type**

We agree it is targeted on CPE.

**2 – Apple AB**

Can the proponent company clarify the UE type question?

**3 – China Mobile Com. Corporation**

**Tunnel scenario**

For tunnel scenario, whether existing requirements can cover or not depends on the scenario and channel model. More study is needed.

**CA scenario**

Extend single carrier HST to CA scenario is straightforward, similar as what we did for FR1 HST enhancement. For demodulation and RRM requirements can be specified in a band agnostic manner. For If new RF requirements are introduced, they may be band specific.

**Multi-panel operation**

Consider multi-panel in a general level is also OK. But so far there is no proposal for consider multi-panel operation in non-HST scenario. We can discuss multi-panel operation for HST as a starting point, and extend to other scenarios.

**Mixed scenario A and B/New uplink timing adjustment mechanism**

OK to consider depends on completion of Rel-17.

**UE type**

OK to limit to CPE/FWA

**4 – QUALCOMM JAPAN LLC.**

In our understanding, FR2 HST is a special deployment with a dedicated network and devices(Rel.17 CPEs). As we are not aware of any such commercial deployments, we still question the need for this work right now without understanding what should be enhanced. We risk working on something useless and having to come back to do more enhancements in the future.

For the tunnel scenario, this will require more RAN4 time because a new channel model is needed.

**5 – Ericsson France S.A.S**

Ericsson:

Regarding UE type, we agree that the focus should continue to be on train mounted UE (i.e. CPE)

To clarify our view on prioritization:

In decreasing priority order:

· Specify the requirement for multi-panel operation for train roof-mounted FR2 high power devices [RAN4]:

Maximum 2 active panels supporting the multi-panel simultaneous reception.

(This can partially be achieved in Rel-17 using each panel as a separate UE, but can make sense also to specify a single UE since the multi-panel functionality is available in the specs)

· Specify the requirements for intra-band carrier aggregation (CA) scenario

This is relatively straightforward and will be needed

· Study the feasibility of supporting HST velocity of up to a maximum of 500km/h, with carrier frequency up to 30GHz.

(For these latter two, it is not clear that there is an immediate market need and they could be downprioritized if needed due to workload, but clearly they will be needed at some time)

Proposals we don't support (mainly because we on't see anything needs to be fixed from Rel-17):

· Specify the new uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays from different TRPs to UE [RAN1, RAN4].

The timing adjustment mechanism should work in Rel-17 already for the feature to operate properly. Could the proponents clarify the proposal.

· Study on reference tunnel deployment scenario for FR2 HST and specify the channel model and corresponding core requirements;

In our understanding, a tunnel would be served by a BS close to the track with a single beam, like scenario A. There will be very little scope for significant delay spread within the tunnel, so it is not obvious why the channel model would differ so much that it needs a special demodulation requirement.

· Specify the requirements to support the scenario with mixed near-to-track (i.e., Scenario-A with Ds = 700m and Dmin = 10m) and far-from-track (i.e., Scenario-B with Ds = 700m and Dmin = 150m) RRH deployment;

In our understanding, the difference between Scenario A and B is the number of RX beams assumed for RRM and if the UE does not know the scenario for the next BS, it will need to take worst case (Scenario B) all of the time. Could proponents clarify what would need to be enhanced ?

**6 – Samsung Electronics Co.**

For **tunnel scenarios**, in our understanding, the leak cable scenarios as in FR1 cannot be applied in FR2 due to specific waveguide design for mmWave cannot be applied in tunnel deployment scenarios considering both cost and performance. Also, in our understanding, the distance between RRH as well as distance between RRH and track in the tunnel are certainly different from the existing scenarios B (Ds = 10m, near-to-track scenarios). It is also questionable if the channel model developed in Rel-17 is applied for tunnel scenarios. With above aspects, we think the tunnel scenarios shall be specified to support operator deployment.

For **CA scenario**, the operating bands depends on operators input. So far, only 28GHz are proposed to be considered. Also, operator input have justified the urgency of market demand

For mixed scenario and also uplink timing, we also agree that somehow these are related to ongoing Rel-17 discussions, it is better to leave it with [ ] for now. Depends on the Rel-17 outcome, RAN4 can further discuss to add these objectives back to the scope

For **multi-panel operation** for HST CPE devices, considering the benefit in the bi-direction scenarios, it could be the first step to start the multi-panel operation discussions in RAN4. On the other hand, we are open to have core requirements specifying for mobile phones in Rel-18 timeframe but multi-panel for CPE and mobile phones have to be seperated discussions given the different form factor and also specific deployment scenarios optimization.

For **UE type**, we agree with Apple that Rel-18 FR2 HST shall still target on the CPE type rather than smart phones. It can be further calrified in objectives (Same bullet as Rel-17 WID can be added for Rel-18 objective as well)

**7 – Intel Corporation (UK) Ltd**

- From our point of view the following scenarios are prioritized – CA, extension to 500km/h, multi-panel operation. Multi-panel operation needs to be considered jointly with proposals under 5.5 and further alignment is needed.
- For tunnel scenario, we are not sure additional requirements are needed, but open to do a study

- For mixed scenario A/B, we are not clear if any specific optimizations are required and whether it will be a typical deployment.
- For new uplink timing adjustment mechanism – we agree that it depends on Rel-17 conclusions and we prefer to handle in Rel-17 timeframe via UE autonomous one-shot large timing adjustment.
- For UE type, we don't think the work shall be limited to CPEs. We could consider the below objectives to allow non-HST UEs to access the HST networks (e.g., for instance UEs located outside of trains on the stations):
  - *Specify applicable RRM requirements for non-HST UE-s in HST FR2 network*
    - *Introduce, if necessary, UE capability signaling to ensure clear alignment between UE and network knowledge on applicable RRM requirements to different types of UE-s*

**8 – Nokia Japan**

In general, we think that majority of current proposal still must be carefully evaluated.

For example, even regarding intra-band CA, we would like to understand better if there is a strong need to extent the BW further in FR2 taking into account that FR2 BW is already wide enough, e.g., 200MHz.

Regarding Mixed deployment and UL timing adjustment, we need to wait for the outcomes of Rel-17 NR*HST*FR2 WI.

We also support limiting the considerations in Rel-18 to CPE/roof-mounted type of devices like in Rel-17.

Regarding multi-panel operation, as we commented in the initial round, even if this item is included in the WID, discussion on multi-panel should not be placed in multiple different WIs. Also, multi-panel operation may have different utilizations such that simultaneous reception of different beams or switching multi-panels to receive more suitable beam. That should be clarified. Then, the objective should be discussed in a more suitable place. And if the generic requirement is established, we can proceed with requirements specific to HST.

**9 – Samsung Electronics Co.**

To Nokia, for CA scenario, given roof-mounted CPE is supposed to provide the back-hual like access for all other UEs in the carbin, high through-put by utlizing larger aggregated BW is the major motivation of introducing CA scenarios for FR2 HST.

**10 – Huawei Technologies France**

We agree to focus on train mounted CPE only.

We support to study the following items:

- Tunnel deployment scenario
- The feasibility of supporting HST velocity of up to a maximum of 500km/h, with carrier frequency up to 30GHz.
- Maximum 2 active panels for multi-panel reception for train roof-mounted FR2 high power devices. But it is also feasible to merge this into other discussion for multi-panel reception in the RF part.
- New uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays

We have concerns on the following items:

- Specify the requirements for intra-band carrier aggregation (CA) scenario: considering the larger channel bandwidth for FR2, we still do not think that there would be urgent market requests even in the near future for FR2 HST CA.

- Specify the requirements to support the scenario with mixed Scenario A and Scenario B deployment: From demodulation point of view, it is not necessary and meaningful to specify the requirements for scenario with mixed Scenario A and Scenario B. Rel-17 FR2 HST is under study to define unified or separate requirements for Scenario A and Scenario B with target to ensure that UE can meet the requirements for both scenarios.

#### 5.4.2.2 Summary for intermediate round

More feedback is provided from companies. Companies' views are kept unchanged and the view are even more diverse. The views on each potential objectives are updated based on the feedback from initial round.

**Tunnel scenario**

Samsung, Huawei, ZTE supported it. China Telecom, CMCC also supported it.

Ericsson thought the existing requirements can cover it and do not need study. Qualcomm questioned that more time is needed for a new channel model. Intel is not sure if the new requirement is needed.

**CA scenario**

Samsung, Ericsson, CMCC, Intel, and ZTE supported it. China Unicom questioned if band specific (e.g. n258) requirements will be specified. China Telecom, CMCC

Huawei commented that it seemed not urgent market request. Nokia questioned the need to extend to CA.

**Mixed scenario A and B:**

Samsung, CMCC supported it.

Ericsson and Huawei thought there is no need to define requirement for it. Nokia commented that further clarification on objectives is needed based on the progress of Rel-17. Intel was not clear if any specific optimizations are required.

**Up to 500km/h for up to 30GHz**

Samsung, CMCC, Intel, Huawei, ZTE supported it.

Ericsson thought it could be with low priority.

**Multi-panel operation**

Samsung, Ericsson, CMCC, Intel, Huawei supported it. China Telecom.

Nokia commented that further clarification on objectives is needed based on the progress of Rel-17 and preferred to consider it on a general level rather only for HST.

**New uplink timing adjustment mechanism**

Samsung, Huawei supported it. China Telecom supported it.

Ericsson and Nokia thought whether it is needed depend on completion of Rel-17. Intel commented that it depends on the Rel-17 conclusion.

**UE type**

Apple commented that WI should be limited to CPE as Rel-17. Nokia and Huawei supported to limit device type to CPE.

Intel did not think that the work should be limited to CPE.

### 5.4.3 Final round

#### 5.4.3.1 Proposals and comments collection

Based on the comments, the only common understanding seems to define the requirements for multi-panel operation. But more discussions are needed about where (in which item) the requirements will be specified. The other proposed objectives need more discussions in the future meeting.

The moderator would like to propose the following bullets for further discussion in the final round for this topic.

- **Proposal # 12-1: for FR2 HST enhancement, the following objectives can be considered**
  - Core part:
    - Specify the requirement for multi-panel operation for train roof-mounted FR2 high power devices [RAN4]:
      - Maximum 2 active panels supporting the multi-panel simultaneous reception.
      - FFS whether this objective will be merged into the other RAN4-led item
    - FFS other core requirements

Please provide your comments in the table below.

**Feedback Form 56:**

| |
|---|
| **1 – China Telecommunications**<br>We are fine with moderator's proposal as the starting point for future discussion. |
| **2 – Nokia Japan**<br>We support the proposal and would like to discuss objectives further in the next RAN also in relation to the OTA testing for UEs with multi-panel reception. |
| **3 – Samsung Electronics Co.**<br>Different from modeator observation, we recognized that there is no actual foundemental concerns on the CA/Tunnel/maximum 500Km/h discussed in this round of e-mail thread. The comments are more like "Study and specify if any" " low priority" and so on. For CA scenario, we are not sure how the scenario supported by multiple operators (4 of them) can be interpretated as no market demand. The most controversial scenario is mixed scenario A and B. We are open to FFS for mixed scenario A and B in this |

round. For uplink timing, the comments are about the ongoing Rel-17 discussion. We are also open to list it as FFS part

Without listing these scenarios but just adding FFS bullet, the risk is to expand the scope in future RAN meeting/e-mail disucssion unnecessary Therefore we suggest to revise the conclusion as below, i.e.,

Core requirements

- Study on reference tunnel deployment scenario for FR2 HST and specify the channel model and corresponding core requirements;
- Specify the requirements for intra-band carrier aggregation (CA) scenario;
- Study the feasibility of supporting HST velocity of up to a maximum of 500km/h, with carrier frequency up to 30GHz.
- Specify the requirement for multi-panel operation for train roof-mounted FR2 high power devices [RAN4]:
  - Maximum 2 active panels supporting the multi-panel simultaneous reception.
  - FFS whether this objective will be merged into the other RAN4-led item
- FFS other core requirements for the below scenario
  - Specify the requirements to support the scenario with mixed near-to-track (i.e., Scenario-A with Ds = 700m and Dmin = 10m) and far-from-track (i.e., Scenario-B with Ds = 700m and Dmin = 150m) RRH deployment
  - Specify the new uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays from different TRPs to UE

**4 – Ericsson France S.A.S**

We support the moderator proposal. From the other issues that could be discussed, as we pointed out earlier, in our view we do not see that the tunnel scenario is different to the existing scenario A in terms of the RRM requirements or demodulation. We would like to see some motivation as to why, in a tunnel with LoS from the BS to the UE the channel model would differ so significantly from Scenario A. CA and higher velocity can be discussed further.

**5 – Intel Corporation (UK) Ltd**

We support Samsung proposal and think it is ok to list identified objectives (although some further prioritization can be required similar to all other areas).

**6 – China Mobile Com. Corporation**

We support Samsung's comments. CA is straightforward enhancement, considering FR2 has wide bandwidth, CA should be included in Rel-18 FR2 HST enhancement. Also for 500km/h, only 1 company thought this can be low priority, we can list this and further discuss in the future.

#### 5.4.3.2 Summary for final round

Samsung provided the modified proposal and Intel, CMCC supported it. Regarding tunnel scenario, Ericsson provided the comments. Regarding CA scenario, the comment from Huawei in the intermediate round is "we have concerns on the following items.. Specify the requirements for intra-band carrier aggregation (CA) scenarios... do not think that there would be **urgent** market requests... for FR2 HST CA."

Moderator: For clarification, all the proposed objectives for each topic will be listed for further discussion. There is not general prioritization discussion in this email discussion.

Based on the feedback, the moderator modified the proposal.

- **Proposal # 12-1: for FR2 HST enhancement, the following objectives can be considered**
  - Core part:
    - Study the feasibility, and if feasible enable supporting HST velocity of up to a maximum of 500km/h, with carrier frequency up to 30GHz
    - Specify the requirement for multi-panel operation for train roof-mounted FR2 high power devices [RAN4]:
      - Maximum 2 active panels supporting the multi-panel simultaneous reception.
      - FFS whether this objective will be merged into the other RAN4-led item
    - FFS other core requirements considering the following potential objectives for the corresponding scenarios below
      - Study on reference tunnel deployment scenario for FR2 HST and specify the channel model and corresponding core requirements
      - Specify the requirements for intra-band carrier aggregation (CA) scenario
      - Specify the requirements to support the scenario with mixed near-to-track (i.e., Scenario-A with Ds = 700m and Dmin = 10m) and far-from-track (i.e., Scenario-B with Ds = 700m and Dmin = 150m) RRH deployment
      - Specify the new uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays from different TRPs to UE

## 5.5 multi-Rx chain DL reception

### 5.5.1 Initial round

#### 5.5.1.1 Proposals and comments collection

**Previous discussion**

- ***Evolution of requirements across RF, RRM and demodulation, with the following example areas***
  - *Support of intra-band non-collocated EN-DC/NR-CA deployment (including FR, RRM and demodulation performance requirements)*
  - *ATG (air-to-ground network)*
  - *[Co-channel HAPS]*
  - ***Requirement for FR2 multi-Rx chain DL reception including 4-layer DL MIMO (including RF, RRM and demodulation requirements and OTA test methods)***
  - *FR2 HST enhancement (including CA FR2, multi-panel simultaneous operation, high velocity supporting up to 500km/h)*
  - *NOTE: further prioritization for above items are needed in future meeting.*

The comments, questions, and responses in the September pre-RAN email discussion were captured in RP-211667.

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- FR2 multi-Rx chain DL reception
  - Potential justifications:
    - Feature was introduced in Rel.17 FeMIMO
    - Currently under discussion in RAN4, however, it is unlikely that RAN4 will finalize the requirements in Rel.17 time frame
      (refer to RP-212140)
  - Potential objectives:
    - Introduce requirements for 4-Layer in FR2, at least for a multi-panel framework (dual TCI).
      - Enhanced RRM requirements: RRM measurement delay reduction, FR2-FR2 DAPS HO
      - Enhanced RF requirements: New spherical coverage requirements for devices with 2 panels
      - UE demodulation requirements: simultaneous and non-simultaneous RX from different directions, 4 DL MIMO layers.

undefined (refer to previous summary and RP-212140)

  - Leading working group:
    - RAN4
  - SI or WI:
    - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 57:**

| |
|---|
| **1 – China Telecommunications**<br>We support the work. As summarized by moderator, the feature was already introduced in Rel.17 FeMIMO. |
| **2 – Nokia Japan**<br>We support the continued work in FeMIMO as we expect RAN4 will not be able to fully finalize the requirements in Rel-17. The detailed objectives can be further discussed based on the Rel-17 WI progress. However, 4 layers have not been an objective in FeMIMO and it requires more work for UE RF and UE demodulation, it should be handled in a dedicated WI for FR2 4 layers. |

**3 – Samsung Electronics Co.**

We are fine to consider this in Rel-18 meanwhile in moderator's summary this proposal linked to Rel-17 FeMIMO feature. That's not aligned with our understanding.

"Multi-Rx chain DL reception" should belongs to UE implementation and RAN4 issue. From RAN1 aspect, even from Rel-15, physical layer design already supports this operation (in transparent or non-transparent manner with some specific optimized features in Rel-16 and Rel-17. The limitation come from RAN4 that: till Rel-17, all RAN4 RF and RRM core requirements and performance requirements are introduced based on the assumption that no simultaneously reception from multiple beam directions in FR2 for smart phones.

We should first study and specify corresponding basic RAN4 core requirements with multi-Rx chain DL reception in FR2. After that, we can extend the requirements in RAN4 introduced in Rel-16 eMIMO and FeMIMO from FR1 to FR2 as well in later stage i.e. multi-TRP/multi-TCI state PDSCH requirements.

**4 – QUALCOMM JAPAN LLC.**

For the FR2 4L DL proposal, this will depend also on the progress in the Rel.17 FeMIMO. Given that there is not much time to discuss/define the requirements in Rel.17, it is likely that this work will be needed to finalize the requirements for the Rel.17 feature.

The main objective covers dual TCI but at least part of the requirements(for example the RF part) will also cover the single TCI case.

We do not think the RRM measurement delay reduction or DAPS belongs here, those are separate objectives that are not directly related to the 4L.

For the RF requirements, we will need new RF requirements but calling them new spherical coverage requirements might be misleading. There is no intention to modify the current requirements of 50%-ile spherical coverage. All new requirements will still keep the current requirements as baseline. Our understanding is that this is introduced especially for simultaneous Rx.

**5 – Intel Corporation (UK) Ltd**

- **Justification**: RAN4 FR2 requirements for single carrier case are defined under an assumption that UE is capable of single panel reception only. Support of FR2 multi-panel simultaneous reception was assumed in the scope of Rel-16 eMIMO WI, but no RAN4 requirements were defined. Further extension of FR2 UE capabilities to support simultaneous reception is required to extract full FR2 benefits including improved FR2 RF, RRM and demodulation performance.
- **Objectives**:
  - We overall fine with the objectives proposed by moderator as a starting point but would like to make a few updates.
  - Multi-panel UEs may not necessarily be limited to 4MIMO layers. Also, in the previous meeting some companies proposed not to preclude single panel implementations and we suggest using term "FR2 UEs with multi-Rx chain DL reception" to denote FR2 UEs with improved reception capabilities.
  - We are ok to consider multi-TCI (dual TCI) scenario as a starting point, but open to consider additional scenarios (single TCI).
  - UEs supporting multiple RX chains reception can be helpful to improve RRM performance, which is one of the existing bottlenecks of FR2, and respective objectives need to be considered. For instance, support of 2 simultaneous chains can reduce the RRM delays by a factor of 2 due to faster Rx beam scanning.

- For RF requirements we agree with Qualcomm that some further refinement of candidate requirements shall be discussed. In our view one candidate requirement is spherical coverage but we are open for further suggestions.
- In addition, the OTA test methods shall be considered to enable UE testing (it can be discussed in section 4.5 or here).

- The proposed set of objectives is as follows:
  - *Define requirements for enhanced FR2 UEs with multi-Rx chain DL reception capabilities*
    - *RF requirements: New spherical coverage requirements for devices with 2 panels, [other requirements]*
    - *RRM requirements enhancements: RRM measurement delay reduction, FR2-FR2 DAPS HO*
    - *UE demodulation requirement: simultaneous and non-simultaneous RX from different directions, 4 DL MIMO layers requirements.*
  - *Study OTA test methodology*
    - *Study FR2 OTA testing methodology multi-Rx chain DL reception including at least scenarios with signals coming from 2 different directions*
  - *Focus on handheld UEs.*

**6 – Huawei Technologies France**

It's not clear whether the multi-layer reception is for two panels or panel agnostic. If that is panel agnostic, we don't see the reason for further enhancement of the spherical coverage requirements.

**7 – Verizon UK Ltd**

We support to continue FeMIMO work in RAN4. RAN4 could discuss the detailed objectives based on the Rel-17 WI, and the objective of FR2 4 layers should be in this Rel-18 WI.

**8 – Apple AB**

In R16, RAN1 considered the simultaneous multi-panel reception by UE and a UE capability was specified. However, there was no RAN4 requirements. In R17 FeMIMO, multi-TCI/TRP feature also relies on this UE capability. Given there is not much time left in R17, it seems reasonable to get the related RAN4 work done in R18.

We also would like to discuss the use cases. For FR2, given the large channel bandwidth, the achieved data rate is already very high (>10Gbps), so it is not clear how much useful it is to support DL 4layer MIMO, considering the increased power consumption. Is the intention mainly to increase robustness in case of beam blocking? Some clarification from proponents is appreciated.

Regarding the work of enhanced RF requirements, since R15 UEs are assumed to use more than one panel to meet the spherical coverage requirement, it is not clear if RAN4 should define new requirements. In addition, how much gain/requirement improvement is unknown. So we don't think it should be included in the work item scope.

#### 5.5.1.2 Summary for initial round

Eight companies provided the comment and feedback. Qualcomm, Intel and Huawei commented on RF requirements. It seemed that proponents proposed to define the new RF requirements rather than modifying spherical coverage requirements, which needs further clarifications. Apple commented on the usefulness to support DL 4-layer MIMO and also had questions on whether the new RF requirement should be specified.

### 5.5.2 Intermediate round

#### 5.5.2.1 Proposals and comments collection

**Objectives which seem acceptable**

Based on the feedback and comments, the moderator would like to propose the following objectives for further discussion.

- Potential objectives:
  - Introduce requirements for enhanced FR2 UEs with multi-Rx chain DL reception (dual TCI).
    - Enhanced RF requirements:
      - Identify and specify necessary RF requirement requirements for devices with 2 panels
      - Keep the current requirements of 50%-ile spherical coverage not being impacted
    - UE demodulation requirements:
      - Simultaneous and non-simultaneous RX from different directions,
      - 4 DL MIMO layers.

Please proponents provide comments to companies. Please companies further comment on the bullets above.

**Feedback Form 58:**

**1 – Apple AB**

First, it is better to clarify that we are talking about simultaneous multi-RF chain/panel reception.

Second, we welcome the clarification made by moderator to keep the current requirement of 50%-ile spherical coverage unchanged. At the same time, regarding the following proposed objective:

"Identify and specify necessary RF requirement requirements for devices with 2 panels"

we think a study phase is needed. We recommend the following rewording:

"Study the feasibility of having improved RF requirement for devices that are capable of simultaneous multi-panel reception compared with devices that are not. If the requirement improvement is significant, new requirement will be specified"

Third, in the initial round, we sought better understanding of the use case of supporting multi-panel reception. We appreciate further discussion/clarification on the use cases from proponents.

**2 – Samsung Electronics Co.**

As we commented in the initial round, given the Rel-17 FeMIMO WI including Demod/RRM/RF for multi-panel is still ongoing. Dual TCI feature has been introduced from Rel-16 timeframe and continued enhanced in mTRP scenario in Rel-17. It is not clear whether the proposals on specifying the RF/RRM and Demod requirements are based on REl-16 dual TCI or REl-17 dual TCI. Also, given the MIMO feature will continue enhanced in Rel-18, we think it is better to postpone such work to March 2022 until the Rel-17 feature and Rel-18 package for MIMO is clear enough.

**3 – Intel Corporation (UK) Ltd**

- RF requirements:
  - We suggest to leave it up to WG-level discussion on the specific requirements to be introduced.
  - One way is to introduce a new type of requirement to ensure that UE can make reception from different directions.
  - Another candidate for improvement is spherical coverage requirement. Rel-15 requirements were defined under assumption of single panel and further improvement is possible. We suggest to remove the 2nd sub-bullet "Keep the current requirements of 50%-ile spherical coverage not being impacted"
- TCI assumptions: As commented by companies, the requirements may not be limited to dual TCI and single TCI can be considered as well. To Samsung - we can consider both Rel-16 and Rel-17 MIMO features in the scope.
- From our point of view support of multi-panel operation requires systematic RAN4 work across RF/R-RM/Demod/OTA track to make sure that the new devices types have a complete set of requirements. Therefore, Rel-18 timeframe seems a practically reasonable timeframe to introduce the new requirements.
- To Apple
  - Support of multi-beam Rx may provide benefits in terms of higher throughput (which is still an important KPI for 5G technologies); improved robustness in case of beam blocking, which is a well-known issue for FR2; improved RRM delay requirements, which is also one limiting factors in mmWave.
  - In our understanding Rel-15 spherical coverage requirements were defined under assumption that UE is equipped with a single panel. So, we expect that further improvement is possible for multi-panel UEs.

**4 – Nokia Japan**

It seems that what want to specify is requirements for 4layers DL in FR2. Then, that should be the title of the topic. And the objectives should be written accordingly. Simultaneous reception is a kind of measures to achieve it. And with that in mind, spherical coverage would not be the main point, but rather if a UE can surely receive beams from different directions simultaneously would be the point. That cannot be achieve by switching multi-panels. Requirements to ensure that feature should be objectives and also, we need to specify achievable performance for 4 layers under such a condition. Finally, it's better to remove "non-simultaneous Rx" unless the necessity is justified.

**RRM requirements**

Companies are invited to further discussion whether the objective for RRM requirement is needed in this item.

- Enhanced RRM requirements:
  - RRM measurement delay reduction, FR2-FR2 DAPS HO
  - Other requirements

Please provide your comments in the table below.

**Feedback Form 59:**

**1 – China Telecommunications**

Maybe FR2-FR2 DAPS HO can be discussed in RRM enhancement WI or Mobility enhancement WI?

**2 – Apple AB**

same comments as the previous one that RRM work can be started after the study phase.

**3 – QUALCOMM JAPAN LLC.**

We do not see any need for FR2 DAPS now so this could be lower priority or dropped. Anyway, this feature is not related directly to the 4L FR2 MIMO or multi-panel reception.

**4 – Samsung Electronics Co.**

Similar comments as for RF/Demod part

**5 – Intel Corporation (UK) Ltd**

- Support of multi-beam reception allows a good opportunity to improve mobility performance for FR2 mmWave devices. Such devices can be seen as devices with improved baseband capabilities. Given that FR2 RRM performance is typically limited by the Rx beam sweeping, we believe it is important to further improve the performance.
- We would like to further justify the RRM objectives for FR2 UE with multiple Rx chain DL reception:
  - Enhancement on RRM measurement delay requirements for UE with multiple Rx chain DL reception (reduction in delay can be achieved for this kind of UE by assuming simultaneous reception of different beams)
  - FR2 – FR2 DAPS HO for UE with multiple Rx chain DL reception (straight forward support)
  - Enhancement on FR2 UE measurement/scheduling restrictions for UE with multiple Rx chain DL reception (lifting restrictions for such UE to boost RRM performance)
  - Define/enhance beam management requirements (L1 measurements, TCI state switch, etc.) for simultaneous reception on different antenna panels (R17 leftover due to not assuming multiple Rx chain DL reception)

**6 – Nokia Japan**

We see that this enhancement is a prerequisite for discussing FR2 DAPS HO as also commented in Feedback 33. Hence, we do not necessarily see that FR2 DAPS HO should be part of the objectives. RRM measurement requirements should be included but there may also be other impact than measurement delay reduction that would need to be part of the WI. In general it should include RRM requirements and although RAN4 has already captured some requirements for IBM capable UEs, this WI would need to look also at RRM requirements for other than inter-band CA scenario. Hence, we suggest to list 'RRM requirements' or at least not limit the scope for now and proponents should provide more detailed input to have a clear scope

#### 5.5.2.2 Summary for intermediate round

Companies' views are diverse. The first issue is on whether the spherical coverage requirements would be improved for this multi-panel reception. Apple did not favor the change and Nokia thought the other new

requirements to verify the simultaneous reception from different directions would be more important, while Intel wanted to keep the possibility for improvement. The second issue is related to dual TCI. Samsung thought it was unclear the dual TCI of which release of Rel-16 and Rel-17 should be baseline and preferred to wait for Rel-18 eMIMO conclusion since dual TCI would be enhanced in Rel-18. Intel though both Rel-16 and Rel-17 dual TCI should be taken into account. Apple and Nokia preferred to focus on simultaneous multi-RF chain/panel reception.

Companies questioned whether DAPS requirements were needed in this item. Intel provided detailed objectives for RRM. Nokia seemed OK to have RRM objectives but more discussions on the details seemed be needed. The moderator suggest to further discuss the RRM objectives.

### 5.5.3 Final round

#### 5.5.3.1 Proposals and comments collection

Based on the comments and feedback, the moderator would like to propose the following potential objectives for discussions in the final round.

- **Proposal #13-1: for FR2 multi-Rx chain DL reception, the following objectives can be considered**
  - Introduce requirements for enhanced FR2 UEs with multi-Rx chain DL reception with 4 DL MIMO layers.
    - Dual TCI assumption
      - FFS dual TCI of which release (Rel-16, Rel-17 or both) are used as baseline.
      - Pending on the objective of dual TCI enhancement in the package of Rel-18 MIMO items
    - Enhanced RF requirements:
      - Identify and specify necessary RF requirement requirements for devices with 2 panels
        - FFS whether to keep the current requirements of 50%-ile spherical coverage not being impacted, or improve spherical coverage requirement
    - Enhanced RRM requirements
      - FFS the detailed objectives
    - UE demodulation requirements:
      - Simultaneous ~~and non-simultaneous~~ RX from different directions,
      - 4 DL MIMO layers.

Please provide your comment in the table below.

**Feedback Form 60:**

| |
|---|
| **1 – Nokia Japan**<br>We support to include this topic in Rel-18 topics and also support the proposal as a starting point. And we believe that the details on the objectives for WID should be further discussed in the next RAN. |
| **2 – MediaTek Inc.**<br>The improvement of spherical coverage should be discussed as a separate work area. To us, enabling simultaneously 2-panel reception does not mean a better EIS performance on particular AoA. More clarification seems needed. |

**3 – QUALCOMM JAPAN LLC.**

We are fine with the proposed objectives. We believe the FFS part on the spherical coverage improvement can be removed. As already commented, we are not proposing any changes to the current spherical coverage requirements.

To reply to some of the comments made in the intermediate round, we do nto think there is need for the ”study the feasibility of having improved RF requirement”. As of now there are no requirements for simultaneous mutli-panel reception so we are not talking about improvements. Some requirements for this feature are needed.

The feature was introduced by other WGs, questioning the use case should have been done in RAN1, not in RAN4. The feature will improve the UE throughput and also capacity similarly to 4Rx in FR1.

The RF requirements can be defined agnostic of whether it is REl.16 or Rel.17 (mTRP or not), single TCI or dual TCI. the UE could also see signals from the same TRP coming from different directions and use simultaneous reception over multiple panels.

**4 – Intel Corporation (UK) Ltd**

- We support moderator’s proposal
- TCI assumptions: we are open to discuss. In general the Rel-18 RAN4 item shall aim to cover all functionality introduced by RAN1 in all prior releases including Rel-16/17. We agree with QC that RF requirements are agnostic, but we can see some difference for RRM/Demod requirements.
- RF requirements: current proposal is fine. We prefer to keep spherical coverage under discussion. As commented before, multi-panel UE can provide better spherical coverage and this aspect should not be ignored.
- RRM requirements: we are open to have more discussion on RRM requirements in the next stage
- UE demodulation: It is ok to focus on simultaneous RX, but same time we are open to consider non-simultaneous RX as well, since this is not covered by existing requirements (although it is not directly relevant to multi-beam simultaneous RX feature).

5.5.3.2 Summary for final round

It seemed that the current proposals were acceptable to the group, although more discussions will be needed.

So the moderator suggest the proposal.

- **Proposal #13-1: for FR2 multi-Rx chain DL reception, the following objectives can be considered**
  - Introduce requirements for enhanced FR2 UEs with multi-Rx chain DL reception with 4 DL MIMO layers.
    - Dual TCI assumption
      - FFS dual TCI of which release (Rel-16, Rel-17 or both) are used as baseline.
      - Pending on the objective of dual TCI enhancement in the package of Rel-18 MIMO items
    - Enhanced RF requirements:
      - Identify and specify necessary RF requirements for devices with 2 panels
        - FFS whether to keep the current requirements of 50%-ile spherical coverage not being impacted, or improve spherical coverage requirement
    - Enhanced RRM requirements

        - FFS the detailed objectives
    - UE demodulation requirements:
        - Simultaneous RX from different directions,
        - 4 DL MIMO layers

# 6 Bandwidths lower than 5MHz in dedicated spectrum

## 6.1 Initial round

### 6.1.1 Proposals and comments collection

**Previous discussion**

The proposal in the summary document RP-211665 is as follows:

- *The following objectives can be considered as a starting point for further discussions on <5 MHz in dedicated spectrum.*
    - *3-5 MHz in dedicated FDD FR1 spectrum (RAN1)*
        - *SCS and CP: 15 kHz with normal CP*
        - *SSB: PSS/SSS without puncturing, PBCH based on current design while minimizing performance degradation*
        - *[PDCCH: Consider minimum changes to existing CORESET#0, e.g. puncturing where necessary]*
        - *[CSI-RS/TRS with flexible bandwidth]*
        - *PRACH format restriction with UL BW < 5 MHz*
        - *[If necessary, PUCCH changes without affecting performance]*
    - *Changes to support deploying NR (RAN4)*
        - *System parameters including channel and sync rasters*
        - *RF requirements for bands while minimizing impacts (reuse 5 MHz BW at least for FRMCS and specify RF requirement of 3 MHz BW for other cases)*
    - *Notes:*
        - *This work is only applicable to FR1 bands identified for utilities, railways and PPDR.*
        - *[Potential clarifications on UE types based on further discussions*

The agreement in the endorsed document RP-212608 is as follows:

- *For RAN4-led email discussion,*
    - *Also including aspects regarding bandwidths lower than 5 MHz in dedicated spectrum as discussed in reference [16]*

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- Bandwidths lower than 5 MHz in dedicated spectrum
  - Potential justifications:
    - TBD
  - Potential objectives:
    - 3-5 MHz in dedicated FDD FR1 spectrum (RAN1)
      - SCS and CP: 15 kHz with normal CP
      - SSB: PSS/SSS without puncturing, PBCH based on current design while minimizing performance degradation
      - [PDCCH: Consider minimum changes to existing CORESET#0, e.g. puncturing where necessary]
      - [CSI-RS/TRS with flexible bandwidth]
      - PRACH format restriction with UL BW < 5 MHz
      - [If necessary, PUCCH changes without affecting performance]
    - Changes to support deploying NR (RAN4)
      - System parameters including channel and sync rasters
      - RF requirements for bands while minimizing impacts (reuse 5 MHz BW at least for FRMCS and specify RF requirement of 3 MHz BW for other cases)
    - Notes:
      - This work is only applicable to FR1 bands identified for utilities, railways and PPDR.
      - [Potential clarifications on UE types based on further discussions
  - Leading working group:
    - RAN4, secondary RAN1
  - SI or WI:
    - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 61:**

**1 – Nokia France**

Generally the situation at the end of the last round of email discussion seemed rather clear and stable, so it seems unnecessary to repeat everything that was said and clarified then.

To summarize regarding the justification, three use cases create a clear market demand:

- Railway communication & control for FRMCS in Region 1 (RMR-900 band)
- Smart grid control in Region 2: 2x3MHz FDD dedicated spectrum in bands n8 and n26
- PPDR in Region 1: 2x3MHz FDD dedicated spectrum in band n28

These target markets do not have significant constraints on device size, complexity, number of antennas, or power consumption, but the system bandwidth is limited by spectrum allocation.

The needed objectives are rather clear, as above, and the square brackets can be removed.

As identified above, if RAN4 is the lead WG then RAN1 should be the secondary group. Both groups would have work to do, and it doesn't really matter which group is designated the lead.

This item should be a WI, and the work kept small and tightly focused in line with the objectives above.

**2 – Swiss Federal Railways Ltd**

Today rail communication in Europe uses GSM-R as an effective communication system. As the designated successor system, FRMCS relies on 5GS with its diverse and necessary functions, e.g. high train speed support, from the beginning.

The allocation of spectrum for the operation of FRMCS in Europe is based on the ECC Decision (20)02 which allows the use of the 900 MHz frequency band for GSM-R and FRMCS. It enables to reuse the existing site infrastructure of GSM-R. However, GSM-R and FRMCS need to be operated in parallel for a period of at least 10 years in order to enable an economically justifiable migration of the rail vehicles and at the same time to continue to guarantee the interoperability of rail communication when crossing the border.

According to a query by the responsible rail regulator, around 1 million rail vehicles are registered in Europe. The vehicles, mostly closed train compositions with two driving heads, which are already equipped with GSM-R today, usually have 2 GSM-R UEs up to 6 UEs when European Train Control System is used. This group of vehicles makes up around 10%. It is expected that a second group of rail vehicles (approx. 40%) will be equipped with FRMCS capabilities during the course of the next decade. Upgrading the remaining vehicles with FRMCS is done in a broader schedule. The responsible authorities and organizations in Europe have set the start of the migration from GSM-R to FRMCS for 2025.

The provision of simultaneous use of the 2x5.6MHz FDD in the 900MHz frequency band and the associated provision of bandwidths less than 5MHz for 5G NR thus has a key function in order to be able to start the migration from GSM-R to FRMCS in Europe. At this point it should also be noted that the further development of the automation of rail operations using FRMCS and thus 5G NR will make an important contribution to reducing greenhouse gases.

**3 – Anterix**

Anterix fully supports the technical summary proposal (RP-211665) for supporting our markets. We are the largest holder of licensed spectrum in the 900 MHz band (896-901/935-940 MHz – Band n8) throughout the contiguous United States, plus Hawaii, Alaska, and Puerto Rico. Anterix has facilitated the licensing of **14 current network deployments** with private LTE utilizing our 900 MHz spectrum allocation. These networks are to designed to support electrical grid modernization (smart grid) in Region 2 (USA) and we are providing a future pathway for upgrades to 5G with support of this work item in Release 18.

To support our customers, we have built an ecosystem of UE devices, EPC, RAN and applications comprised of over **65 vendors**. Many of these vendors are 3GPP members that provide 5G upgradeable infrastructure and devices for our customers private LTE networks.

Additionally, our partner Southernlinc, provides a full mobility mission critical LTE network with VoLTE, PTT and data across 4 southern states (Alabama, Mississippi, Georgia, Florida) in a 3 MHz x 2, Band 26 (800 MHz) allocation.

Ensuring a timely upgrade path to 5G NR for our respective licensed spectrum, in the Release 18 timeframe, is crucial to commercial success of these networks and we look forward to fully supporting this effort in RAN1 and RAN4. We have worked to define the changes necessary in RAN1 and the supporting changes necessary in RAN4, therefore the tentative potential objectives should be the initial WI objectives. Anterix does not have a preference what group leads this effort but if RAN4 leads the work group, then RAN1 should

be the secondary group. Given the expected number of TU available for Rel-18 content we support moving to a WI to start this effort.

For reference a draft WID has been uploaded to the RAN 94e Drafts FTP folder for RAN94e-R18Prep-22

**4 – QUALCOMM JAPAN LLC.**

We agree with the WI for this feature, because we have seen the strong motivation and clear market requirement/timeline of NR BW < 5MHz in dedicated spectrum:

- For **Railway**

o (E)R-GSM 900MHz FDD bands are dedicated for Railway, which would be re-farmed for FRMCS to share 5.6MHz x 2 by NR and GSM and approximate 3MHz x 2 can be used for NR railway.

- For **Smart Utilities**

o A dedicated nationwide allocation of 900MHz FDD band with 3MHz x 2 can be adopting 5G for smart grid private network.

- For **PPDU**

o PPDU applications in Europe with 3MHz x 2 in B28 (700 APT) to be specified in n28 is potentially based on 5G.

Regarding the above potential objectives, we think the square brackets should be removed:

- For PDCCH, no need to define a new CORESET0. The existing CORESET0 can be reused with minimum changes, i.e., puncturing to limit the BW of CORESET0 within the dedicated spectrum.

- For CSI-RS/TRS, the nominal DL BWP of 5MHz can be used but flexible CSI-RS/TRS BW is to be supported within dedicated spectrum (similar as *trs-AdditionalBandwidth-r16* in Rel-16).

- For PUCCH, nominal UL BWP of 5MHz can be reused but the PUCCH frequency hopping may be out of the dedicated spectrum. Disabling the FH or changing FH pattern can be further considered.

According to the listed objectives, RAN1/RAN4 workload are pretty clear. No matter who is first or secondary leading WG, RAN1/RAN4 need to coordinate together and target to finish the WI in Rel-18.

**5 – LG Electronics Deutschland**

We are generally not sure what will be the spec impact of the items [CSI-RS/TRS with flexible bandwidth] and [If necessary, PUCCH changes without affecting performance] in RAN1.

We may bundle them as, for example, “any other specification impacts essential to support 3 5 MHz bandwidth” rather than having ambiguity in the objectives.

**6 – Intel Corporation (UK) Ltd**

**[Intel]** We are fine to have a WI and are mostly fine with the proposed objectives.

1) The objective “If necessary, PUCCH changes without affecting performance” is unclear. In particular, it is not clear what should be considered as the reference when interpreting “without affecting performance”. We suggest the qualifier “without affecting performance” can be simply removed.

2) Possible need to define separate UE type(s) can be discussed as part of UE feature discussions towards end of the WI.

3) On the need for “secondary leading working group”, in fact, we are wondering why RAN4 is the leading WG for this WI/SI. Considering the listed objectives, it appears better suited as a RAN1-led topic with some of RAN4 work being dependent on design choices adopted in RAN1.

4) For "*This work is only applicable to FR1 bands identified for utilities, railways and PPDR*" we suggest to clearly list the set of affected FR1 bands in WID so that sync raster and CBW requirements can be defined accordingly.

5) For RAN4 Core part objectives we suggest to clearly differentiate scenarios with reusing 5MHz CBW and scenarios with the definition of a new 3MHz CBW. For instance, we do not expect any modifications to RF requirements for the case of reusing 5MHz CBW. In addition, RRM requirements need to be updated to account for changes in SSB design.

- o *Changes to support deploying NR (RAN4)*
  - § *System parameters including channel and sync rasters*
  - § *RF requirements for identified bands*
    - · *Reuse 5 MHz **C**BW at least for FRMCS use case* ***and no additional RF requirements are defined for this case***
    - · *Specify requirements for 3 MHz **C**BW for other cases*
  - § ***RRM requirements to support 3-5MHz CBW operation***

**7 – MediaTek Inc.**

We have no concern to start this work in Rel-18. Just some comments beow:

- This work should start from RAN1. RAN1 needs to firstly try to identify the required PHY changes and make the change (if needed). Then RAN4 would be in a better position to work on the corresponding requirements.
- Minimizing the PHY changes should be one of the main target in this work. Degraded performance requirements can be considered.
- This work should include performance part

**8 – ZTE Wistron Telecom AB**

Considering strong market demands for <5MHz support, and according to the discussions up to now, it might be more specific with a new title for the topic "Addition/support of 3MHz channel bandwidth for both UE and BS", and it has fundamental impacts on RAN1/RAN4 specs. This new 3MHz channel bandwidth does not belong to the release independent item(Channel bandwidth) specified in TS 38.307 since this might involve a new UE type.

**9 – Samsung Electronics Co.**

We understand this request applied for specific deployment scenario with dedicated spectrum.

This proposal includes RAN1 for SSB and PDCCH CORESET #0. RAN4 also need to consider the channel arrangement especially sync raster design. This should be considered carefully to avoid impact on legacy UEs for backward compatibility issue.

Also the target UE type need to be clarified, special UE vs traditional smart phones?

On the objectives, one missing part is performance requirements □demod and CSI□ for both BS side and UE side with 3MHz CHBW.

**10 – QUALCOMM JAPAN LLC.**

We agree with the WI for this feature, because we have seen the strong motivation and clear market requirement/timeline of NR BW < 5MHz in dedicated spectrum:

- For **Railway**

o (E)R-GSM 900MHz FDD bands are dedicated for Railway, which would be re-farmed for FRMCS to share 5.6MHz x 2 by NR and GSM and approximate 3MHz x 2 can be used for NR railway.

- For **Smart Utilities**

o A dedicated nationwide allocation of 900MHz FDD band with 3MHz x 2 can be adopting 5G for smart grid private network.

- For **PPDU**

o PPDU applications in Europe with 3MHz x 2 in B28 (700 APT) to be specified in n28 is potentially based on 5G.

Regarding the above potential objectives, we think the square brackets should be removed:

- For PDCCH, no need to define a new CORESET0. The existing CORESET0 can be reused with minimum changes, i.e., puncturing to limit the BW of CORESET0 within the dedicated spectrum.

- For CSI-RS/TRS, the nominal DL BWP of 5MHz can be used but flexible CSI-RS/TRS BW is to be supported within dedicated spectrum (similar as *trs-AdditionalBandwidth-r16* in Rel-16).

- For PUCCH, nominal UL BWP of 5MHz can be reused but the PUCCH frequency hopping may be out of the dedicated spectrum. Disabling the FH or changing FH pattern can be further considered.

According to the listed objectives, RAN1/RAN4 workload are pretty clear. No matter who is first or secondary leading WG, RAN1/RAN4 need to coordinate together and target to finish the WI in Rel-18.

**11 – QUALCOMM JAPAN LLC.**

Through the continuous work for DSS in Releases 15 – 17, various solutions (PDSCH rate-matching around LTE-CRS(s), cross-carrier scheduling from SCell to PCell) have been specified. Considering that PDSCH rate-matching around LTE-CRS(s) is only based on semi-static configuration today, DCI based dynamic rate-matching pattern indication for LTE-CRS(s) could be a topic that we can consider for Rel-18.

**12 – Anterix**

The devices used in our markets include the full array of available UE from embedded IoT modules, mobile routers to the latest VoLTE enabled smartphones (CAT12+). Since we offer global roaming capabilities, **we do not see a need to define a separate category of devices**. Pending approval of this WID we will also be looking to do CA and DC with other bands and 4G.

**13 – Ericsson LM**

Comments on the objectives:

- For the bullets in the list that are in brackets, we suggest replacing them with one bullet: ”Consider minimum changes to PDCCH, CSI-RS/TRS and PUCCH”
- Suggest removing ”[Potential clarifications on UE types based on further discussion]” since it is unclear what this means.

**14 – Southern Linc.**

Southern Linc is a supporting partner for FDD bandwidths less than 5MHz to be added to NR. We have been a 3GPP member since the very beginning of B26. We currently operate a 3MHz LTE system in FDD B26. We also have a trial deployment of a 3MHz LTE FDD B8 system. Our mission critical LTE network supports a lot of different use cases such as VoLTE, eMBMS, MCPTT, smart grid, video, and mobile broadband. Southern Linc provides both voice and data smart grid communications services to the subsidiaries of its parent company, Southern Company [Southern Company], as well as to many government and public safety customers within its service area. Southern Linc requires a path to evolve its network to 5G and supports this work item in Release 18. Thanks for everyone's help on this.

**15 – Huawei Technologies France**

We understand the scenarios and justifications according to previous email discussion, and here share the following comments on the proposed objectives:

- For the PDCCH bullet, we think the bracket could be removed. And since the scenario is spectrum bandwidth limitation thus only mentioned CORESET#0 is a bit strange, also better to add similar wording in term of performance as PBCH part, with suggested update:
  - [PDCCH: Consider minimum changes to existing CORESET#~~0~~ while minimizing performance degradation, e.g. puncturing where necessary]
- For the CSI-RS/TRS bullet, we think so far it is not clear what exactly meaning and what should to do, we prefer to see more clarification on this. Otherwise, it should be deleted.
- For the PUCCH bullet, it is unclear for us why changes is needed. Our understanding the existing PUCCH and BWP bandwidth can be flexibly configured with RB level granularity. And such a dedicate system does not have any coexistence issues with legacy cellular networks. Thus, this bullet should be deleted unless issues clearly identified and motivated.
- For the main bullet of second basket objectives, we are not sure whether all listed things below need to be changed. For example, if pucturing is supported why sync rasters need to be change? Thus, we propose the following update to the second main bullet.
  - Changes (if found neccessary) to support deploying NR (RAN4)
- Besides, if the intention is no limitation on any 3GPP defined UEs supporting such dedicated band to access the system, it is better to add a note to clarify this point.

**16 – Apple AB**

we understand the importance of this work. For RAN4 objectives, shouldn't system parameters including channel and sync rasters be limited to 3MHz BW? For 5MHz BW, the existing rasters can reused. We also agree that demod requirements for 3MHz BW need to be specified, which means a new objective needs to be added.

Regarding UE types, we suggest it is explicitly captured in the RAN4 work scope: UE types and applicable requirements will be decided.

### 6.1.2 Summary for initial round

For justificaiton, companies provided the inputs. It seems that this topic is fully justified. Following Nokia comments, there are manily three use cases:

- Railway communication & control for FRMCS in Region 1 (RMR-900 band)
- Smart grid control in Region 2: 2x3MHz FDD dedicated spectrum in bands n8 and n26
- PPDR in Region 1: 2x3MHz FDD dedicated spectrum in band n28

Anterix, UIC, Nokia, Qualcomm provided the draft WID, which was uploaded into inbox. Companies can further commented the justification part in the draft WID.

For objectives, companies commented on PDCCH, CSI-RS/TRS and PUCCH related objectives which are in [ ]. Qualcomm provided more detailed objectives. LGE, Intel, Ericsson and Huawei questioned and/or commented those objectives. It seemed that the specification impacts of one or all of those objectives are unclear. More discussions are needed in intermediate round.

Regarding RAN4 related objectives, Intel commented to clearly list the affected FR1 bands so that sync raster and CBW requirements can be define accordingly. For the channel bandwidth (CBW), Intel commented that the 5 MHz CBW should be differentiated from 3 MHz and accordingly proposed the change of RF objective, and ZTE commented that the work should focus on addition of 3 MHz CBW,Intel, Samsung, Huawei, and Apple commented on the objective for channel and sync raster. More discussions are needed.

Intel proposed adding the objective for RRM requirements. Mediatek, Samsung and Apple proposed to add performance objective for RRM test and demodulation requirements for 3 MHz CBW. Moderator think those proposals are reasonable.

Regarding UE type, Intel, Samsung, and Apple proposed to define or clarify the UE type for use cases in the potential WIs, while Anterix, Ericsson proposed to remove the related objective in []. More discussions are needed.

## 6.2 Intermediate round

### 6.2.1 Proposals and comments collection

**Justifications**

The draft WID was provided in https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_94e/Inbox/Drafts/%5BRAN94e-R18Prep-22%5D/Proposed_WID_RP-21xxxx_RAN_94e-R18Prep-22_NR_DSLT5_v2.doc. If you have comment for modification on the justification part, please directly provide the revised version and upload it into inbox, and please indicate that you make the modification in the following feedback table.

**Feedback Form 62:**

| **1 – Ericsson LM** |
|---|
| We agree with the justification in the draft WID. |

**Objectives which seem stable:**

Based on the draft WID and feedbacks from companies, the following objectives seem stable. In moderator understanding, 5MHz CBW should not be within the scope because the new band as well as 5MHz CBW is defined in Rel-17 WI NR_RAIL_EU_900MHz for FRMCS use case and clearly 3MHz CBW is requested for

other two use cases. The unclear part is what the exact CBW is for FRMCS use case. It is better to make it clear that the work focus on CBW < 5MHz.

**Core part:**

The following objectives shall be included for dedicated FDD spectrum in FR1:

- Specify necessary changes to NR physical layer with minimum impact to operate in spectrum allocations with 3 MHz channel bandwidth or channel bandwidth of approximately 3 MHz and less than ~~between approx. 3 and~~ 5 MHz [RAN1]:
  - Restrict to subcarrier spacing of 15kHz and the use of normal cyclic prefix.
  - For SSB:
    - Reuse PSS/SSS specification without puncturing.
    - Reuse PBCH specification with puncturing (at least keep RE mapping of PBCH).
  - For PRACH
    - PRACH format restriction within uplink bandwidths less than 5 MHz.
  - Specify necessary ~~changes~~RAN4 requirements (if found necessary) to support deploying NR in dedicated spectrum with 3MHz channel bandwidth or channel bandwidth of approximately 3 MHz and less than 5 MHz [RAN4]:
    - The dedicated spectrum in this WI include RMR-900 band, n8, n26 and n28.
    - Specify system parameters (including channel and sync raster) for the associated dedicated spectrum.
    - Minimize impact on RF requirements:
      - Reuse 5 MHz channel bandwidth at least for FRMCS use case (assuming co-located NR and GSM-R with same operator).
      - Specify the required RF requirement for 3 MHz channel bandwidth in bands: RMR 900 (874.4 - 880 MHz/919.4 MHz – 925 MHz), n8, n26 and n28.
    - Specify RRM requirements to support operation in dedicated spectrum with 3 MHz channel bandwidth or channel bandwidth of approximately 3 MHz and less than 5 MHz.

**Perf. part:**

Specify necessary UE performance requirements for NR operation in dedicated FDD FR1 spectrum allocations ~~between approx. 3 and 5 MHz~~ with 3 MHz channel bandwidth or channel bandwidth of approximately 3 MHz and less than 5 MHz.

- Specify necessary RRM performance requirements (RAN4)
- Specify necessary UE demodulation performance and CSI reporting requirements (RAN4)
- Specify necessary BS demodulation performance requirements (RAN4)

Please provide further comments on the above objectives.

**Feedback Form 63:**

**1 – Futurewei Technologies**

On the objectives for SSB, the key point is that existing SSB design and specifications shall be reused, as we have in the previous wording. This new texts now point to a specify solution. Should it not be part of the WI/SI to study and consider this further?

**2 – Intel Corporation (UK) Ltd**

**[Intel]**

We are fine with most of the objectives. However, it is not very clear how to interpret "*channel bandwidth of approximately 3MHz and less than 5MHz*". 3 MHz CBW seems to be already included. Thus, it'd be better to avoid confusing terminology of "approximately 3 MHz". **We suggest proponents to clarify if additional CBW on top of 3MHz shall be considered.**

**3 – Apple AB**

we support moderator's effort to make it clear that the work focuses on CBW < 5MHz. In addition, as commented in the first round, we suggest the targeted UE types are either clearly stated in the WID or captured as an objective to be worked on in the WID.

**4 – QUALCOMM JAPAN LLC.**

We support the objectives, however, for RRM we think there will be very little work needed since PSS/SSS is kept the same as now. The only change will be to PBCH, however, this is only used to derive the beam ID(likely only 4 beams for this frequency range is needed) so the impact should be very limited (PSS/SSS SNR is normally the limiting factor for the requirements, not demod of PBCH). We expect the impact to be just formal to change some of the side conditions for the bandwidths.

A new set of performance requirements specific for the new channel BW will be needed to enable testing of these devices.

**5 – Nokia France**

It seems that the new wording on channel bandwidths may be causing some confusion. "Channel bandwidth" is a RAN4 concept that implies new RF requirements. In this regard, we can confirm that only one new channel bandwidth is intended, namely 3MHz. This is why "channel bandwidth" was not originally mentioned in the RAN1 objective. From the RAN1 perspective, the objective is to "Specify necessary changes to NR physical layer with minimum impact to operate in spectrum allocations **from approximately 3 MHz up to below 5 MHz.**" Hopefully this wording makes it clear that no changes are intended for 5 MHz allocations, which was the original question.

We do not see any problem with the SSB objective as written.

For the RAN4 objective, similarly to the RAN1 objective, we should not imply that more than one new channel bandwidth would be specified. Similar wording could be used, i.e. "**Specify necessary RAN4 requirements to support deploying NR in dedicated spectrum allocations from approximately 3 MHz up to below 5 MHz.**" The same wording should be used for the RRM objective.

The new bullet "The dedicated spectrum..." could be appended to the bullet "Specify system parameters...".

It could also be clarified, as suggested by Intel in the initial round, that no additional RF requirements are expected for 5 MHz channel bandwidth (we thought that was clear from "reuse", but no harm to clarify further.)

**6 – Ericsson LM**

We agree with the objectives proposed by the moderator.

**7 – Samsung Electronics Co.**

First of all, we would like to clarify on ”at least keep RE mapping of PBCH”, do we intend to keep the RE mapping of PBCH but define a puncturing of PBCH? what does ”at least” mean is not clear. Suggest to delete ”at least”

For PRACH, current PRACH fomats for FR 1 are all less than 5MHz. We think the intention is to ues the exsiting PRACH format it that less than the UL BW, i.e. 3MHz. Therefore, we suggest to change to ”restriction of exsiting PRACH format within the uplink bandwidth”

**8 – Huawei Technologies France**

It seems the proposal in the draft WID is different to previous RAN#93e outcome of moderator’s summary, we have the following comments and suggested changes:

For SSB, we prefer the way in previous RAN#93e moderator’s summary on PBCH part since performance degradation should be taken into consideration, i.e.

*PBCH based on current design while minimizing performance degradation*

**9 – Anterix**

We agree with the moderator that the objectives and core part of the WI proposal are stable and agreed upon in the previous email discussion.

Current plans support up to 4 antenna ports on BS and UE. As of now, we do not have any specific or defined RRM, UE demodulation, BS modulation or CSI reporting requirements. We expect any specific new requirements for 3 MHz CBW will be minimal and we will work with the other members to define this further for submission

Regarding OOBE/SEM, for the Band n8 deployment in Region 2 we use an asymmetrical emission mask specification as follows:

- UL: 43+10log(P) -13dBm as measured in an RBW of 100kHz
- DL: 50+10log(P) -20dBm as measured in an RBW of 100kHz
- The FCC adopted rules to also allow for 30kHz RBW if required.

**Objectives which need more discussions:**

More discussions are needed for PDCCH, CSI-RS/TRS and PUCCH related objectives in [ ]. There seemed two alternatives:

- Alternative #1: (Qualcomm, Anterix …):
  - For PDCCH:
    - Consider minimum changes to existing CORESET#0, e.g. puncturing where necessary.
  - For CSI-RS/TRS:
    - Support CSI-RS/TRS with flexible bandwidth between approx. 3MHz and 5MHz.
  - For PUCCH

- Specify necessary changes for PUCCH while keeping PUCCH performance, if existing design has limitations (e.g., frequency hopping).

– Alternative #2 (try to accommodate the comments from other companies):
  - Consider minimum changes to PDCCH, CSI-RS/TRS and PUCCH

Please provide your comments below.

**Feedback Form 64:**

**1 – Futurewei Technologies**

Our understanding of the items in Alternative #1 is that all would be quite affected by the reduced bw from 24PRBs to 15PRBs for 3MHz, for CORESET#0 for example. We are not clear when and if these would be considered.

**2 – vivo Communication Technology**

The justification of any change on PUCCH design is unclear to us. NR support flexible PUCCH resource allocation thus there is no issue for PUCCH transmission. While it is true that frequency diversity could decreased due to the reduced Channel BW, however, existing PUCCH coverage recovery solutions can be used to improve the performance, e.g. PUCCH repetition. And considering the railway scenario, the higher device transmission power and antenna gain are possible therefore the need for additional PUCCH coverage compensation is not clear. And even thought there is any interest for PUCCH coverage improvemen, we prefer to consider it in a more general way so that the solution is not restricted to the narrow band operation only.

Therefore, we suggest to remove the PUCCH related objective in this WID.

**3 – Intel Corporation (UK) Ltd**

**[Intel]**

Alternative #2 is preferred. It is still not clear what the phrase “while keeping PUCCH performance” in Alternative #1 implies.

**4 – QUALCOMM JAPAN LLC.**

We obviously prefere Alternative #1.

**5 – LG Electronics Deutschland**

We think these details need WG level discussion for very specific specification points. We are not objecting to have this discussion in the WI period, but it seems sufficient to say “including” not to exclude necessary changes in the first main objective as follows:

Specify necessary changes to NR physical layer with minimum impact to operate in spectrum allocations with 3MHz channel bandwidth or channel bandwidth of approximately 3MHz and less than ~~between approx. 3 and~~ 5MHz, including [RAN1]:

Anyhow, if we need to select between two alternatives, we would prefer alternative #2.

**6 – Ericsson LM**

In our opinion, the two alternatives are not that different. In our opinion, RAN1 should first study and identify the required enhancements/changes needed for PUCCH, CORESET#0 and CSI-RS/TRS before moving on to specifications. Therefore, we suggest to go with Alternative# 2 with modification in wording:

- Specify necessary minimum changes to PDCCH, CSI-RS/TRS, and PUCCH.

**7 – ZTE Corporation**

For PUCCH and CSI-RS/TRS related discussion in alternative 1, from our understanding, it might be not needed since the existing RAN1 spec would also support it.

**8 – Nokia France**

We believe Alternative #1 does give some useful additional detail, and is therefore helpful, but we would also be OK with a slight modification to Alternative #2 as follows: ”Consider and specify minimum necessary changes to PDCCH, CSI-RS/TRS and PUCCH”

**9 – Nokia France**

(Ericsson’s wording is also OK for us. )

**10 – Samsung Electronics Co.**

We support Ericsson’s wording proposal

**11 – Huawei Technologies France**

For PDCCH, we think the bracket could be removed. And since the scenario is spectrum bandwidth limitation thus only mentioned CORESET#0 is a bit strange, also better to add similar wording in term of performance as PBCH part, with suggested update:

- [PDCCH: Consider minimum changes to existing CORESET#~~0~~ while minimizing performance degradation, e.g. puncturing where necessary]

For CSI-RS/TRS we don’t see the justified motivation so far since existing schemes already support flexible configuration between 3MHz and 5MHz. Thus, this bullet should be deleted unless any issue confirmed.

For PUCCH, it is unclear for us why changes is needed. Our understanding the existing PUCCH and BWP bandwidth can be flexibly configured with RB level granularity. And such a dedicate system does not have any coexistence issues with legacy cellular networks. Thus, this bullet should be deleted unless any issue clearly confirmed.

**12 – Anterix**

The intent of these objectives was to ensure minimal changes, if any to CSI-RS/TRS, PDCCH and PUCCH - so the differences between Alt #1 and #2 seem very smal to us but we support Alternative #1.

For utilities, rail and PPDR the UL is crucial and with all the proposed changes we want to ensure that the PUCCH performance is maintained. Any changes made need to ensure this.

With CSI-RS/TRS there are some considerations that may need to be examined with the implementation of DSS as it is something we are considering for migration from LTE to NR.

And in the draft WID, there seems a new proposal compared to the previous summary. Please comment on it.

- For SSB:
  - [Allow power boosting for PBCH to compensate potential coverage loss.]

**Feedback Form 65:**

**1 – vivo Communication Technology**

To our understanding, PBCH/SSB power boosting is gNB implementation issue. Clarification from proponent would be needed.

**2 – QUALCOMM JAPAN LLC.**

Power boosting was discussed before as a way to compensate for the loss due to PBCH puncturing, however, it is true that this is an implementation issue and would not influence the RAN4 specs.

**3 – LG Electronics Deutschland**

Similarly with our answer for feedback form 47 above, we think having some text indicating not to exclude any necessary changes will be enough rather than including a technical solution in the objectives.

**4 – Ericsson LM**

We are in general neutral to it. However, this can be considered as a part of work item. We suggest to first study the performance loss due to puncturing and the need to allow power boosting.

**5 – Nokia France**

We agree with Qualcomm, there is not expected to be any specification impact for PBCH power boosting. So this bullet could be omitted without losing the possibility to perform power boosting in line with the existing stipulations of 38.213.

**6 – Huawei Technologies France**

We are OK with this in general. But the sentence seems as a solution rather than an objective, maybe it could be merged into previous objective on PBCH as

- *PBCH based on current design while minimizing performance degradation*

*Note: power boosting for PBCH can be considered*

**7 – Anterix**

We know that the lowest impact and likely scenario to enable 3 MH CBW is to puncture the SSB using 12 - 16 RBs. Where or how this is done will need to be determined but we expect SNR loss (as compared to LTE) and the PBCH power to have potentially 3dB or more loss. Power boosting those REs will help mitigate this loss and recover some of the SNR degradation incurred and minimize coverage loss. However,

this is an implementation specific related issue and not a new specification and could be removed or use the Huawai language.

### 6.2.2 Summary for intermediate round

Comments from companies will be captured in the proposals in Section 6.3.

## 6.3 Final round

### 6.3.1 Proposals and comments collection

Based on the comments, the moderator would like to propose the following modified objectives for discussions in the final round.

- **Proposal #14-1: for bandwidth lower than 5 MHz in dedicated spectrum, the following objectives can be considered**
  - **Core part:** The following objectives shall be included for dedicated FDD spectrum in FR1:
    - Specify necessary changes to NR physical layer with minimum impact to operate in spectrum allocations from approximately 3 MHz up to below ~~between approx. 3 and~~ 5 MHz [RAN1]:
      - Restrict to subcarrier spacing of 15kHz and the use of normal cyclic prefix.
      - For SSB:
        - Reuse PSS/SSS specification without puncturing.
        - PBCH based on current design while minimizing performance degradation
        - ~~Reuse PBCH specification with puncturing (at least keep RE mapping of PBCH).~~
      - For PRACH
        - ~~PRACH format restriction within uplink bandwidths less than 5MHz.~~
        - Restriction of existing PRACH format within the uplink bandwidth
      - Specify necessary minimum changes to PDCCH, CSI-RS/TRS, and PUCCH
    - Specify necessary ~~changes~~RAN4 requirements (if found necessary) to support deploying NR in dedicated spectrum allocations from approximately 3 MHz up to below 5 MHz [RAN4]:
      - The dedicated spectrum in this WI include RMR-900 band, n8, n26 and n28.
      - Specify system parameters (including channel and sync raster) for the associated dedicated spectrum.
      - Minimize impact on RF requirements:
        - Reuse 5 MHz channel bandwidth at least for FRMCS use case (assuming co-located NR and GSM-R with same operator).
        - Specify the required RF requirement for 3 MHz channel bandwidth in bands: RMR 900 (874.4 - 880 MHz/919.4 MHz – 925 MHz), n8, n26 and n28.
      - Specify RRM requirements to support operation in dedicated spectrum allocations from approximately 3 MHz up to below 5 MHz.
  - **Perf. part:** Specify necessary UE performance requirements for NR operation in dedicated FDD FR1 spectrum allocations ~~between approx. 3 and 5 MHz~~ from approximately 3 MHz up to below 5 MHz.
    - Specify necessary RRM performance requirements (RAN4)

- Specify necessary UE demodulation performance and CSI reporting requirements (RAN4)
- Specify necessary BS demodulation performance requirements (RAN4)

Please provide your comments in the table below. □

**Feedback Form 66:**

**1 – Skyworks Solutions Inc.**

”from approximately 3MHz up to below 5MHz. ” seem to indicate any granularity of BW could be used. We assume that is not the case, the exact BW targets should be agreed (granularity of 1MHz like for >5MHz irregular BW case?)

**2 – Nokia France**

These objectives are now in good shape - thank you.

We have just a couple of small comments:

The modified PRACH bullet does not seem so clear. It may be better simply to include PRACH in the following bullet, i.e. ”Specify necessary minimum changes to PDCCH, CSI-RS/TRS, ~~and~~ PUCCH and PRACH. ”

”If found necessary” should be deleted from the RAN4 bullet.

**3 – Futurewei Technologies**

In general ok but find the use of ’Specify necessary’ (first sub-bullet of Core Part) and ”Specify necessary minimum changes..” (for PDCCH, CSI-RS/TRS, and PUCCH) confusing, assuming there is no difference. In our understanding, all the objectives in the Core aspects would require some effort to identify the necessary or needed changes to existing spec. If that is the case, can we start the first sub-bullet of the Core part:

- Identify and Specify necessary changes to NR physical layer with minimum impact to operate in spectrum allocations from approximately 3MHz up to below ~~between approx. 3 and~~ 5MHz [RAN1]:

If the above is acceptable, then we think subsequent use of ”Specify necessary minimum changes..” can be deleted.

**4 – Nokia France**

In response to the comment from Skyworks: as no new RF requirements are included except for 3MHz, it should not be necessary to constrain the bandwidth granularity.

**5 – Nokia France**

In response to Futurewei: perhaps the current wording is not the most elegant, but we don’t think it leads to any misunderstanding. We would be OK to simply add ”Identify and” as suggested, but do not see the need to make the subsequent deletion.

**6 – Anterix**

Anterix and our partner Southern Linc in general support the modified objective summary by the moderator and the updated WID proposal.

Just to note that our spectrum allocations in Band 8 and Band 26 will all utilize a 2x3 MHz FDD allocation (similar for FRMCS and PPDR).

To help clarify the objectives we agree with Nokia to simply remove the PRACH bullet and modify the bullet ”Specify necessary minimum changes to PDCCH, CSI-RS/TRS, and PUCCH and PRACH.”

**7 – QUALCOMM JAPAN LLC.**

We are generally fine with the proposed scope. It might be useful to add something that impact to RRM requirements in RAN4 should be minimized, for example:

Specify RRM requirements while minimizing specifications impact to support operation in dedicated spectrum allocations from approximately 3MHz up to below 5MHz.

**8 – Intel Corporation (UK) Ltd**

**Intel**

We are mostly fine with the latest version, and would also like to support the suggestion from Nokia to remove the PRACH bullet and merge it with the following:

- Specify necessary minimum changes to PDCCH, CSI-RS/TRS, ~~and~~ PUCCH**, and PRACH.**

**9 – vivo Communication Technology**

Regarding “Specify necessary minimum changes to PDCCH, CSI-RS/TRS, and PUCCH”, we appreciate the feedback from Anterix, and we agree that PUCCH performance is important. However, it is still unclear to us what exactly the problem is and how it motivates any change on PUCCH design. RAN1 has performed extensive study in Rel-17 RedCap and coverage enhancement SI for coverage analysis, in which PUCCH was concluded to be not the bottleneck channel in UL. Therefore, we would like to hear more justification on why in NR <5MHz narrow band operation, the PUCCH will become the limiting channel that requires special attention among all the UL channels.

**10 – Ericsson LM**

One comment on the performance part. Please also add the following objective:

- Specify necessary BS conformance tests (RAN4)

**11 – Ericsson LM**

Two minor comments:

Change to the first main objectivet to emphasize minimum specification changes:

- Specify necessary changes to NR physical layer with minimum **specification** impact to operate in spectrum allocations from approximately 3MHz up to below 5MHz [RAN1]

Also for PBCH, minimum specification impact should be the main criteria. Hence:

- PBCH based on current design ~~while minimizing performance degradation~~

**12 – ZTE Corporation**

In general, we are also fine with the existing wording from RAN4 chairman and just one more wording update as following:

- Identify and Specify necessary minimum changes to PDCCH, CSI-RS/TRS, ~~and~~ PUCCH**, and PRACH.**

**13 – Intel Corporation (UK) Ltd**

Additional comment. In the initial round we commented that "Considering the listed objectives, it appears better suited as a RAN1-led topic with some of RAN4 work being dependent on design choices adopted in RAN1." We prefer to have RAN1 as a leading WG (and RAN4 as secondary) in the WID or at least keep it open for further discussion before final WI approval.

### 6.3.2 Summary for final round

Skyworks comments on channel bandwidth to be specified can be addressed by the sub-bullets under core part for RAN4, i.e., "specify the required RF requirement for 3MHz…" RAN4 only consider 3MHz channel bandwidth.

To Ericsson's comment to remove "while minimizing performance degradation" for PBCH. The moderator observed that some company favored this sentence since it was extensively discussed in September RAN plenary. So the moderator did not delete it as proposed rather putting it in [] for further checking.

Besides, Apple as well as other companies commented on UE type. In the initial round Anterix and Ericsson proposed not to include the note related to UE type. So the bullet was not added since the intermediate round. In the final round, no further comment was received on that point. In case that companies are too busy not to closely follow the discussion, the moderator would like to list it as open issue for further discussion in the summary section.

Regarding leading WG, RAN4 was proposed as the leading WG since the initial round, and the same guidance was received from RAN Chair. According to comments in the initial round and intermediate round, companies were not against it but seemed have no strong view. In the final round, Intel proposed RAN1 as leading WG and RAN4 as secondary WG. The moderator followed Intel comment to put RAN1 as leading and RAN4 as secondary and put [ ] on it for further checking.

Based on the feedback, the moderator modifies proposal #14-1.

- **Proposal #14-1: for bandwidth lower than 5 MHz in dedicated spectrum, the following objectives can be considered**
  - **Core part:** The following objectives shall be included for dedicated FDD spectrum in FR1:
    - Identify and specify necessary changes to NR physical layer with minimum impact to operate in spectrum allocations from approximately 3 MHz up to below 5 MHz [RAN1]:
      - Restrict to subcarrier spacing of 15kHz and the use of normal cyclic prefix.
      - For SSB:
        - Reuse PSS/SSS specification without puncturing.
        - PBCH based on current design [while minimizing performance degradation]
      - ~~For PRACH~~

        - ~~Restriction of existing PRACH format within the uplink bandwidth~~
      - Identify and specify necessary minimum changes to PDCCH, CSI-RS/TRS, ~~and~~ PUCCH, and PRACH
    - Specify necessary RAN4 requirements ~~(if found necessary)~~ to support deploying NR in dedicated spectrum allocations from approximately 3 MHz up to below 5 MHz [RAN4]:
      - The dedicated spectrum in this WI include RMR-900 band, n8, n26 and n28.
      - Specify system parameters (including channel and sync raster) for the associated dedicated spectrum.
      - Minimize impact on RF requirements:
        - Reuse 5 MHz channel bandwidth at least for FRMCS use case (assuming co-located NR and GSM-R with same operator).
        - Specify the required RF requirement for 3 MHz channel bandwidth in bands: RMR 900 (874.4 - 880 MHz/919.4 MHz – 925 MHz), n8, n26 and n28.
      - Specify RRM requirements while minimizing specification impact to support operation in dedicated spectrum allocations from approximately 3 MHz up to below 5 MHz.
  - **Perf. part:** Specify necessary UE performance requirements for NR operation in dedicated FDD FR1 spectrum allocations from approximately 3 MHz up to below 5 MHz.
    - Specify necessary RRM performance requirements (RAN4)
    - Specify necessary UE demodulation performance and CSI reporting requirements (RAN4)
    - Specify necessary BS demodulation performance requirements (RAN4)
    - Specify necessary BS conformance tests (RAN4)

- **Proposal #14-2: for bandwidth lower than 5MHz in dedicated spectrum, it is proposed to have RAN1 as leading WG and RAN4 as secondary WG, and in the draft WID the leading WG and secondary WG will be captured in [ ].**

# 7 Improved NR spectrum efficiency for LTE-NR coexistence (DSS)

## 7.1 Initial round

### 7.1.1 Proposals and comments collection

**Previous discussion**

The proposal in the summary document RP-211665 is as follows:

- ***Others (RAN1-led)****: DSS received strong level of support especially from the operators in all three rounds. However, a number of companies have expressed negative views or questioned the benefits of DSS enhancements in different rounds. Other than DSS, wireless sensing was proposed but the level of support was not as strong.*
  - *The following items were proposed for DSS during the email discussions (provided for information purposes only).*
    - *Improved NR spectral efficiency for LTE-NR coexistence (RAN1)*
    - *More efficient NB-IoT and eMTC coexistence on NR carriers (RAN1)*

        - *Coexistence with non-3GPP radio technology (RAN1)*
    - *Note that the first item received the most support among the three but also received strong concerns from two companies.*

The agreement in the endorsed document RP-212608 is as follows:

- *For RAN4-led email discussion,*
    - *Also including aspects regarding DSS (note: this is also related to the ongoing Rel-17 discussion)*

**Proposals for discussion**

Based on the proposals and feedback in the previous discussions, the moderator tries to propose the following bullets as the starting point for discussions.

- Improved NR spectrum efficiency for LTE-NR coexistence (DSS)
    - Potential justifications:
        - TBD
    - Potential objectives:
        - Improved NR spectral efficiency for LTE-NR coexistence (RAN1)
        - More efficient NB-IoT and eMTC coexistence on NR carriers (RAN1)
        - Coexistence with non-3GPP radio technology (RAN1)
    - Leading working group:
        - RAN1
    - SI or WI:
        - WI

**Comments and suggestions:**

Companies are invited to provide the general comment on this topic, and provide feedback/suggestions on the justification, detailed objectives, whether secondary leading working group is needed, and whether it should be SI or WI.

**Feedback Form 67:**

**1 – BOUYGUES Telecom**

Bouygues Telecom considers NR/LTE DSS as a key topic for smooth LTE spectrum evolution to 5G. Any improvement of this feature, given its current limitations are welcomed.

In particular, among the previously discussed topics, we consider that:

- Dynamic Rate Matching (layer 1 based) around multiple CRS patterns is interesting. Thus, avoiding NR scheduling in RE which are strongly interferred by neighbor CRS, could improve NR spectral efficiency. The fact of having slot-based granularity for this adaptation would allow to take into account RF environment changes, in which either the strongest interferer will change, or the interference decreases and the Rate Match may be disabled. Also, in our view, is better the RAN to have control on this operation. Thus, UE based LTE CRS interference cancellation is today implemented by some

UE/chipset vendors based on some proprietary techniques. It is difficult for the operator to quantify the real gain and to understand this mode of operation. One may also note that RAN controlled techniques will be favored in practice by the fact that with the 5G expansion, the 4G and 5G sites will be more and more time synchronized. Time synchronization of the LTE agressor and 5G victim cell is in our view an important enabler for the dynamic CRS rate matching method proposed here.

- Transmitting NR PDCCH in symbols containing LTE CRS. This will in practice allow to send the NR PDCCH, e.g. in LTE symbol 1 (counting starts at 0), which is not possible today in 4T4R configuration. NR PDCCH is clearly a bottleneck of DSS and the situation will become worst with NR traffic increase. One absolute requirement for this would be in our view to avoid impact on LTE legacy UEs.
- For both ideas above, there should be as less as possible UE impact, such as to create the premises for a widescale adoption of these techniques by the UE manufacturers. It worths nothing to mention that these features become meaningless if there is no widespread adoption in the ecosystem.

**2 – Telia Company AB**

Telia Company sees that Release 18 should continue to evolve and improve DSS solution for operators to achieve seamless transition and refarming from LTE towards 5G technology. We agree with above reasoning from BOUYGUES Telecom when considering TX-based dynamic CRS rate matching and NR PDCCH enhancements.

Additionally, DSS item in Release 18 should be led by RAN1 with corresponding TU allocation in RAN1.

**3 – AT&T**

First, we'd like to thank the moderator for conducting the email discussion, and for the well written and organized discussion document.

Regarding the justification, this can be addressed when we are ready to draft a WID.

We support the proposal to have this RAN1 led and a work item.

Now referring to the objectives, we don't think coexistence with non-3GPP radio technologies belongs under the umbrella of DSS. Before DSS became the moniker for this technology, it was actually called LNC (or LTE/NR Coexistence) for the longest time, incl. all of Rel. 14 (NR SI) and most of Rel. 15 (NR WI). DSS is thus clearly defined as LTE/NR coexistence which precludes non-3GPP radio technologies by definition. LTE is the 36 series of specifications, NR the 38 series, and DSS allows the two to coexist in overlapping spectrum, i.e., LTE eMBB and LTE eMTC/NB-IoT with 5G NR. Hence, coexistence with non-3GPP radio technologies should not be discussed in this proposed work item, but independently based on its own merit.

Thus, all the other proposed objectives, namely, improved NR spectral efficiency for LTE-NR coexistence (focusing on LTE MBB), and more efficient NB-IoT and eMTC coexistence on NR carriers are in the scope of DSS and should be enhanced in R18. Specifically, we need to keep in mind the clear and present commercial need for both LTE MBB and NB-IoT/eMTC coexistence with NR when deployed in overlapping carriers.

On the LTE MBB side, we support two objectives. First, dynamic CRS rate matching, which can serve both better LTE CRS interference mitigation and NR overhead reduction. Both these issues are highly important from a deployment perspective.

Second, we strongly support enhancements that increase NR PDCCH capacity. This has been a long standing issue with DSS since R15 that has not been addressed in R16 or R17 on the same carrier. RAN1 should thus specify means that allow more than one NR PDCCH symbol in cells with four LTE CRS ports without having to rely on CA and cross-carrier scheduling techniques.

Lastly, there will be a day when operators turn off their 4G LTE broadband networks but need to maintain eMTC and NB-IoT. Today, when eMTC is embedded into a wideband carrier, the eMTC UE knows the bandwidth of said wideband carrier and multiple so-called narrowbands can be deployed. After LTE sunset, when eMTC standalone carriers are embedded into NR wideband carriers, these eMTC standalone carriers cannot make use of multiple narrowbands anymore as the system bandwidth in the LTE PBCH is set to 1.4 MHz. RAN1 needs to address this limitation as soon as possible, as eMTC UEs have very long lifetime cycles.

Because all the above address urgent deployment needs, we ask for consideration and strong support in R18.

**4 – QUALCOMM JAPAN LLC.**

Through the continuous work for DSS in Releases 15 – 17, various solutions (PDSCH rate-matching around LTE-CRS(s), cross-carrier scheduling from SCell to PCell) have been specified. Considering that PDSCH rate-matching around LTE-CRS(s) is only based on semi-static configuration today, DCI based dynamic rate-matching pattern indication for LTE-CRS(s) could be a topic that we can consider for Rel-18.

**5 – Nokia France**

If DSS enhancements are to be included in Rel-18, the scope needs to be very clearly and tightly defined.

In our view, and considering the previous discussions, out of the three "potential objectives" above only the first one is worth discussing: "Improved NR spectral efficiency for LTE-NR coexistence". This objective should be made much more precise, for example "Specify the possibility for NR PDCCH to occupy symbols containing LTE CRS [RAN1]."

Regarding dynamic rate-matching, we have not seen any scenarios in which the existing semi-static configuration of rate-matching for LTE CRS is not sufficient.

The second bullet has already been addressed in Rel-16.

In relation to the third bullet, it should be noted that Rel-15 already addresses generic in-carrier coexistence with dynamic RB/symbol level rate matching patterns, answering the requirement for future-proofness; optimizing this further in Rel-18 for a specific non-3GPP technology is not seen as a priority.

**6 – LG Electronics Deutschland**

The objectives above are too general and ambiguous. We think a much more focused objective is necessary for the progress of the discussion.

**7 – KDDI Corporation**

We want to have NR PDCCH capacity enhancement which allows NR PDCCH in symbols with LTE-CRS.

**8 – ZTE Wistron Telecom AB**

For Objective #3, we don't think co-existence with non-3GPP technologies should be within the scope.

**9 – China Mobile Com. Corporation**

The motivation, scenario and benefit need more clarification and judgment before we draw the conclusion on these proposals.

1. Regarding the objective "Improved NR spectral efficiency for LTE-NR coexistence", it is too broad and cannot give a clear guidance to companies what to do in Rel-18, especially considering many DSS techniques have been introduced from Rel-15 to Rel-17. In the Rel-18 workshop and RAN#93 e meetings discussions, some potential Rel-18 DSS enhancement techniques were widely discussed, but we don't see strong motivation and benefit on them.

- For "dynamic adaptation of rate-matching around LTE CRS pattern(s)", we are unclear its feasibility since the CRS pattern are semi-statically configured per LTE carrier and if NR carrier share the same frequency resource with LTE carriers, the CRS(s) are always transmitted, why gNB needs to dynamic indicate the CRS pattern? In addition, Rel-17 CRS-IC in RAN4 can also improve the demodulation performance in DSS scenario, the additional gain on top of it should also be considered.
- For "NR PDCCH reception in symbols overlapping with LTE CRS", the scenario should be clarified first. In the scenario which NR carrier frequency range is much wider than LTE, the PDCCH capacity is not a big issue, since flexible resource allocation of CORESET has been facilitated in NR, it is unnecessary to use the overlapped REs with CRS. In the scenario which NR carrier frequency range equals to LTE, the benefit of CRS puncture NR PDCCH also needs clarification and judgement. If the second OFDM symbol can be used for NR PDCCH, that means the LTE PDCCH capacity is not the bottleneck, one alternative LTE/NR coexistence solution is gNB cutting down the bandwidth of LTE which NR and LTE share the band in FDM manner and it has the same effect with CRS puncture NR PDCCH to improve NR PDCCH spectral efficiency without spec impact. For example, the LTE bandwidth decrease into half but the LTE PDCCH occupies two OFDM symbol and the LTE PDCCH capacity is the same with the case only one OFDM symbol is used for LTE PDCCH in the full bandwidth. In addition, the NR PDCCH capacity issue can be solved by Rel-17 cross carrier scheduling form sSCell to PCell.
- For "FR2 SCell scheduling PDSCH/PUSCH on FR1 P(S)Cell", we have concern on its feasibility, since the FR2 PDCCH coverage is worth than FR1.
- Besides, some other Rel-18 SI/WI can also be used in DSS to further solve NR PDCCH capacity issue. For example, in flexible spectrum integration, once the DSS carrier is among the carriers of one elastic cell, it can be scheduled by DCIs on the other frequency resources, the NR PDCCH capacity limit issue on DSS carrier can be solved.

2. Regarding the objective "More efficient NB-IoT and eMTC coexistence on NR carriers", since the NB-IoT and eMTC can coexist with LTE, and LTE can also coexist with NR, we think the coexistence between NB-IoT/eMTC and NR has been supported already, whether needs further enhancement and the detailed scope is not widely discussed before.

3. Regarding the objective "Coexistence with non-3GPP radio technology", we don't know why need to do it in 3GPP.

**10 – SoftBank Corp.**

DSS is one of the very important functionalities in NR. We believe this will continue in Rel-18 era. We support the proposal by moderator.

**11 – MediaTek Inc.**

In general we are OK to have some continuing work on DSS.

- Dynamic CRS rate-matching can be one of the direction for further consideration. The serving cell can decide whether to enable this rate-matching pattern based on some L1 CSI-report for neighboring TRPs or L3 RSRP report.
- On enhancement for NR PDCCH, we need to be very careful on the UE complexity and power consumption. PDCCH is not like PDSCH which has direct relation to the end-user throughput. What we want to avoid is the case that UE burned out all its power for CRS cancellation in every slot but get nothing, e.g., no actually data were scheduled to that UE. This is going to bring a very poor user experience.

**12 – TELENOR ASA**

Telenor considers DSS evolution to be important area also within the release 18 time frame to allow for seamless transition from 4G to 5G. We agree on the comment given by Bouygues and Telia Company. Dynamic CRS rate matching and NR PDCCH enhancements should be given the highest priority. Besides, to our understanding this work should be RAN1-led, and hence requiring corresponding RAN1 TUs.

**13 – Samsung Electronics Co.**

1) Among the potential objectives, we do not think "Coexistence with non-3GPP radio technology (RAN1)" belongs to the scope of DSS (LTE-NR coexistence).

2) Focusing on the first potential objective, "Improved NR spectral efficiency for LTE-NR coexistence (RAN1)":

A. We would like to understand which specific DSS enhancement feature(s) is the scope of this discussion.

B. Both feasibility and possible benefits are unclear based on previous discussions. Regarding dynamic PDSCH rate-matching around CRS, we are still not convinced from the 'dynamic adaptation' since current LTE networks does not change CRS configuration dynamically. Specifically, how can a gNB have instantaneous accurate knowledge of the best "CRS RM pattern" for each UE in order to provide the dynamic indication? For example, even if few additional REs from a "CRS RM pattern" could be used with perfect accuracy for PDSCH to the proper UE each time, the SE gains are marginal as the power of those REs can be used for power boosting – the proposal is just trading off power for few REs/BW but, even under ideal operating conditions, that trade-off would have practically no impact on SE. Similar arguments for feasibility and benefits apply for the "rate matching PDCCH".

**14 – Intel Corporation (UK) Ltd**

**Justification**: DSS allows LTE and NR to share the same carrier by dynamically allocating resources to LTE or NR users depending on the traffic loading conditions. At the same time, since commercialization of Rel-18 NR features is not expected earlier than by 2024, the relative ratio of LTE users comparing to NR user by that time are expected to be substantially reduced. As the result DSS enhancements in Rel-18 should primarily focus on the scenario, where the number of NR users noticeably exceeds that the number of LTE users. One of the possible spectral efficiency enhancements targeting the scenario with small number of LTE users is support of uplink MU-MIMO between LTE and NR users. In RP-212350, by using system-level simulation it was shown that noticeable performance improvement can be achieved by allowing MU-MIMO pairing between LTE and NR users in the uplink in such scenario.

**Detailed objectives**: Specify enhancements to support uplink MU-MIMO between LTE and NR users to improve NR spectral efficiency for LTE-NR coexistence (RAN1)

**Leading working group**: RAN1

**SI or WI**: WI

**15 – Huawei Technologies France**

The scope is not clear. All the three potential objectives listed here are too general. Thus, as a general comment, the objective should be written more precisely, otherwise this is completely unclear. Besides, the gain we can get from the proposed candidate solutions on top of what we have in Rel-15/16/17 need clarification.

Regarding dynamic adaptation of rate-matching around LTE CRS pattern(s): Not sure why RRC-based configuration is not enough for the following reasons,

- It is not clear how much gain could be achieved on top of Rel-17 CRS-IC, which is being specified especially for this scenario. It should be avoided to specify multiple options for the same target.
- Typically which cell creating stronger CRS interference will not change dynamically but rather gradually as the UE moving in a cell. Therefore, it is unclear how much gain such a more complex solution can provide compared to the current specified semi-static configuration among multiple CRS patterns.
- Without UE reporting of CRS interference measurement, it is unclear how a gNB can have dynamic assessment of CRS interference for a UE to enable this dynamic rate-matching around CRS.

Regarding NR PDCCH reception in symbols overlapping with LTE CRS: Our understanding is that the minimum necessary standard work would be to remove the constraint that a UE cannot receive PDCCH in a symbol where some REs belong to a CRS rate-matching pattern configured for the UE. Then, scheduling the UE with a sufficiently large aggregation level would help the UE decode the PDCCH in spite of the punctured PDCCH symbols. One issue is that the LTE CRS REs will also puncture the PDCCH DMRS, so it is not obvious that sufficiently good PDCCH BLER can be achieved even with a large aggregation level. In this sense, a study is needed first. We should also note that Rel-17 already specifies a method to increase the capacity for scheduling a NR UE on a DSS carrier, with SCell scheduling PCell, which is another way to provide additional capacity for scheduling NR UEs on a DSS cell.

Regarding "More efficient NB-IoT and eMTC coexistence on NR carriers" and "Coexistence with non-3GPP radio technology", it is better to clarify what the issues, the corresponding motivation, standard impact and benefits could be.

**16 – VODAFONE Group Plc**

Along with Bouygues Telecom, Telia, Telenor and other operators we see DSS as a key technology. It is actively deployed and (until Redcap device volumes exceed those of LTE cat 1/3/4/ IoT devices - and the R18 Redcap 5 MHz proposal makes this more likely to never happen) we expect that DSS will remain essential functionality in live networks. Consequently we see DSS enhancements as important, long term, functionality.

We see that the work will be in RAN 1 area and hence should be RAN 1 led.

We see that the following 2 objectives are most important:

1) "Dynamic CRS rate matching" allows for better LTE CRS interference reduction in general (either by actively rate-matching around strong CRS interference or by consciously turning-off the rate matching pattern in case of low CRS interference and hence using the REs for NR PDSCH instead)

We prefer CRS-rate matching is base station based solution to the UE-based CRS-IM is a receiver-based solution. This is because the long term issue is with IoT devices (which are not under VPLMN control) and hence we need solutions that do not rely on (least cost) UEs actually implement the optional CRS-IC.

2) "The additional OFDM symbol for NR PDCCH" : this will increase PDCCH (and even PDSCH) capacity

****

While the co-existence of NB-IoT and eMTC with NR (and any future 6G technology) is essential, we are not aware of improvements that need to be made in this area. However, perhaps more study is needed to ensure eMTC works with DSS?

**17 – TELECOM ITALIA S.p.A.**

We support Bouygues comments

Moreover, we do not think coexistence with non-3GPP technologies is in scope of this activity.

The activity should be a WI

**18 – Ericsson LM**

On justification:

LTE UEs are likely to be around for a long time, and hence it is important to continue to evolve DSS, especially there are room for performance improvements in scenarios where NR traffic starts to dominate with very low LTE traffic.

Potential objectives:

- Introduce dynamic CRS ratematching pattern selection (via DCI)
  - CRS ratematching pattern selection via DCI will increase DSS flexibility and allow for e.g. dynamic ratematching around strong LTE interference. This would improve performance compared to more static (RRC reconfiguration-based) solutions. There is already support for dynamic symbol/RB level RM adaptation in the specs and that framework can be straightforwardly extended for CRS RE level RM
- Support NR PDCCH reception in symbols overlapping with LTE CRS
  - To maximize resource utilization and increase PDCCH capacity for DSS, it would be beneficial to allow NR PDCCH reception in symbols overlapping with LTE CRS. Our proposal is that the LTE CRS would puncture NR PDCCH and DMRS, and hence no or little changes to the receiver is needed. This naturally impacts decoding performance, but the gain from the additional PDCCH resources generally outweighs this loss.
- Extend SCell scheduling PCell to FR2
  - This can also be considered as part of a potential CA work item

We agree with RAN1 as leading work group and that it is a WI

**19 – Telstra Corporation Limited**

We agree with Ericssons proposal

### 7.1.2 Summary for initial round

Companies's view on the objectives for this topic are diverse, especially for detailed objectives of improved NR spectral efficiency for LTE-NR coexistence.

**Improved NR spectral efficiency for LTE-NR coexistence**

Many operators including Bouygues Telecom, Telia, AT&T, KDDI, Softbank, Telenor, Vodafone, Telecom Italia and Telstra supported the DSS evolution in Rel-18 and showed interests in increasing NR PDCCH capacity and/or dynamic CRS rate matching.

Qualcomm showed the support for DCI based dynamic CRS rate matching, Nokia showed the interests in increasing PDCCH capacity but had different views for dynamic rate matching, and Mediatek supported dynamic rate matching but had concern on PDCCH enhancement (more specific, UE complexity and power consumption).

CMCC, Samsung, Huawei expressed not being convinced for dynamic rate matching and increasing PDCCH capacity in terms of the motivation, benefits or specification impact, and thought that the existing semi-static RRC signaling based rate matching, cross-carrier scheduling PDCCH, and/or other BS implementation solutions can address the issue.

There were question on the feasibility of FR2 SCell scheduling PDSCH/PUSCH on FR1 P(S)Cell since FR2 PDCCH coverage is worth than FR1. Moderator suggested to discuss it under Rel-18 CA/DC enhancement WI.

Ericsson provided the more detailed objectives and in the intermediate round companies can discuss them.

**More efficient NB-IoT and eMTC coexistence on NR carriers**

AT&T expressed the commercial need to further enhancement for NB-IOT/eMTC coexistence on NR carriers and elaborated on the potential issues *after LTE sunset, when eMTC standalone carriers are embedded into NR wideband carriers, these eMTC standalone carriers cannot make use of multpile narrowbands as more as the system bandwidth in LTE PBCH is set to 1.4MHz*.

Nokia, CMCC, Huawei, Vodafone thought that the issue were addressed in previous release (Rel-16 NB_IOTenh3/LTE_eMTC5). More discussion would be needed.

**Coexistence with non-3GPP radio technology**

Almost all the companies commented this working area should not be included in this topic. Moderator suggested to drop this working area.

## 7.2 Intermediate round

### 7.2.1 Proposals and comments collection

In the intermediate round, moderator suggests to continue discussion on the detailed objectives based on the concrete proposals from the proponent (Ericsson) to see if the group could reach the consensus on dynamic CRS rate matching and increasing PDCCH capacity.

Besides, the other topics, i.e., NB-IoT/eMTC coexistence, support uplink MU-MIMO between LTE and NR users and Scell scheduling PCell for FR2, can also be discussed.

**Dynamic CRS rate matching pattern selection**

The proponent needs to address the concern and answer the questions from other companies:

- Why does gNB needs to dynamically indicate CRS pattern considering that the CRS pattern is semi-statically configured on one LTE carrier and the strong interference cell(s) does not change dramatically?

- How can gNB accurately know of the best CRS RM pattern (strong interference observed by UE)?
- What is the additional gain compared to Rel-17 CRS-IM solution?
- Is the spectrum efficiency gain marginal as the power of the CRS REs can be used for power boosting even if those REs could be used for transmission rather than skipped by rate matching?

Based on the more concrete objective from the proponent and feedback from companies, moderator proposed the modified objective as below to check if it is agreeable

- Investigate and if necessary introduce dynamic CRS rate matching pattern selection (via DCI)
    - Study the feasibility and possible benefits of CRS rate matching pattern selection via DCI compared to CRS-IM and static RRC reconfiguration solutions

Please provide the responses to companies, and comment on the moderator proposal below.

**Feedback Form 68:**

| |
|---|
| **1 – China Telecommunications**<br>We understand the motivation of this work according to the R17 discussion on CRS-IM receiver. However, we'd like also to ask the following question as commented by companies in the initial round, especially considering the best CRS RM pattern should be per UE basis (i.e., depending on UE location).<br>· *How can gNB accurately know of the best CRS RM pattern (strong interference observed by UE)?*<br>Are we going to introduce some enhancement on the UE measurement and reporting to support this? If yes, we need to add this aspect in the objective. |
| **2 – QUALCOMM JAPAN LLC.**<br>We agree with the moderator's proposal |
| **3 – AT&T**<br>We agree with the proposal |
| **4 – MediaTek Inc.**<br>We are fine with moderator's proposal.<br>Just a clarification. As the indication is through DCI, it is only applicable to PDSCH, not PDCCH. |
| **5 – LG Electronics Deutschland**<br>While we appreciate the proponents' concerns and willingness for the study, we are negative to having this objective considering both the overall RAN1 work load and the necessity of dynamic adaptation on top of the semi-static solutions we already have |
| **6 – TELENOR ASA**<br>We agree with the moderator's proposal. |

**7 – Samsung Electronics Co.**

While waiting for proponents answers on above questions, we do not think it is worth to introduce 'dynamic CRS rate matching pattern selection' as a separate Rel-18 work item (or one objective thereof). Rather, if the above raised questions are addressed, it can be part of Rel-18 TEI. The expected work scope is more suitable for consideration in TEI

**8 – China Mobile Com. Corporation**

We understand the willingness of dynamic CRS rate matching, however, as we have not seen convinced answers corresponding to questions listed by the moderator, we can not support for such a study before we have a clear understanding.

**9 – Telia Company AB**

Agreeing with the moderator's proposal.

**10 – BOUYGUES Telecom**

On the question :

*How can gNB accurately know of the best CRS RM pattern (strong interference observed by UE)?*

I believe that the existing L3 measurement for intra frequency cases can be reused. Then, it is up to gNB software to switch the CRS rate matching if needed.

**11 – Ericsson LM**

Addressing the concerns answer questions from other companies:

- On the need to dynamically indicate the CRS pattern, as described in RP-212420, dynamic adaptation between different CRS RM patterns avoids frequent RRC reconfigurations. The interference/interferer will not be static (e.g., due to shadowing, user mobility, etc.) and dynamic signaling helps to efficiently manage rate-matching patterns to improve NR throughput. It aligns the CRS ratematching with other PDSCH symbol/RB level ratematching approaches for which dynamic adaptation is already specified.
- On how the gNB accurately knows of the best CRS RM pattern, the gNB uses the L1/L3 measurements in existing specifications.
- The additional gain compared to Rel-17 CRS-IM solution, the Rel-17 solution depends on specific UE implementation (RAN4 only specifies minimum requirements). The proposed approach is expected to provide gains by allowing the NW to control the CRS interference handling (as also mentioned by several operators) and for wider range of devices and scenarios.
- On the power boosting, we are not sure we understand how power boosting could be used to help with CRS interference issues and would appreciate if this could be explained further. As we understand Samsung's input, they compare using some REs for data (by adapting the CRS RM pattern) with leaving those REs empty and using the extra available power for power boosting. For transmissions with modulation order 16QAM or higher, the power per RE cannot change between symbols (unless the receiver is aware that it does, which is not supported in NR. Since power cannot be "borrowed" between symbols, we do not understand how the power gained by leaving some REs empty could be used for power boosting, since CRS is not present in all symbols.

Given the simplicity of this feature with a clear use case and strong operator support, we do not see the need for an investigation first. The time and effort needed to agree on a meaningful simulation setup to evaluate the feature, run simulations, compile the results and reach a conclusion is much larger than the effort needed

to standardize the feature, and that the time needed for such evaluations will benefit the Rel-18 work more if spent on other topics. Hence, *we* propose the following objective:

- Support DCI based dynamic adaptation of rate-matching around LTE CRS pattern(s)
  - Current CRS ratematching specifications and already existing DCI fields should be reused when viable

**12 – Nokia France**

In principle we would be OK to investigate the benefits of the LTE CRS RM for neighbour cell RM over whatever is done in Rel-17 demodulation enhancements, but, as discussed over several rounds, it is not at all clear that there is any benefit in dynamic adaptation of the RM pattern, or that there is benefit over enhanced demodulation, and we are therefore not convinced that this investigation is worth the time that would be needed.

If the proposal were to go ahead, it should also be clarified whether some L1 feedback would be available to help the gNB decision making or not. (Having none makes the point of dynamic adaptation signalling questionable, whereas having something would add significant cost in running the feature due to the frequency UL reporting that would be needed, as well as significantly increasing the complexity of the 3GPP work.) If L3 measurements are to be relied on, the existing semi-static configuration should be more than sufficient.

**13 – VODAFONE Group Plc**

We are generally ok with the moderator's proposal. However, we also share Ericsson's view that, given the simplicity of the feature, clear use case and strong operator support, there seems little need to invest the time and effort on an investigation stage.

**14 – Intel Corporation (UK) Ltd**

We still have concerns on the assumed scenario and benefits offered by dynamic indication of CRS rate matching. We think proponents should provide more detailed justification beyond argument on flexibility.

**15 – Huawei Technologies France**

Without proponent's answers or justification to the questions summarized above, there seems no potential benefit that could be studied. If the motivation is about a scenario with IoT devices that does not implement CRS-IC, then the proposed dynamic pattern selection still seems no gain because such IoT devices do not implement any reporting of CRS interference measurement. Therefore, we do not see the necessity of this objective yet, more justification, especially answers to the questions summarized above, are suggested.

**Support NR PDCCH reception in symbos overlapping with LTE CRS**

The proponent needs to address the concern and answer the questions from other companies on feasibility and benefits, e.g., whether the implementation solution can address this issue, and there has already been the solution to provide additional capacity with SCell scheduling PCell. Huawei commented that the minimum necessary standard work would be to remove the constraint that a UE cannot receive PDCCH in a symbol where some REs belong to a CRS rate-matching pattern configured for the UE.

Based on the concrete objectives from proponent and feedback from companies, moderator proposed the modified objectives as below to check if they are agreeable

- Investigate and if necessary increase PDCCH capacity for DSS

- Study and if agreeable allow NR PDCCH reception in symbols with LTE CRS REs.
- Investigate the performance, and enable LTE CRS to puncture NR PDCCH and DMRS if there is the performance gain from the additional PDCCH resources.

Please provide the responses to companies, and comment on the moderator proposal below.

**Feedback Form 69:**

**1 – China Telecommunications**

One aspect that might to be considered is the legacy DSS UEs not supporting the Rel-18 feature. With the legacy DSS UEs in the network, it seems the symbols with LTE CRS still cannot be used for NR PDCCH (considering the LTE CFI is cell specific).

Meanwhile, there are also some low bands (like in 800/900MHz) without legacy DSS UEs, i.e., not re-farmed so far. But it seems usually 2Tx BS with 2 CRS ports are deployed in these low bands.

**2 – AT&T**

We agree with the proposal

**3 – MediaTek Inc.**

A clarification again. In our understanding, it is not possible to use DCI for rate-matching on PDCCH. (Chicken-and-egg problem )

The remaining solutions could be static rate-matching, LLR weighting and interference cancellation. We have concern on interference cancellation for PDCCH.

**4 – KDDI Corporation**

We are fine with the objectives, prefer to prioritise this objectives over other objectives Dynamic CRS rate matching pattern selection.

**5 – TELENOR ASA**

We agree with the moderator's proposal.

**6 – Telia Company AB**

Objectives are ok for us.

**7 – China Mobile Com. Corporation**

Considering the spec effort, more justification is needed for this study since there are already PDCCH capacity extension schemes such as SCell scheduling Pcell specified in R17 and gNB implement methods such as compressing LTE bandwidth since only one symbols is assumed for the study. We are not convinced for such a study until now.Considering the spec effort, more justification is needed for this study since there are already PDCCH capacity extension schemes such as SCell scheduling Pcell specified in R17 and gNB implement methods such as compressing LTE bandwidth since only one symbols is assumed for the study. We are not convinced for such a study until now.

**8 – BOUYGUES Telecom**

We agree with the proposal.

**9 – Ericsson LM**

As for the previous discussion, we do not believe a study phase is needed. We have already provided simulation results for NR PDCCH when it is punctured by LTE CRS, R1-2110143, showing that the gains from the extra resources are larger than the losses in decoding performance due to puncturing.

Proposed objective:

- Support NR PDCCH reception in symbols overlapping with LTE CRS
  - Note: The UE is not required to ratematch NR PDCCH and corresponding DMRS around LTE CRS for this objective.

**10 – Nokia France**

We would be supportive of this work, but it would be important to get the UE/chip vendor buy-in, as studying something that impacts the PDCCH channel estimator without buy-in from the ones who have to implement it may lead to spending time on investigation of something that doesn't get implemented.

**11 – VODAFONE Group Plc**

We are ok with the moderator's proposal.

**12 – Intel Corporation (UK) Ltd**

Intel is OK to have more studies on this aspect in Rel-18 with possible normative work if feasibility / sufficient gains are shown.

**13 – ZTE Corporation**

we support this proposal since this could enable more flexible PDCCH configuraiton in time domain and increase PDCCH capacity.

**14 – Huawei Technologies France**

We prefer to justify its necessity on top of what we have in Rel-15/16/17 first, especially why Rel-17 DSS enhancement with cross-carrier scheduling is insufficient. Besides, in order to better understand the potential standard work and resulting UE complexity, the scope can be clarified and refined a bit, e.g. whether or not new PDCCH DMRS pattern is allowed for the second sublet.

**15 – KT Corp.**

KT would like to support NR PDCCH reception in symbols overlapping with LTE CRS without any study phase since this is the most obvious way to increase NR throughput when DSS is deployed.

**More efficient NB-IoT and eMTC coexistence on NR carriers**

AT&T proposed to address the issue *after LTE sunset, when eMTC standalone carriers are embedded into NR wideband carriers, these eMTC standalone carriers cannot make use of multiple narrowbands as more as the system bandwidth in LTE PBCH is set to 1.4MHz*.

Please provide the comments and feedbacks.

**Feedback Form 70:**

**1 – AT&T**

It is our understanding that an eMTC carrier embedded into a wideband LTE carrier (e.g., 10 MHz) and an eMTC carrier embedded into a wideband NR carrier (e.g., 10 MHz) do not perform the same. In the former case, the LTE PBCH signals 10 MHz, in the latter case, the LTE PBCH signals 1.4 MHz and the specifications define different behaviors for bandwidths less than 5 MHz.

**2 – LG Electronics Deutschland**

We are negative to this potential objective since we are not sure about the importance/urgency of handling that case

**3 – TELENOR ASA**

We need to understand this topic and how to handle. However, we are uncertain about the urgency.

**4 – Telia Company AB**

Clarification of embedded eMTC standalone carriers in NR wideband carriers would be appreciated. Urgency still unclear.

**5 – BOUYGUES Telecom**

If AT&T understanding is right (probably, but not 100% sure), then it follows that the frequency hopping among NarrowBands for certain eMTC channels (e.g.: SIBs, PUSCH, PDSCH) cannot be ensured. This would incur a loss in coverage (lack of frequency diversity) and potentially an interference increase between the eMTC cells. So, making frequency hopping among narrowbands possible is important for NR/eMTC coexistence.

And as a more general comment: as other companies mentioned, there is a probability to have eMTC within NR spectrum for at least a decade from now, so any improvement in the area is important. And since the low band spectrum where LTE-M is usually deployed is expected to go massively to NR in the next few years, I think that this is the perfect timing, from the ecosystem perspective) to have the NR/eMTC coexistence improvement.

The objective would be to have eMTC multiplexing within NR spectrum as easy and as flexible as it is today within LTE spectrum.

**6 – China Mobile Com. Corporation**

We need to understand more about the intended solution direction. For the described scenario, what is expect from NR? According to our understanding, specs influence should be on NR part and nothing can be done to eMTC part.

**7 – Huawei Technologies France**

Regarding the above sentence, it is appreciated if proponents could elaborate a bit the issues, the corresponding motivation, and potential standard impact.

**Uplink MU-MIMO between LTE and NR users**

Intel proposed the objective

– Specify enhancements to support uplink MU-MIMO between LTE and NR users to improve NR spectral efficiency for LTE-NR coexistence (RAN1)

Please provide the comments and feedback.

**Feedback Form 71:**

**1 – China Telecommunications**

It seems not easy to be implemented.

**2 – vivo Communication Technology**

We don't see use case for UL MU-MIMO pairing between LTE and NR, it is mainly related to scheduling by eNB/gNB, reception/demodulation at eNB/gNB. From UE perspective, UE transmits SRS according to network configuration, and transmits PUSCH according to scheduling DCI. DMRS is configurable in NR while fixed in LTE, that means DMRS are not overlapping for LTE UE and NR UE, and PUCCH in NR is multiplexed in time domain which will have impact on eNB/gNB demodulation performance.

Having said above, if agreed, it should be RAN4 item only, no RAN1 involvement is needed.

**3 – QUALCOMM JAPAN LLC.**

We do not see a clear use case for this feature and it would also have a relatively big impact in the specifications. By the time this feature would be implemented in UEs that are in the field, it is unlikely there would be a need for such a feature.

**4 – LG Electronics Deutschland**

We are negative to this potential objective since we are not sure about the importance/urgency of this scenario.

**5 – Ericsson LM**

It would be good to have more details on what exactly these enhancements would be. As now, the proposed objective is too general in our opinion.

**6 – Nokia France**

Uplink carriers can be shared in time and in frequency already. We don't see the added benefit of sharing in the spatial domain.

**7 – Nokia Japan**

This proposal looks something new and this was not listed in the initial round summary by moderator. It would be great if HW could share what has been discussed in the previous RAN and relevant t-docs

**8 – VODAFONE Group Plc**

This is interesting in principle, but the inter-RAT aspect seems complex. Considering the amount of work, the gain/benefit/need for given use cases should be made clear.

**9 – Intel Corporation (UK) Ltd**

Intel supports this objective to address DSS scenario with small number of LTE users.

**10 – Huawei Technologies France**

Not sure what standard impact is needed and the potential benefits. Is that new DMRS design (e.g. position?). If so, it will also disable MU-MIMO between legacy NR UEs and Rel-18 UEs, which , however, seems much more important than MU-MIMO between LTE UEs and Rel-18 NR UEs because the target scenario has smaller number of LTE users than NR UEs as the proponent explained.

### 7.2.2 Summary for intermediate round

Companies (China Telecom, LGE, CMCC, Nokia, Intel) still questioned on the feasibility and benefit of dynamic CRS rate matching. Samsung thought the work can be done as TEI if needed.

Ericsson did not think that study is needed and proposed the modification to remove the invesigation. Qulacomm, AT&T, Mediatek, Telenor ASA, Telia, Bouygues, and Vodafone supported Ericsson proposal.

The similar situation happened for potential objective to support NR PDCCH reception in symbols overlapping with LTE CRS.

Regarding NB-IoT and eMTC coexistence on NR carriers and uplink UL-MIMO between LTE and NR carriers, the group need further clarification from the proponent on the potential issues. The moderator suggests to discuss those issues further in future meetings.

## 7.3 Final round

### 7.3.1 Proposals and comments collection

Moderator suggests further discussing the dynamic rate matching and increasing PDCCH capacity. There would be two alternative sets of objectives:

- Alternative #1:
  - Investigate and if necessary introduce dynamic CRS rate matching pattern selection for PDSCH (via DCI)
    - Study the feasibility and possible benefits of CRS rate matching pattern selection via DCI compared to CRS-IM and static RRC reconfiguration solutions
  - Investigate and if necessary increase PDCCH capacity for DSS
    - Study and if agreeable allow NR PDCCH reception in symbols with LTE CRS REs.
    - Investigate the performance, and enable LTE CRS to puncture NR PDCCH and DMRS if there is the performance gain from the additional PDCCH resources.
- Alternative #2:
  - Support DCI based dynamic adaptation of rate-matching around LTE CRS pattern (s)
    - Current CRS rate matching specifications and already existing DCI fields should be reused when viable.
  - Support NR PDCCH reception in symbols overlapping with LTE CRS
    - NOTE: the UE is not required to rate match NR PDCCH and corresponding DMRS around LTE CRS for this objective.

Please provide your comment how to move forward based on those alternatives in the final round.

**Feedback Form 72:**

**1 – Nokia France**

It would be good to enable some work to proceed in this area, but we cannot avoid recognising that there were far more substantial concerns and questions around the dynamic CRS rate matching than for the increased PDCCH capacity. Hence, we believe a good way forward would be simply to agree on the following objective (from Alt 2):

- **Support NR PDCCH reception in symbols overlapping with LTE CRS**

**- NOTE: the UE is not required to rate match NR PDCCH and corresponding DMRS around LTE CRS for this objective.**

We hope that this could be a good compromise.

**2 – ZTE Corporation**

For NR PDCCH reception in symbols overlapping with LTE CRS, we are fine to specify it, Nokia's revision seems good for us.

For dynamic CRS rate matching, it seems the motive is still unclear and the benefit is also not justified. In our view, we can simply consider whether we need to extend semi-static configurations of multiple CRS patterns overlapped in a frequency range for rate-matching which have been already supported by Rel-16 MTRP. Hence, the Rel-18 work will be to discuss whether to support PDSCH rate matching around CRS REs from more than one LTE cells in the case when Rel-16 multi-DCI based MTRP is not configured. Note: multiple overlapping CRS patterns for PDSCH rate-matching is only supported for multi-DCI based MTRP PDSCH transmission).

**3 – China Telecommunications**

**Dynamic CRS rate matching pattern selection**

We asked the "How gNB accurately know of the best CRS RM pattern (strong interference observed by UE)?" in the intermediate round, and companies fed back that it can be based on L1/3 measurement.

We wonder how could gNB do dynamic CRS rate matching pattern indication based on L3 measurement? Also, this will rely on the UE capability for inter-RAT L1/3 measurement, and the system performance impact by the measurement gap needs also to be considered.

**Support NR PDCCH reception in symbols overlapping with LTE CRS**

If our understanding is correct, this feature is not applicable to BS with 2 CRS ports. And for BS with 4 CRS ports, as commented in the intermediate round, considering the legacy DSS UEs not supporting the Rel-18 feature, not sure whether the 2nd OFDM symbols can be fully used for NR PDCCH.

In general, we are not against the two features since we understand the motivation. But we'd like to know how the features could be used in the network and how much gain could be really obtained.

Alternative #1 with study phase is fine for us.

**4 – QUALCOMM JAPAN LLC.**

We prefer Alt.1. Considering the situations where companies have still different views on motivations, performance gains, etc, having investigations as part of the scope should be helpful.

**5 – AT&T**

AT&T supports Alt. 2

**6 – Samsung Electronics Co.**

1) Some follow-up from previous discussions:

- In case of dynamic CRS rate matching, concerning the UE measurement/reporting, if the measurement/reporting are based on L3, we don't see additional gain of this dynamic adaptation over the existing semi-static approach. Otherwise (L1 measurement/reporting), the cost to support this feature would be moved to UE (e.g., UE processing of interference measurement, UE power consumption for reporting, …). Moreover, it would incur insufficient accuracy of the L1 measurements and the reporting delay that will be needed – cannot have immediate PUCCH resources for all UEs.
- As for power boosting, it can be used for PDSCH transmissions that do not use QAM modulation – typically, not all transmissions use QAM.

2) In case of NR PDCCH overlapping with CRS, as already commented by others, there is already the tool to address the PDCCH capacity issue (e.g., Rel-17 DSS).

3) To summarize, from the discussion so far, the views are still split – no consensus to pursue this topic.

**7 – MediaTek Inc.**

We support dynamic rate-matching but can also compromise to Alt. 1.

**8 – vivo Communication Technology**

Support Alternative #1. We think a more clear justification of the listed features is needed. However, the study phase should be short by setting a clear deadline for the decision on whether to specify or not.

**9 – China Mobile Com. Corporation**

Considering it is still controversial on the motivation, benifit and feasibility about two objectives, we think Alt 1 is a good compromise.

**10 – LG Electronics Deutschland**

The detailed objectives in the proposal seem to require quite different levels of workload. Some of them may be discussed as Rel-18 TEI topic as commented by other company. However, we are not sure if the whole topic should be prioritized over other Rel-18 topics under discussion if we should approve them in a bundle (either alt 1 or alt 2)

**11 – KDDI Corporation**

We prefer to go with Alternative #1, better to start from the study. But both study item and work item should be completed within Rel-18 timeline.

With regard to DCI based dynamic adaptation of rate-matching, we are not so convinced of its performance gain compared to the current mechanism using RRC signalling. We would like to study and clarify how much gain we will have with this feature first.

**12 – VODAFONE Group Plc**

We support dynamic rate-matching but can also compromise to Alt. 1.

**13 – Ericsson LM**

We continue to support alternative 2.

**14 – Intel Corporation (UK) Ltd**

Intel prefers Alt 1 only with the second bullet focusing on PDCCH aspects (without dynamic CRS indication)

**15 – VODAFONE Group Plc**

Regarding the draft WID, we would still prefer to see at least an investigation phase included for dynamic CRS rate matching pattern selection for PDSCH (via DCI), in line with alt 1.

**16 – Huawei Technologies France**

We are open to the second bullet in Alternative#1 only if minimize the potential standard work and resulting UE complexity.

However, for the first bullet in Alternative#1, we still fail to see the necessity of this objective yet. More clarification on any potential benefit are appreciated. For example, There is no existing L1 measurement for LTE CRS as proponent claimed, thus it could not be true that the gNB can accurately know of the best CRS RM pattern by existing mechanism. If L3 measurements are to be relied on, the existing semi-static configuration should be more than sufficient. The existing R15 dynamic RE-level RM was motivated to avoid interference from/to **aperiodic** CSI-RS REs whose interference presence and level are well controlled by the gNB. Since LTE-CRS is not aperiodic, we are afraid that the motivation to have dynamic RM for CSI-RS is not applicable to LTE-CRS, neither its mechanism.

**17 – TELENOR ASA**

Telenor supports alternative 2.

**18 – TELECOM ITALIA S.p.A.**

support both comments from Vodafone

**19 – Telia Company AB**

Alternative 2.

**20 – Verizon UK Ltd**

Support Alt 2. Agree we should try to minimize the potential standard work and be mindful of UE complexity.

### 7.3.2 Summary for final round

The views were still diverse. Nokia, ZTE suggested to take PDCCH part from Alternative 2. China Telecom, Qualcomm, Mediatek, Vivo, CMCC, KDDI, Vodafone, Telecom Italia preferred Alternative 1, while AT&T, Telenor, Telia, Verizion preferred Alternative 2. Samsung thought there was no consensus to pursue the topic. The big concern on dynamic rate matching for PDSCH seems still exist.

In the moderator view, maybe the objective on increasing PDCCH capacity is the middle ground. And taking feedback from companies who were not convinced for this topic, maybe some study is still needed before normative work.

Based on the feedback, the moderator would like to suggest the following objective.

- **Proposal #15-1: for DSS topic, the following objectives can be considered**
  - Study and if needed specify NR PDCCH reception in symbols with LTE CRS REs.
    - Investigate the performance, and enable LTE CRS to puncture NR PDCCH and DMRS if there is the performance gain from the additional PDCCH resources.

# 8 Others

## 8.1 Initial round

### 8.1.1 Proposals and comments collection

Please provide your proposals or comments on the topic or working areas, which do not belong to the previous sections, with justification and proposed objectives.

**Feedback Form 73:**

**1 – Charter Communications**

We support continued improvements in Measurement Gaps enhancements with specific goal of making MG feasible for MUSIM as there is an LS for RAN4 to look into this but it might not have enough TU's to address in Rel-17 and might move over to Rel-18

**2 – Huawei Technologies France**

There are some discussions about FR1 HST enhancements during last RAN#93-e meeting, but in section 5.4, only FR2 HST enhancements are included. Actually based on the discussions for FR1 HST performance in previous releases, companies observed some points which need further enhancements for FR1 HST. Considering the widely deployed FR1 HST in many countries, it would be very beneficial to do some further enhancements for FR1 HST to improve the performance further in Rel-18.

We have the following observations and consideration:

- 500km/h velocity cannot be fully supported on NR FR1 bands.
  - For downlink, the supported max Doppler shift is 875Hz for 15KHz SCS without any margin, which corresponds to supporting 500km/h on 1.88GHz bands. There is a performance gap compared to LTE, which is better than NR.
  - For uplink, the max supported Doppler shift is 1750Hz with DM-RS configuration 1+1+1, which cannot meet the 500km/h for 2.1GHz band that requires 1944Hz.
- Need to enhance TRP switching and handover
  - The existing TRP switching delay requirement only considers SSB which cause unnecessary long delay for HST
  - Combined with CHO, handover can be faster
- Enhance HST-DPS performance: HST-DPS can provide good performance under high Doppler for multi-RRH connecting to one BBU scenario. The performance can be further improved to address the following issues:
  - UE estimates the CSI based on a set of CSI-RS resources which may come from one TRP. Thus the reported CSI may not met the PDSCH channel condition when TRP is switched.
  - If SSB is transmitted from multiple TRPs, when RAR and Msg4 would be transmitted from one TRP during random access procedure, there will be no TCI state information about TRS available for accurate RAR and Msg4 reception, which would degrade the performance.

The objectives:

- Support 500km/h velocity on NR FR1 bands >1.88GHz.
  - Improve downlink performance
  - Improve uplink performance requirements
  - Enhance TRP switching delay requirements
  - Define the CHO RRM requirements for HST scenario
- Improve the HST-DPS performance
  - Improve CSI reporting requirements
  - Improve RAR and Msg4 performance during random access

### 8.1.2 Summary for initial round

Moderator: Measurement Gaps enhancements with specific goal of making MG feasible for MUSIM was discussed in section 5.1 for RRM enhancement.

More discussion on FR1 HST enhancement is needed.

## 8.2 Intermediate round

### 8.2.1 Proposals and comments collection

Please provide the feedback and comments on FR1 HST enhancement.

**Feedback Form 74:**

**1 – TELECOM ITALIA S.p.A.**

We are in general supportive of improving support of HST in FR1, in particular support of 500 km/h in n78.

**2 – China Mobile Com. Corporation**

Firstly, we want to clarify that 500km/h velocity with frequency carrier up to 3.6GHz is already supported for 30KHz SCS in Rel-16 HST WI. So for the objective of "support 500km/h velocity on NR FR1 bands >1.88GHz", it is suggested to clearly say that it is only for 15KHz SCS. i.e. Support 500km/h velocity on NR FR1 bands >1.88GHz for 15KHz SCS.

Secondly, we have some questions for clarification:

1. For 15KHz SCS, the reason only support maximum Doppler shift of 870Hz for DL is the limitation of TRS design. To support of 500km/h velocity on NR FR1 bands >1.88GHz for 15KHz, we would like to know whether it is expected to have enhancement on physical layer design.

2. For "enhance TRP switching delay requirements", we would like to know the detail on how to enhance the TRP switching delay.

3. For HST-DPS performance, we would like to know whether there will be RAN1 impact.

**3 – Intel Corporation (UK) Ltd**

1) For 500km/h - in our understanding this is already supported for 30kHz SCS for up to 3.6GHz

2) Rel-17 feMIMO Tx scheme with distributed TRS Tx allows to support higher Doppler frequency compared to the baseline HST-SFN. Therefore, 500km/h requirements can be considered as a part of Rel-17 feMIMO discussion in RAN4 (it is already in scope of performance part for feMIMO)

3) For HST-DPS we have same question as CMCC whether RAN1 impacts are considered.

**4 – Huawei Technologies France**

Based on the previous HST performance requirements discussion from NR Rel-15 to Rel-17 and real market request, it is very beneficial to consider further enhancements for FR1 HST to support 500km/h velocity for all FR1 bands, faster TRP switching and handover, enhanced HST-DPS performance for more accurate CSI-RS measurements and reporting, higher random access procedure success rate to further improve UE and network performance under HST.

### 8.2.2 Summary for intermediate round

Four companies made the comments. Telecom Italia supported it. CMCC had some clarification questions. Intel thought all the things have already been addressed. The moderator thinks more discussion is needed but in this email discussion there seems no chance for proponent to convince other companies who had different views. So there seems no need for final round.

## 8.3 Final round

# 9 Summary

In this section, the potential stabilized objectives and objectives which need further discussion will be listed separately for each working areas each topic. Please note all the potential objectives are subject to further discussion in December RAN plenary, February email discussion next year and March RAN plenary next year.

Besides, for each topic, how to organize the projects, including whether to have a WI or SI, how many WI(s) or SI(s) are needed, whether a certain working area should be moved or merged to other topic and etc, will be discussed in the future meeting.

## 9.1 Genral : RAN4 TU planning

The moderator proposes the following bullets for general part.

- **Proposal #1-1: Approve Rel-18 RAN4 WI/SI package (except for <5MHz and DSS in this email thread) in March 2022.**
- **Proposal #1-2: for RAN4 spectrum related and non-spectrum related topics,**
  - Boundary between RAN4 spectrum related items and non-spectrum related items,
    - Spectrum related items are item which aim to introduce band-specific and/or band combination specific requirements without impacting generic RF core requirements and/or core specifications of other WGs.
    - All the other items shall be defined as non-spectrum related.
  - Approach to specify RAN4 related features with both general requirements and band specific requirements
    - A non-spectrum related item with the chosen example band(s) and/or example band combination(s) is needed to study and/or specify the general RAN4 requirements as well as other necessary mechanism and the band or band combination specific requirements for the examples
      - The example band(s) and/or band combination(s) should be chosen to ensure that the finalized general requirements can be applied to other bands and/or band combinations.

## 9.2 Spectrum related topics (except for basket WIs and WIs for new bands)

### 9.2.1 Topic #1: Simplification of band combination specificiation

#### 9.2.1.1 Working areas with stable objectives

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #2-1: for RAN4 spectrum specification simplification, the following potential objectives can be considered**

- Investigate and simplify the working procedure for approving documents for TS and TR for band combinations to improve the quality of specifications
  - RAN4 reduces the redundancy and unnecessary work for big CRs, draft CRs and TPs
  - RAN4 improves the procedures for cross-checking to avoid conflict between big CR/CRs across basket WIs
  - [RAN4 identifies the potential consolidation/re-alignment of basket WIs]
- Investigate the feasibility and optimize the specification structure and reduce the test burden
  - Study the methodology to simplify the test efforts for a UE supporting multiple features, e.g., NR-CA, EN-DC on the same band combination
    - Study of similarity and dependency of RF requirements for different features on the same band combination
  - Study the methodology to simplify RF requirements specifications for
    - MSD requirements in 38.101-1 and 38.101-3, e.g., reducing the test configurations with different bandwidth combinations.
    - [Leftover issues from Rel-17 SI including Delta_TIB, Delta_RIB, Delta_TC,c in Pcmax for low boundary formula.]
- Leading working group:
  - RAN4, RAN5 as secondary group

#### 9.2.1.2 Working areas which need more discussions

N/A

### 9.2.2 Topic #2: Enhancement for 700+800+900MHz band combination

#### 9.2.2.1 Working areas with stable objectives

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #3-1: for enhancement of 700+800+900 band combinations, the following bullets can be considered**
  - Potential justifications
    - The available spectrum on bands of 700, 800 and 900 MHz is small. Although the coverage on those bands is excellent, the small available channel bandwidth cannot fulfill high data rate NR service.
    - Band combination of 700+800+900 can only be supported by FWA devices with larger form factor.
    - Extend the support of features, e.g., NR-CA, EN-DC, on 700+800+900 band combinations to smartphone
  - Potential objectives:
    - Investigate the feasibility to enable simultaneous transmission on two UL bands and simultaneous reception on three bands for the band combination of 700, 800 and 900 MHz spectrum for smart phone with small form factor (RAN4)
      - The following band combinations will be considered:

        - CA_n8-n20-n28 with uplink configurations of CA_n8-n20, CA_n8-n28, CA_n20-n28
        - CA_n5-n8-n28 with uplink configurations of CA_n5-n8, CA_n5-n28, CA_n8-n28
      - The following aspects need be studied
        - UE architecture including n-plexing, PA
        - Wideband antenna
        - Performance due to impacts including inter-modulation products
        - Method to manage the inter-modulation product impacts
      - Power class 3 (PC3) is considered in this study.
    - Identify and specify necessary RAN4 requirements including Tx and Rx RF requirements (RAN4)
  - SI or WI
    - SI

#### 9.2.2.2 Working areas which need more discussions

N/A

## 9.3 Non-spectrum related topics: RF centric

### 9.3.1 Topic #3: UE FR1 requirement evolution

#### 9.3.1.1 Working areas with stable objectives (4Tx, part of 3Tx, >4Rx, lower MSD, small A-MPR)

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #4-1: for UE FR1 requirements evolution, the following objectives can be considered**
  - 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
  - Enable 8Rx for FWA/CPE on higher frequency bands (RAN4)
    - Consider NR TDD bands higher than 1.8 GHz 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 requirements with MIMO layer larger than 4
  - 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 1.8 GHz 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 requirements with MIMO layer larger than 4
    - 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
          NOTE: for the above working areas (four big bullets), how to organize the projects in terms of WI and/or SI needs further discussion after stabilizing the scope.

- **Proposal #4-2: for simultaneous 3Tx working area under FR1 requirement topic, it is proposed**
    - Drop the potential objective in u~~U~~se case #1: 3Tx on single uplink band for MIMO enhancement
    - FFS the potential objective of 3Tx for transmission diversity on single uplink band for power enhancement with the understanding that there is no RAN1 impact

- **Proposal #4-3: for UE FR1 requirements evolution, the following objectives can be considered**
    - Investigate and if necesary, 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 bands inter-band UL CA with 1Tx on each uplink 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]

- **Proposal #4-4: for UE FR1 requirements evolution, the following objectives can be considered**
    - 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

#### 9.3.1.2 Working areas which need more discussions

The following working areas (main bullets) may need further discussions.

- **New low power class for Uu and/or sidelink (14dBm)**
- **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.
- **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)
- **Others: irregular channe bandwidth follow-up WI and pi/2 BSPK follow-up WI**

### 9.3.2 Topic #4: UE FR2 requirement evolution

#### 9.3.2.1 Working areas with stable objectives (UL 256QAM, enhancement for 39GHz, FR2-1 CA/DC)

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #5-1: For UE FR2 requirement evolution, the following objectives can be considered**

- Investigate and if possible, enable UL 256QAM for FR2 (RAN4)
  - Study the gain, operating SNR, implementation aspects
  - Specify the UE RF requirements
  - Specify the BS demodulation performance requirements
- RF enhancement in FR2-1 for 39GHz band (RAN4)
  - Vehicular UE requirements for power class in 39GHz
  - Vehicular UE requirements for inter-band DL/UL CA, e.g., 28+39GHz

undefined NOTE: for the above working areas (two big bullets), how to organize the projects in terms of WI and/or SI needs further discussion after stablizing the scope.

- **Proposal #5-3: For UE FR2 requirement evolution, the following objectives can be considered**
  - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators' requests (RAN4)
    - Define RF requirement for support of inter-band UL CA in FR2-1 based on CBM
      - Take the capability alignment between UL and DL CA into account, e.g., only consider the case where DL CBW is available

#### 9.3.2.2 Working areas which need more discussions

The following working areas (main bullets) may need further discussions.

- **Inter/intra-band DL/UL CA enhancement for FR2-2 and between FR2-1 and FR2-2 based on CBM/IBM**
  - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-2 depending on operators' requests (RAN4)
    - Define RF requirements for support of FR2-2 intra-band DL CA based on CBM and/or IBM
    - Define RF requirements for support of CA/DC between FR2-1 and FR2-2 based on CBM/IBM
- **Enhanced switching time (ON/ON transient time)**
  - Investigate (gain) and if possible enhance FR2-1 and FR2-2 switching time (ON/ON transient time)
- **UE Antenna scaling (Refer to RP-212306)**
  - As a technique to reduce FR2-1/FR2-2 power consumption, Study to enable/disable antenna elements & RF chains (antenna scaling) by UE
- **Others**
  - Beam correspondence requirements for RRC_INACTIVE and initial access
    - The small data transmission is supported in RRC inactive state from R17 on CG-SDT resources (PUSCH). Without beam correspondence the UE transmission may be incorrect/lost.
    - Small data transmission is supported in RRC inactive state from R17 also on RACH-SDT resources. Also there are no requirements for RACH transmission in idle mode but RACH at initial access is quite critical to prevent delay in setup. Beam correspondence is therefore needed for initial access.

- Spherical coverage enhancement for initial access
  - There is no spherical coverage requirement for PRACH msg1 transmission. It is important to enhance initial access performance.
- Power-control tolerance
  - Both absolute and relative tolerances for power control in FR2 are too coarse with large margins. There is potential to improve them to enhance performance. Several procedures reply on pathloss are impacted by the power control tolerance.

### 9.3.3 Topic #5: BS RF requirement evolution

#### 9.3.3.1 Working areas with stable objectives (Home BS)

In this topic, the following potential stabilized objectives can be considered:

- **Proposal #6-1: for BS RF requirement evolution, the following objectives can be considered:**
  - Home base station (HBS) (RAN4)
    - Example band is n41
    - Specify RF requirements for BS
      - Identify the scenario and conduct co-existence study for defining the BS requirements
    - Specify conformance testing requirements
    - No new demodulation performance requirement is needed

undefined NOTE: Further discuss on what kind of simulation campaigns are needed and what the scenarios are in the future meetings before Rel-18 RAN4 package approval.

#### 9.3.3.2 Working areas which need more discussions

The following working areas (main bullets) may need further discussions.

- **mmWave multi-band BS**
  - mmWave multi-band BS (RAN4)
    - Specify RF requirements for mmWave BS capable of multi-band operation
- **NTN BS Type 1-O**
  - Requirements for NTN BS Type 1-O
    - Investigate reference architecture
    - Specify RF requirements
    - Specify conformance testing requirements
- **Others**
  - Investigate and if possible simplify declaration.
  - Rel-17 leftover

### 9.3.4 Topic #6: EMC enhancement

#### 9.3.4.1 Working areas with stable objectives (RP-211825)

The justification and scope in the draft WID RP-211825 are stable and acceptable.

#### 9.3.4.2 Working areas which need more discussions

N/A

### 9.3.5 Topic #7: OTA testing enhancement

#### 9.3.5.1 Working areas with stable objectives (FR2 FWA testing, multi-panel OTA testing)

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #7-1: for OTA testing, the following objectives can be considered with understanding that some bullets need more discussions.**
  - Dynamic OTA testing method for FR2-1
    - No intention to introduce the new RAN4 requirements in Rel-18
    - Take the test method and outcome in Rel-17 MIMO OTA WI into account
      NOTE: to agree on the objectives for dynamic OTA testing method, further discussions on the benefit of dynamic OTA testing method compared to the existing multi-AoA tests and beam management tests are needed.
      NOTE: to stabilize the objectives, further discussion on whether Rel-17 MIMO OTA will impact the work for dynamic OTA testing is needed
  - [Testing framework for FR2 FWA devices (PC1/PC5 in FR2)]
  - FR2 OTA testing for UEs with multi-panel reception and 4DL layer for FR2-1
    - Depend on the status of other Rel-18 RAN4-led items proposal where core requirements will be specified
    - How to handle multi-panel reception, i.e., assuming simultaneous multi-panel reception and/or multi-panel reception with switching between panels is decided depending on objectives to specify relevant core requirements in another potential WI proposal

#### 9.3.5.2 Working areas which need more discussions

N/A

### 9.3.6 Topic #8: ATG

#### 9.3.6.1 Working areas with stable objectives

In this topic, the following potential objectives which seem stable are proposed.

- **Proposal #8-1: for ATG, the following objectives can be considered**

- Specify features to core specifications of RF requirements for coexistence between ATG and IMT terrestrial network [RAN4]
  - Core part: Specify core requirements for coexistence between ATG and IMT terrestrial network [RAN4]
    - Example bands include n1, n78 and n79.
    - Perform FR1 co-existence evaluation for ATG network (e.g. ACLR, ACS)
    - Identify key characteristics where it is necessary to differentiate ATG BS and UEs from ground based BS and UEs
      - Aim to reuse existing requirements for BS and UE where possible.
    - Specify RF requirements for ATG UE/BS
      - Considering the results of co-existence simulations in terms of impact on emissions and RX requirements, cell sizes and link budgets, technology capabilities, likely BS and UE architectures and other relevant aspects.
      - Taking into account identified differences between ATG and ground based systems
      - Consider BS type 1-C/1-H/1-O and specify the requirements
      - Consider conductive requirements for UE
    - Specify RRM core requirements for ATG UE
      - Taking into account identified differences between ATG and ground based systems
      - Considering the different nature of ATG UEs and their view of the network, increased cell sizes and other relevant aspects
    - Specify new UE/BS type(s) for ATG network if necessary
  - Perf part: Identify and specify RRM/demodulation performance requirements for ATG, taking into account the decisions/outcome of Rel-17 NTN work item. [RAN4]
    - Specify test procedures for ATG BS conformance testing
    - RRM performance requirements and test cases for ATG UE type. [RAN4]
    - Demodulation performance requirements and test cases for ATG UE/BS. [RAN4]

NOTE: further refinement of objectives would be needed in the future meeting.

#### 9.3.6.2 Working areas which need more discussions

N/A

### 9.3.7 Topic #9: Co-channel HAPS

#### 9.3.7.1 Working areas with stable objectives

N/A

#### 9.3.7.2 Working areas which need more discussions

The following working areas with objectives were proposed (China Unicom)

- **Co-channel HAPS**

- Evaluate Co-channel interference issue between HAPS and TN;
- Identify RF requirements for coexistence between HAPS and IMT terrestrial network
  - Identify the FR1 potential band(s) to be used as example for HAPS, and FR2 bands can also be considered as example band if needed
  - Co-existence evaluation for HAPS network (e.g. ACLR, ACS)
  - Identify UE/BS requirements for HAPS network if necessary

## 9.4 Non-spectrum related: RRM & demodulation centric

### 9.4.1 Topic #10: RRM requirements enhancement

#### 9.4.1.1 Working areas which seem stable

In this topic, the following working areas are proposed.

- **Proposal #9-1: for RRM requirements enhancement topic, the following high level working areas can be endorsed**
  - FR2 RRM enhancements
  - General RRM requirement enhancement and leftover
  - Measurement gap related enhancement and leftover

#### 9.4.1.2 Working areas which need more discussions

To discuss the objectives for each working area in future meetings, it is proposed

- **Proposal #9-2: companies are encouraged to provide more details on the motivation, benefit and specification impacts for each proposed objective for RRM requirement enhancement in RAN#94-e.**

The potential objectives proposed in previous meetings for each working areas as well as the new objectives proposed in this meeting were captured below:

- **FR2 RRM enhancements (RAN4, RAN2)**
  - Enhancement RF beam measurement requirements, e.g., allow UE to measure a subset of the configured resources
  - Define FR2-FR2 DAPS requirements
  - SCell activation enhancement in FR2
  - Enhancement type 2 BWP switching in FR2
  - RRM for different Rx beam sets in FR2
  - Network controlled gaps for UE Rx beam switching
  - FR2 delay reduction enhancements
  - Others (intel): Leftover deployment scenario in Rel-17 (FR2-2 NR-DC and FR2-1-FR2-2 NR CA/DC)

- **General RRM requirement enhancement and leftovers (RAN4, RAN2)**
  - UL frame boundary offset reporting
  - FR1-FR1 NR DC RRM requirements
  - Enhancement for CSI-RS based L3 measurement
  - HO with PSCell for new scenarios
  - TCI switching enhancement
  - CMTC
  - RLM enhancements
- **Measurement gap related enhancement and leftover (RAN4, RAN2)**
  - NeedForGap
  - Per-FR gap
  - Inter-RAT NR measurement without gaps
  - Measurement gap sharing enhancement
- **Others**
  - Joint requirements for pre-configured MG (Mediatek, CATT)
  - Co-current MG and NCSG (Mediatek, Ericsson, CATT)
  - New gaps for MUSIM (Mediatek, Ericsson)
  - HST RRM enhancement (Intel)
  - CGI reading requirement for NR-U cell (Apple, Vivo)
  - Harmonized RLM/BM (Apple)
  - RRM enhancement for large CC number (Apple)
  - Allow interruption for de-actived SCell measurements (Apple)
  - CSI-RS based CFRA in RRM requirement (Apple)
  - Fast and gapless Scell activation (Ericsson)
  - Fast RRC connection re-establishment (Ericsson)
  - Enhance pre-configured gaps (Ericsson)
  - Dynamic activation and switching of the measurement gap pattern for different applications (Ericsson)
  - RRM enhancement for NR-U (Vivo)

### 9.4.2 Topic #11: Demodulation requirement evolution

#### 9.4.2.1 Working areas with stable objectives (MU-MIMO advanced receiver)

To facilitate the discussions in the future meeting for this topic, it is proposed that

- **Proposal #10-1: for the demodulation requirements evolution topic, it is proposed to de-prioritize the following working areas**
  - Enhanced CRS-IC

        - Depending on the progress of Rel-17. CRS-IC could be further discussed in Rel-18 RAN4 package if it is not introduced in Rel-17
    - eMIMO two UE rate matching CRS patterns

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #10-2: for the demodulation requirements evolution topic, the following objectives can be considered**
    - UE advanced receiver (RAN4)
        - Evaluate and specify advanced receiver to cancel inter-user interference for MU-MIMO
            - FFS on reference receiver
            - Study the performance gain, testability, required signaling overhead, as well as impact on other WGs before specify the requirements

#### 9.4.2.2 Working areas which need more discussions

To facilitate the discussions in the future meeting for this topic, it is proposed that

- **Proposal #10-3: for the demodulation requirements evolution topic, companies are encouraged to provide more simulation results and analysis related UE implementation complexity, required level of network assistant frameworks and their impact on other WGs for each proposal in RAN#94-e.**

The following working areas (main bullets) may need further discussions.

- **SoftIC**
- **Enhanced DL receivers for multi-DCI multi-TPR**
- **Inter-cell CSI-RS/SSB interference mitigation (IM)**
- **E-MMSE-IRC under uneven interference**
- **BS advanced receiver (MMSE-IRC)**
- **ATP**
- **Extend MMSE-IRC receiver for inter-cell and intra-cell MU-MIMO to CA case**

### 9.4.3 Topic #12: Support of intra-band non-collocated EN-DC/NR-CA deployment

#### 9.4.3.1 Working areas with stable objectives

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #11-1: for support of intra-band non-collocated EN-DC/NR-CA deployment, the following objectives can be considered:**

- Study and if feasible, support non-co-located scenario for FR1 intra-band non-contiguous EN-DC/NR-CA
    - Work is limited to CA/EN-DC for EN-DC/NR-CA for bands 42, n77/n78
- Core part
    - Study and if feasible, define requirements for UE which is not capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way to support inter-band CA, i.e., UE not indicating interBandMRDC-WithOverlapDL-Bands-r16
        - Study feasibility of UE RF architecture to support both DL and UL operation [RF]
        - Study and if necessary, define
            - Feasible value of the power imbalance [RF]
            - Feasible value of MRTD and MTTD in non-collocated deployment [RRM]
            - NOTE: MTTD requirements are subject to the decision whether UL Tx is needed for both (or all) carriers
    - Define requirements for UE which is capable of supporting intra-band non-contiguous NR-CA and EN-DC in the same way as to support inter-band CA, i.e., UE indicating interBandMRDC-WithOverlapDL-Bands-r16.
        - Identify feasible MRTD and power imbalance level, considering the network deployment scenario and UE implementation feasibility [RF, RRM]
- Performance part [Demodulation]
    - Specify PDSCH demodulation requirements for non-collocated scenarios for intra-band non-contiguous EN-DC and NR-CA
        - Define PDSCH demodulation performance requirement based on the applicable MRTD and power imbalance values.
            - Power imbalance between the carriers is limited to [X]dB

undefined NOTE: Power imbalance may be specified as the condition in the demodulation performance requirements

#### 9.4.3.2 Working area which need more discussions

N/A

### 9.4.4 Topic #13: FR2 HST enhancement

#### 9.4.4.1 Working areas with stable objectives

In this topic, the following potential stabilized objectives are proposed.

- **Proposal # 12-1: for FR2 HST enhancement, the following objectives can be considered**
    - Core part:
        - Study the feasibility, and if feasible enable supporting HST velocity of up to a maximum of 500 km/h, with carrier frequency up to 30 GHz
        - Specify the requirement for multi-panel operation for train roof-mounted FR2 high power devices [RAN4]:
            - Maximum 2 active panels supporting the multi-panel simultaneous reception.

        - FFS whether this objective will be merged into the other RAN4-led item
    - FFS other core requirements considering the following potential objectives for the corresponding scenarios below
        - Study on reference tunnel deployment scenario for FR2 HST and specify the channel model and corresponding core requirements
        - Specify the requirements for intra-band carrier aggregation (CA) scenario
        - Specify the requirements to support the scenario with mixed near-to-track (i.e., Scenario-A with Ds = 700m and Dmin = 10m) and far-from-track (i.e., Scenario-B with Ds = 700m and Dmin = 150m) RRH deployment
        - Specify the new uplink timing adjustment mechanism for FR2 HST scenario with large propagation delays from different TRPs to UE

#### 9.4.4.2 Working areas which need more discussions

N/A

But the UE type may need further discussions.

### 9.4.5 Topic #14: Requirement for FR2 multi-Rx chain DL reception

#### 9.4.5.1 Working areas with stable objectives

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #13-1: for FR2 multi-Rx chain DL reception, the following objectives can be considered**
    - Introduce requirements for enhanced FR2 UEs with multi-Rx chain DL reception with 4 DL MIMO layers.
        - Dual TCI assumption
            - FFS dual TCI of which release (Rel-16, Rel-17 or both) are used as baseline.
            - Pending on the objective of dual TCI enhancement in the package of Rel-18 MIMO items
        - Enhanced RF requirements:
            - Identify and specify necessary RF requirements for devices with 2 panels
                - FFS whether to keep the current requirements of 50%-ile spherical coverage not being impacted, or improve spherical coverage requirement
        - Enhanced RRM requirements
            - FFS the detailed objectives
        - UE demodulation requirements:
            - Simultaneous ~~and non-simultaneous~~ RX from different directions
              4 DL MIMO layers

#### 9.4.5.2 Working areas which need more discussions

N/A

## 9.5 Topic #15: Bandwidths lower than 5MHz in dedicated spectrum

### 9.5.1 Working areas with stable objectives

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #14-1: for bandwidth lower than 5 MHz in dedicated spectrum, the following objectives can be considered**
  - **Core part:** The following objectives shall be included for dedicated FDD spectrum in FR1:
    - Identify and specify necessary changes to NR physical layer with minimum impact to operate in spectrum allocations from approximately 3 MHz up to below 5 MHz [RAN1]:
      - Restrict to subcarrier spacing of 15kHz and the use of normal cyclic prefix.
      - For SSB:
        - Reuse PSS/SSS specification without puncturing.
        - PBCH based on current design [while minimizing performance degradation]
      - Identify and specify necessary minimum changes to PDCCH, CSI-RS/TRS, PUCCH, and PRACH
    - Specify necessary RAN4 requirements to support deploying NR in dedicated spectrum allocations from approximately 3 MHz up to below 5 MHz [RAN4]:
      - The dedicated spectrum in this WI include RMR-900 band, n8, n26 and n28.
      - Specify system parameters (including channel and sync raster) for the associated dedicated spectrum.
      - Minimize impact on RF requirements:
        - Reuse 5 MHz channel bandwidth at least for FRMCS use case (assuming co-located NR and GSM-R with same operator).
        - Specify the required RF requirement for 3 MHz channel bandwidth in bands: RMR 900 (874.4 - 880 MHz/919.4 MHz – 925 MHz), n8, n26 and n28.
      - Specify RRM requirements while minimizing specification impact to support operation in dedicated spectrum allocations from approximately 3 MHz up to below 5 MHz.
  - **Perf. part:** Specify necessary UE performance requirements for NR operation in dedicated FDD FR1 spectrum allocations from approximately 3 MHz up to below 5 MHz.
    - Specify necessary RRM performance requirements (RAN4)
    - Specify necessary UE demodulation performance and CSI reporting requirements (RAN4)
    - Specify necessary BS demodulation performance requirements (RAN4)
    - Specify necessary BS conformance tests (RAN4)
- **Proposal #14-2: for bandwidth lower than 5 MHz in dedicated spectrum, it is proposed to have RAN1 as leading WG and RAN4 as secondary WG, and in the draft WID the leading WG and secondary WG will be captured in [ ].**

### 9.5.2 Working areas which need more discussions

N/A

But the UE type may need further discussions.

## 9.6 Topic #16: Improved NR spectrum efficiency for LTE-NR coexistence (DSS)

### 9.6.1 Working areas with stable objectives

In this topic, the following potential stabilized objectives are proposed.

- **Proposal #15-1: for DSS topic, the following objectives can be considered**
  - Study and if needed specify NR PDCCH reception in symbols with LTE CRS REs.
    - Investigate the performance, and enable LTE CRS to puncture NR PDCCH and DMRS if there is the performance gain from the additional PDCCH resources.

### 9.6.2 Working areas which need more discussions

The following working areas (main bullets) may need further discussions.

- **Dynamic CRS rate matching pattern selection**
  - Investigate and if necessary introduce dynamic CRS rate matching pattern selection (via DCI)
    - Study the feasibility and possible benefits of CRS rate matching pattern selection via DCI compared to CRS-IM and static RRC reconfiguration solutions
- **More efficient NB-IoT and eMTC coexistence on NR carriers**
- **Uplink MU-MIMO between LTE and NR users**

## 9.7 Topic #17: Others

### 9.7.1 Working areas with stable objectives

N/A

### 9.7.2 Working areas which need more discussions

The following working areas (main bullets) may need further discussions.

- **FR1 HST to improve the performance further in Rel-18**
  - Support 500km/h velocity on NR FR1 bands >1.88GHz
    - Improve downlink performance
    - Improve uplink performance requirements
  - Enhance TCI switching delay RRM requirements
  - Define the CHO RRM requirements for HST scenario
  - Improve the HST-DPS performance
    - Improve CSI reporting requirements
    - Improve RAR and Msg4 reception performance during random access

# 10 Annex: guidance from RAN Chair

The related guidance from RAN Chair are as follows. We copied some more relevant guidance here for your convenience. For more detailed please refer to RP-212657.

- *The **goal** of the email discussion is to **focus on potential scope/areas for each potential WI or SI**, with **NO intention to update the set and the organization of the topics as endorsed in** RP-212608*
  - *Any further update/consolidation of the topics/structure is to be handled in RAN#94-e*
  - *Aim to identify whether a topic should be a **SI, or WI** (including possibly a study phase for some scope(s))*
  - *Aim to identify on the **leading WG** (including if any change compared with those in RP-212608) and the secondary WG(s)*
  - *Aim to identify on the potential **interaction with SA/CT***
  - *Critical to keep all items under **rigorous check**; important to avoid "number counting" driven discussion, but focus on **tangible commercial interests** (near & longer terms)*
- *All companies are expected to provide comments including detailed justification for areas/scopes for each topic in discussion*
  - *Note: the focus should be on the potential areas/scopes, instead of debating the detailed technical solutions!*
- ***Initial Round**: for each email thread,*
  - *Moderators are expected to use RWS-210659 and RP-212608 (including the references therein) to come up with an initial template*
  - *At the end of the initial round, each moderator is expected to summarize the proposals for further discussion, including those for the areas/objectives*
- ***Intermediate Round:***
  - *Aim for initial convergence on the areas/objectives*
- ***Final Round:***
  - *At the beginning of the final round, Moderators are expected to produce an initial draft of the overall justification*
  - *Aim for final convergence on the areas/objectives, and an initial version of the overall justification*
  - *Each email discussion will get 2 pre-allocated Tdoc numbers from MCC:*
    - *A "Moderator's summary for discussion [RAN94e-R18Prep-xx]" to summarize the email/NWM discussion*
    - ***As a by-product**, a new WID or new SID using the official template (https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_94e/Templates/WID_template_190920_adapted_for_F with clarification whether it is a WI/SI, justification and objectives, and leading WG /secondary WGs, but leaving blank the rapporteur and supporting companies (both will not be subject of the pre-RAN #94e email discussion). These new WID/SID Tdocs will be inputs for RAN#94-e*
    - *Both Tdocs shall be uploaded to https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_94e/Inbox before end of Mon 01.11.2021*
  - *In the final round, aim at defining as much detail as possible for the areas/objectives deemed stable*