[RAN95e-RAN4-R18Prep-02] FR2 RF Enhancements - Version 0.0.4
RAN

3GPP TSG-RAN Meeting#95-e

draft RP-210020

Electronic Meeting, March 17-23, 2022

(Pre-RAN#95-e e-mail discussion February 7-11, 2022)

Agenda item: xxxx

Source: Moderator (NTT DOCOMO, INC.)

Title: Moderator's summary for discussion [RAN95e-RAN4-R18Prep-02] FR2 RF Enhancements

Document for: report

1 Introduction

In this e-mail thread, the moderator follows the guidance in RP-220003 to organize the pre-RAN#95-e discussion for FR2 RF enhancements. This e-mail thread will treat topic#4 (UE FR2 requirement evolution) and topic#14 (Requirement for FR2 multi-Rx chain DL reception) described in the latest e-mail discussion summary (from October 2021) in RP-212682.

The template for initial round is based on the latest e-mail discussion summary in RP-212682. Although the template for initial round explicitly lists only topics discussed in October as per RAN chairman's guidance, new proposals and the contributions submitted after October, i.e., in RAN4#101-e, RAN#94-e, and RAN4#101-e-bis can be also treated. Companies can use "Others" section to provide proposals.

As mentioned in RP-220003, the goal of the email discussion is to focus on the potential RAN4-led topics, and the potential scope/areas for each potential WI or SI. This discussion also aims to identify whether a topic should be a SI or WI (including possibly a study phase for some scope(s)), and to identify potential impact to other WG(s), if any.

Plan on discussion in each round:

In initial round, moderator tries to collect detailed comments on objectives, justification, SI or WI, and potential impact to other WG(s)(secondary WGs) for each objective. Individual sections are provided for each objective.

In intermediate round, based on the comments in initial round, moderator tries initial convergence on the areas/objectives for the potential projects. Discussion on establishing objectives, justification, SI or WI, and potential impact to other WG(s) may continue if necessary.

In final round, moderator tries to suggest an initial draft of the justification for potential WI or SI. If possible,

outcome of discussions on objectives, justification, SI or WI, and potential impact to other WG(s)will be captured in the form of WID or SID. Note that we should leave blank the rapporteur and supporting companies ((both will not be subject of the pre-RAN #95e email discussion) and the draft of WID or SID will be input for RAN#95-e where they can be revised further, as per the guidance in RP-220003.

2 Initial round

2.1 General

As mentioned in introduction section, in initial round, moderator tries to collect detailed comments on the following aspects:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved
- Issue#4: Potential impact to other WG(s)

Individual sections are provided for each objective.

2.2 Topic #4 UE FR2 requirements evolution

2.2.1 UL 256QAM

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- *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*

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - 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

- Justification:
    - TBD
- SI or WI (or WI with study phase) if approved:
    - WI with study phase?
    - Dedicated WI?
- Potential impact to other WG(s):
    - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved
- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 1:

1 – Guangdong OPPO Mobile Telecom. Generally UL 256QAM is challenaging for UE to implement if we remember how difficulty BS to achive the EVM requirements in Rel-16 discussions. However, we are open in introducing this feature to FR2 if there is demands to improve UL performance. Regarding WI or SI, maybe WI with a study phase is better since anyway there is items to study the gain, SNR, implementation etc.
2 – QUALCOMM JAPAN LLC. Issue#2, Issue#5: We understand the intention of this work, however, we believe that the actual performance gains will be very limited considering the UE will require a large power backoff and the FR2 power dynamic range is already quite small. As such, this feature will only be usable in a very small range in actual network so the gains will be very limited. We believe other topics might bring more tangible system gains. Issue#3: Considering the above, a SI would be more appropriate and system gains should be studied.
3 – TELECOM ITALIA S.p.A. We suggest to have a WI focused on CPE/FWA devices

4 – MediaTek Inc.

Issue#1: Objective

We prefer change "**possible"** to "**feasible"**, to reflect consider practical benefit(s) would be important.

- Investigate and if **feasible**, enable UL 256QAM for FR2 (RAN4)

Issue#3: SI or WI (or WI with study phase) if approved

SI would be more appropriate, because study is needed.

Issue#5: Other (General comments)

It would be helpful to understand operator's demand/wish on UL 256QAM.

5 – NTT DOCOMO INC.

We generally support this kind of enhancement to increase UL peak rate. Although FR2 full beneficial usecase basically assumes LOS and relatively small coverage than that of FR1, we agree that some study phase is needed to know the performance gain and the feasibility of UL 256QAM in FR2.

Dedicated WI may be better approach as it also includes BS demod aspect.

6 – KT Corp.

Device supporting UL 256QAM may be limited to CPE/FWA type devices. However, the maximum throughput we achieve from this work could be extremely useful for research and marketing purposes which can also give some guidance to UL performance KPI for 6G. We support this work.

7 – Nokia Corporation

Issue#1: Objectives are acceptable

Issue#2: Justification is improved data rates and accompanying capacity increase.

Issue#3: Either WI or WI with study phase if approved are acceptable. Should be own WI as impacts both UE and BS and both aspects need to be discussed together

Issue#4: There should not be impact to other WG(s)

8 – Apple (UK) Limited

We understanding several operators support it. In our view, a feasibility study is needed to evaluate the performance gain vs. implementation feasibility before starting the normative work. If a WI is being considered, a study phase needs to be included for the feasibility study. Furthermore, it would be good to clarify whether this feature is targeted for CPEs only or both CPEs and smartphones. Our preference is to target CPEs only.

9 – SoftBank Corp.

We are supportive of the objectives. Considering the above comments, WI with study phase seems to be reasonable.

10 – AT&T GNS Belgium SPRL

We agree with the objectives and with the Nokia responses to the first four issues. As part of the study phase, RAN4 can consider the device types.

11 – China Mobile Group Device Co.

Issue#1: we support the objectives

Issue#3: it's better to start with study phase since it is listed to study the performance gain at first in the objective. Furthermore, it's suggested to be merged into UE RF FR2 enhancement WI instead of a dedicated WI

Issue#4: no impact to other WG(s)

12 – Huawei Technologies France

Issue#1: We support the objectives

Issue#2: The intention of 256QAM is to improve the peak data rate. UE type is for CPE/FWA devices. Especially in some industry use case, e.g. the machine transmits the photograph with super high resolution to the cloud, which needs Gbps data rate. In such case, we see the need for 256QAM. And in such scenario thanks to lower path loss, the possibility to use 256QAM would be higher.

Issue#3: WI or WI with study phase, either is ok for us. We think it would be better to include it into UE RF FR2 enhancement WI instead of a dedicated WI.

Issue#4: no impact to other WG(s)

13 – KDDI Corporation

We also support the enhancement and share the view with docomo.

14 – China Telecommunications

Support WI with study phase. Prefer to include it in FR2 enhancement WI.

15 – Intel Deutschland GmbH

We support this objective. Enabling UL 256QAM for FR2 can be a good direction to increase peak data rates for selected scenarios.

Issue#1: Current objectives are fine for us

Issue#3: Our preference is a WI with a study phase. The objective can be a part of the FR2 evolution WI; we do not think a separate WI is required.

Issue#4: No impact to other WGs is expected

16 – vivo Communication Technology

We also support adding a clear statement that the UL 256 QAM is for CPE/FWA devices. the feasibility study is preferred in a study phase

17 – Samsung Electronics Co. Issue #1: It is better to clearly indicate the UL 256QAM is for CPE or smart phones in the objectives Issue #3: This objective can be included in the FR2 UE RF umbrella WI. Issue #5: Heavy Demod work in this objective, proper TU in RD session has to be reserved
18 – LG Electronics Deutschland We support this considering CPE/FWA type of devices. And also similar view with other companies that study phase is necessary if handheld device is taken into consideration.
19 – ZTE Corporation We also think UE supporting UL 256QAM would need large power back off to achieve EVM requirements, and the gain may be small. It is more appropriate to study the performance gain, SNR, implementation feasibility etc first, also whether it is for CPE only or for smartphone may need to be studied. So a SI is preferred.
20 – Sony Group Corporation We are fine to consider the 256 QAM for UL in Rel-18. However, as multiple companies have suggested, such a enhancement is more feasible for CPE/FWA devices. Therefore, we suggest to clarify the scope.
21 – Samsung Electronics Co. To derive the EVM requirements for 256QAM, RAN4 also shall study which phase noise model shall be used. RAN4 shall further study whether to reuse the phase noise model as in RAN4 Rel-14 NR SI TR or further enhanced phase noise model shall be considered for 256QAM in terms of specifying the UL EVM for 256QAM. With above, we suggest to revise the first sub-bullet as - Study the gain, operating SNR, phase noise model and implementation aspects

2.2.2 RF enhancement in FR2-1 for 39GHz band

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- *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*

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - 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
- Justification:
    - TBD
- SI or WI (or WI with study phase) if approved:
    - WI
    - Dedicated WI or merged into UE RF FR2 enhancement WI including other objectives?
- Potential impact to other WG(s):
    - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved
- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 2:

1 – Guangdong OPPO Mobile Telecom. Generally ok with the objective, one thing to clarify is that which beam management is targeting in 28+39GHz DL/UL CA, is it both CBM/IBM or part of it? This may need to be clarified in the scope.
2 – QUALCOMM JAPAN LLC. Issue#2: We haven't yet seen any commercial need for such devices. These type of devices have already been enabled for 28GHz, however, they have not yet been deployed, at least to the best of our knowledge. It seems premature to develop requirements for 40GHz if no devices for 28GHz are deployed yet. This item can be postponed until there is a real commercial need for it.
3 – MediaTek Inc. **Issue#1: Objective & Issue#2: Justification**

- Real commercial demand on single-band and inter-band CA shall be clarified firstly and respectively.
- Exact band number shall be clarified. (ex: n259 and/or n260?)
- The exact inter-band CA type demand, i.e. ”IBM/CBM + UL/DL”, shall be clarified.

4 – KT Corp.

We are struggling to find the use case for 39GHz and working on vehicular UE power class can lead us into finding a good use case for utilizing this spectrum. We would like see the work on specifying RF requirements for vehicular UE in 39GHz.

5 – Nokia Corporation

Issue#3: If approved then a dedicated WI. Should not be coupled with UE RF FR2 enhancement WI. Vehicular topics have been treated as own package.

Issues#5: If there are Tus available could be part of REL18 package. But this topic should not be considered as a top priority in RAN4.

6 – Apple (UK) Limited

We appreciate KT’s interest and would like to see if other operators also have interests in enabling the use of vehicular UEs in this band.

7 – Ericsson LM

In our view this should be of low priority or at least not part of FR2 RF enhancement WI

8 – Intel Deutschland GmbH

Industry interest and near/mid-term deployment plans are unclear. Given this, and prioritization of other enhancements, we do not support the objective right now.

9 – ZTE Corporation

It is not clear which beam management type is targeted, CBM, IBM or both? Also, it should specify in the objective that the band combination should base on the operator’s request. In general, RAN4 should not start the work on the band combination without operator’s demands.

10 – LG Electronics Deutschland

We support this objective since this is included in the stabilized objectives in the last NWM summary and would not require much workload for discussion. Another aspect is that this is kind of a pre-requisite requirement for the Rel-18 FR2 sidelink evolution in which many operators showed their interests. Also it is clear that there is interest from operators on this topic.

11 – Sony Group Corporation

In general, we are positive for this item, and would like to hear more on the commercial interesting from operators.

12 – Samsung Electronics Co. The objectives are stable based on the previous discussions. It is good to have this objective in the FR2 UE RF WI.
13 – LG Electronics Deutschland **Issue#3: SI or WI (or WI with study phase) if approved** We think this can be WI merged into UE RF FR2 enhancement WI. **Issue#4: Potential impact to other WG(s)** We don't think there is an impact on other WG(s) **@MediaTek** Regarding the band number of 39GHz, we are considering n260(37~40GHz). Regarding "IBM/CBM+UL/DL", we are considering IBM+UL CA at this moment.
14 – LG Uplus To be honest, in Korea only 28GHz has been allocated to all three operators in 2019 and the 28GHz B2C(mobile type phone) use case is not quite identified but only for B2B where 5G NPN and subway(also B2G?). It means that the example use case should be found from something other than mobile phone. In this sense, the vehicular UE can be the potential use case for FR2 like KT indicated. Regarding the 39GHz, n260(above 37GHz(40GHz)) is in planning from government around 2025~2026. So, n257 and n260 are of interests. Considering that the completion of Rel-18 is the end of 2023, Rel-19 is late to meet this schedule in advance. Also I am interested in the opinion from other operators who already have 39GHz like the United States.

2.2.3 Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- *Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators' requests (RAN4)*
    - *Define RF requirement(s) 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*

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators' requests (RAN4)
        - Define RF requirement(s) 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
- Justification:
    - TBD
- SI or WI (or WI with study phase) if approved:
    - WI
    - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
    - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved
- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 3:

1 – Guangdong OPPO Mobile Telecom.

Generally ok with objective, and maybe example band combination is needed in the inter-band UL CA for CBM.

2 – QUALCOMM JAPAN LLC.

This work should be based on band combination proposals from operators. If there are no proposals then there is no need to discuss this further for the time being.

3 – MediaTek Inc.

Issue#1: Objective and Issue#2: Justification

1) We support "**depending on operators' requests**".

2) We suggest adding "**study and if feasible**" before define requirement.

- "**Study and if feasible**" define RF requirement(s) for support of inter-band UL CA in FR2-1 based on CBM
- Further breakdown to "**same frequency group**" and "**different frequency groups**" could make objective be clearer.

3) There is a typo:

- "where DL CB**M** is available"

4 – NTT DOCOMO INC.

We are OK with the objective.

FR2-1 CA/DC topics included in Rel-17 WID such as UL CA with IBM should continue to be discussed in Rel-18 as Rel-17 leftover if these are not finished in Rel-17.

5 – Nokia Corporation

Issue#1: Objectives in this document are acceptable but also Rel17 FR2 CA related topics which are not completed needs to be added, if any. Potential leftovers are DL CA with CBM. DL CA within same frequency group with IBM. UL CA with IBM.

Issue#2: CA is important feature for all 3GPP RATs

Issue#3: Natural place would be FR2 UE RF Enhancement WI.

Issue#4: Potential impact to WG2 unless Rel17 WI completes certain features which need new UE capabilities.

6 – Apple (UK) Limited

We would like to see if there are operator requests to for support of inter-band UL CA in FR2-1 based on CBM. If it is included in R18, we agree the UL and DL capabilities should be aligned, i.e., to enable CBM in the UL only when UE supports CBM in the DL.

7 – Huawei Technologies France We are ok with the objectives. As ususal, examble band combinations or based on requests from operators.
8 – Intel Deutschland GmbH We do not support the objective. Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 were studied during Rel-16 and Rel-17 with sufficient progress made. However, we note that the proposed inter-band UL CA CBM scenario was originally a part of Rel-17 but was deprioritized due to lack of industry interest. We would like to avoid this situation, where RAN4 spends time discussing a scenario which does not have real interest. Further clarifications on the use case are encouraged.
9 – vivo Communication Technology There are several band combinations in current spec: n260-n261/n257-n259/n258-n260, we can start this item with these band combinations first. As for same frequency group, we prefer to clarify the target band combination first.
10 – Samsung Electronics Co. In general, the objective is really related to operators request but it seems less interest from operators. So, even though we can say objectives part with ”depending on operators’ request” is fine but eventually we have to see operators interest before we discuss to include such objective in the Rel-18 or not.
11 – ZTE Corporation It would be better to specify which band combination should be used as example combination. If not, it may trigger the discussion on the band combinations in RAN4. In general, RAN4 should not start the work on the band combination without operator’s demands.
12 – LG Electronics Deutschland We support this objective since this is included in the stabilized objectives in the last NWM and also this is the continuation of Rel-17 inter-band UL CA for n257+n259 which was requested by operators saying that operators’ input should not be a problem.
13 – LG Uplus We agree with NTT docomo and also like LGE said all the interested band combinations have been already introduced in Rel-17. So a bit confused whether operator should reveal again the interests for CBM where the IBM is clearly better unless we do not worry of the UE price.

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

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- *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*

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - 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
- Justification:
    - TBD
- SI or WI (or WI with study phase) if approved:
    - WI with study phase?
    - Merged into UE RF FR2 enhancement WI including other objectives?
- Potential impact to other WG(s):
    - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification

- Issue#3: SI or WI (or WI with study phase) if approved
- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 4:

1 – Guangdong OPPO Mobile Telecom.

We understand this is normal extention of CA/DC to more band combinations, therefore ok with the intention. Regarding the objective, it is better to explicitly clarify what is the target band combination rather than saying based on operator request since if no request during the WI phase then times will be wasted. Therefore, we encourage proponent to clarify the example band combination in the objective.

Another point for clarification is make it clear what is the targeted beam management type (both CBM and IBM or only one of them), there are different wording and may cause confusion:

- FR2-2 intra-band DL CA based on **CBM and/or IBM**
- CA/DC between FR2-1 and FR2-2 based on **CBM/IBM**

2 – QUALCOMM JAPAN LLC.

This item also should be based on some clear band combination proposals. As of now, there doesn't seem to be a strong need for such CA combinations

3 – TELECOM ITALIA S.p.A.

Support Qualcomm's view.

This work should be based on band combination proposals from operators. If there are no proposals then there is no need to discuss this further for the time being.

4 – MediaTek Inc.

Issue#1: Objective and Issue#2: Justification

1) The enhancement objectives are also related to outcome of Rel-17 FR2-2 single-band operation WI.

2) Operator's request shall be clarified firstly, for intra-band and inter-band, respectively. And then, objectives shall be further clarified, for example for inter-band CA:

- Inter-band CA_FR2-2_FR2-2 and/or CA_FR2-1_FR2-2
- IBM and/or CBM

3) Typo? Is it "**inter**-band"?

- Define RF requirements for support of FR2-2 **intra(?)**-band DL CA based on **CBM and/or IBM (?)**

5 – Nokia Corporation

Given the limited amount of TU available this item should be clearly de-prioritized. There is no urgent market demand at the moment.

6 – Apple (UK) Limited

We do not see an urgent need to work on FR2-2 in R18, as it is unclear when FR2-2 deployments may take place.

7 – Ericsson LM

We also do not see any need to start this work and should be down prioritized

8 – Huawei Technologies France

The work should be based on requrest from operators or at least based on some potential deployment scenario. Compared to the work for FR2-1, this work has low priority.

9 – Intel Deutschland GmbH

We are supportive of this objective but note that it will depend on operators' request. Clarification of band combinations being targeted is needed.

10 – TELECOM ITALIA S.p.A.

To clarify the previous message: no interest in this feature

11 – Samsung Electronics Co.

Same view as 2.2.3, i.e. we have to see operators interest before we discuss to include such objective in the Rel-18 or not

12 – LG Electronics Deutschland

We support this objective since this is included in the stabilized objectives in the last NWM and also this is the continuation of Rel-17 inter-band UL CA for n257+n259 which was requested by operators saying that operators' input should not be a problem.

13 – ZTE Corporation

Share similar view as Qualcomm, it should based on clear band combination, it seems there are not urgent marked demands at this moment. In general, RAN4 should not start the work on the band combination without operator's demands.

It is confusion with this objectives:Define RF requirements for support of FR2-2 intra-band DL CA based on CBM and/or IBM. Is it typo, intra-band -> inter-band?

14 – LG Electronics Deutschland

Please ignore the above comment from LGE. Sorry for the inconvenience.

2.2.5 Enhanced switching time (ON/ON transient time)

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

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

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - Enhanced switching time (ON/ON transient time)
        - Investigate (gain) and if possible enhance FR2-1 and FR2-2 switching time (ON/ON transient time)
- Justification:
    - TBD
- SI or WI (or WI with study phase) if approved:
    - WI with study phase?
    - Merged into UE RF FR2 enhancement WI including other objective?
- Potential impact to other WG(s):
    - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved

- Issue#4: Potential impact to other WG(s)Issue
- Issue#5: Other (General comments)

Feedback Form 5:

1 – Guangdong OPPO Mobile Telecom.

For clarification, is the same enhancement as FR1 transient period capability? If it is, what is the target enhanced switching time? And we need to avoid similar conflict discussions as in FR1, therefore, maybe adding sub-bullet saying ”reuse the conclusions in FR1 transient period capability discussion as much as possible” to reduce workload.

2 – QUALCOMM JAPAN LLC.

This area could deserve some further discussion also depending on what will be finalized in the Rel.17 discussions. If the group agrees to such work, there doesn’t seem to be much point to have a SI that would lead to a lot of time wasted.

3 – Nokia Corporation

Issue#1: There is ongoing work in RAN4 on this for FR2-2 and in previous meeting there was a following agreement :*Use 5 µS as ON/ON transient periods for 480 and 960 SCS, FFS on optional capability for a single value among {1, 2, 3} µS.* There may be further agreement in Feb RAN4.

Issue#2: Would be beneficial from network point of view.

Issue#3: If there are TU available this topic should be own WI

Issues#5: Better to see the outcome of the February meeting and to synch up Rel-17 discussion

4 – Apple (UK) Limited

It is better to wait for the conclusion of R17 discussion. It is also worth noting that there is no significant changes/improvement in terms of UE implementation between R17 or R18.

5 – Ericsson LM

We support this objective and can be part of FR2 enhancement WI if not done in R17. It does not need a separate SI.

6 – AT&T GNS Belgium SPRL

Issue#1: We support the objective in Rel-18 if the work is not completed in Rel-17.

Issue#2: Improved performance for higher SCS (480/960kHz).

Issue#3: Include as part of FR2 RF Enhancements WI.

7 – MediaTek Inc.

Improving ON-ON transient times is a challenge due to UE hardware impact, and it is not so clear that any gain justifies the pain, based on what we have seen for FR2-2.

8 – Huawei Technologies France The FR2 UE implementation is quite different from that of FR1. We didn't see solid justification for such target for FR2. Also we think that the transient time is not related to certain SCS. No urgency to consider this kind of improvement as the hardware has no big breakthrough from Rel-17 to Rel-18.
9 – Intel Deutschland GmbH We support this objective. The enhanced capability can be helpful to improve UL performance for both FR2-1 and FR2-2, and the work can cover the full FR2 range. As pointed out by Nokia, this depends on the outcome of ongoing RAN4 discussions, where a decision on improved ON/ON transient period for FR2-2 is expected in the upcoming February meeting. Issue#1: The proposed objectives are fine Issue#2: ON/ON transient time has a significant impact on UL performance, especially for high SCS scenarios in FR2-2 and FR2-1. Improved UE capabilities to support up to 1us ON/ON transient period can be considered for FR2, similar to FR1. Issue#3: We prefer a WI with a study phase. The objective can be a part of the FR2 evolution WI; we do not think a separate WI is required. Issue#4: No impacts to other WGs are expected
10 – vivo Communication Technology We are supportive for this work. But considering there are some converged decisions in RAN4, we also think it would be good if we wait for further agreements in Feb. RAN4 meeting.
11 – TELECOM ITALIA S.p.A. Neutral view on this topic, but we recommend not to work on FR2-2 enhancements in Rel 18
12 – ZTE Corporation We also support this work if it cannot been done in Rel-17, this further improvement could help alleviate the guard period overhead especially on higher SCSs.

2.2.6 UE antenna scaling

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- 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

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - 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
- Justification:
    - TBD
- SI or WI (or WI with study phase) if approved:
    - SI or WI with study phase?
    - Merged into UE RF FR2 enhancement WI including other objective
- Potential impact to other WG(s):
    - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved
- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 6:

1 – Guangdong OPPO Mobile Telecom.

If we understand correctly antenna scaling is one of UE implementation to reduce power consumption, similar as FR1 UE overheating assistance information. And current overheating assitance information allows UE to indicate the reducced BW, CC number and MIMO layer. Does antenna scaling can be covered by these information or something new need to be introduced? Besides, not sure whether there is impact to RAN1 beam management and power control since reduce antenna elements may cause the beam changes?

2 – QUALCOMM JAPAN LLC.

Issue#1: Objective is not very clear, it is not clear what problem we are trying to solve.

Issue#2: The justification presented so far is not convincing, it is not clear that there is a need for such work. What has been proposed so far is already possible through UE implementation and it is not clear what is

the real problem that should be solved. For the network side, what is the difference between a change in the number of elements used or a switch to a different UL Tx beam with less gain?

3 – MediaTek Inc.

If our understanding on ”UE antenna scaling” correct, we think it is up to UE implementation.

4 – Nokia Corporation

Issue#1: Objective is ok.

Issue#3: Could be part of FR2 UE RF WI if approved

Issue#4: Potential impact to WG2 if new signalling is needed.

Issues#5: If there are TUs available could be part of REL18 package. But this topic should not be considered as a top priority in RAN4.

5 – Ericsson LM

We do not see any need to specify anything about antenna scaling in the specification.

Nothing prevents current UE from doing this already today as part of power control. This aspect was discussed already in Rel-15.

6 – Huawei Technologies France

Power saving or beam management are other WGs topics, it’s not clear for the purpose of power saving, whether it is necessary to consider antenna scaling. The necessity should be justified by RAN1 firstly.

7 – Intel Deutschland GmbH

We need further clarification of the objective’s intent, as we assume there is a performance improvement associated with it. Would new requirements be defined for UEs who support this scaling? What is the performance gain of supporting this antenna scaling?

Considering other potential enhancements being discussed, we prefer to deprioritize this one.

8 – ZTE Corporation

We also think it is like UE implementation if our understanding is corrected.

9 – Sony Group Corporation

We see this is a UE implementation issue, so we would like to understand what is the benefit to specify it.

2.2.7 Beam correspondence requirements for RRC_INACTIVE and initial access

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- 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.

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
  - 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.
- Justification:
  - TBD
- SI or WI (or WI with study phase) if approved:
  - WI?
  - Merged into UE RF FR2 enhancement WI including other objective
- Potential impact to other WG(s):
  - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved

- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 7:

1 – Nokia Corporation

Issue#1: Objective

We propose the following objectives:

• Specify UE beam correspondence requirements for initial access and RRC_INACTIVE state [RAN4 RF]

• SSB-based without UL beam sweeping

• For RRC_INACTIVE at least requirements for Random Access SDT and Configured Grant SDT

• For initial access, verification of beam correspondence requirements based on msg1 spherical coverage (at least)

Issue#2: Justification

We propose the following text for justification:

UE beam correspondence functionality for RRC*CONNECTED, RRC*INACTIVE and initial access in IDLE is specified in the RAN1 and RAN2 specifications already in Release 15 but no FR2 UE beam correspondence requirements have been defined for RRC*INACTIVE and initial access in IDLE yet. The current UE beam correspondence requirements are only defined for RRC*CONNECTED. Without UE beam correspondence requirements for RRC_INACTIVE and initial access it is not possible to ensure good UE RACH and msg1 performance and UL coverage in FR2 deployments due to varying UE performances.

Rel-15 RRC*INACTIVE and Rel-17 small data transmission (SDT) have a large potential in UE power efficiency, latency and signalling overhead reduction. RRC*INACTIVE allows for reduced latency and UE power saving, while SDT further enhances this for small data sessions. Considering that 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. Without well performing UE beam correspondence support wide usage of RRC*INACTIVE and Small Data Transmission may not be feasible in practical FR2 deployments.

To enable efficient use of RRC*INACTIVE and Small Data Transmission in FR2 deployments to save UE power with reasonable latencies we see it important to develop FR2 UE beam correspondence requirements for RRC*INACTIVE in Rel-18.

Issue#3: SI or WI (or WI with study phase) if approved.

UE beam correspondence requirements should be done under a WI as UE beam correspondence functionality for RRC*CONNECTED, RRC*INACTIVE and initial access in IDLE has already been specified in the Release 15 RAN1 and RAN2 specifications. The UE beam correspondence requirement development for initial access and RRC_INACTIVE can be included to the Rel-18 UE RF FR2 enhancement WI.

Issue#4: Potential impact to other WG(s)

No impacts on RAN1 and RAN2, only additional test cases may be defined for the RAN5 test specifications.

Issue#5: Other (General comments)

These missing UE beam correspondence requirements should be prioritized in the Rel-18 RAN4 projects as beam correspondence is one of the very basic FR2 functionalities needed for achieving good FR2 performance.

2 – Guangdong OPPO Mobile Telecom.

We understand the motivation and agree with importance for UE to do fast beam management in the initial access, however, we are not convenced to introduce requirements and test cases for initial access.

The beam correspondence is very basic behavior for UE to do beam selection and the process is straight forward that UE measure DL RS to select the best Rx beam then mapping to Tx beam. This process has already been verified in connected mode we don't see the reason to re-introduce requirements for initial access. Beam correspondence is introduced since R15, if there is problem in the initial access then the UEs on the market already suffers from that, but we didn't notice that in the field.

Therefore, in our view, this is somehow over defining requirements in RAN4. If we worry problems for initial access just because of requirements are tested in connected mode, maybe we also need to worry about other RAN4 requirements in initial access like Tx power, Refsens...

3 – SoftBank Corp.

We support the Nokia's suggestion.

4 – QUALCOMM JAPAN LLC.

This is an area that could bring some performance gains and potentially covers a hole in the specifications. However, so far, it hasn't been shown that there is any real problem.

5 – TELECOM ITALIA S.p.A.

We support the proposal from Nokia

6 – MediaTek Inc.

We understand the motivation, however, we didn't see real problem while no specific additional requirement on initial access so far. In our understanding, if there is real problem, we shall know it from Rel-15 commercial devices.

7 – KT Corp.

We support Nokia's proposal.

8 – NTT DOCOMO INC.

We have interest in this topics, and support the objective proposed from Nokia.

9 – Apple (UK) Limited

First, as UE is supposed to choose its UE beam based on SSB measurements, and there is RAN4 BC requirements for RRC_CONNECTED mode, it is unclear if UE will exhibit a different behavior in RRC_INACTIVE and initial access and thus additional requirements are needed. Some field data on different UE behaviors in

RRC_CONNECTED vs. RRC_INACTIVE and initial access would be useful. Second, it would be helpful to understand what requirements are being considered, RF requirements like the current R15/16 BC requirements or some RRM requirements with a delay constraint? Third, we would also like to understand if testability is an issue, since it was raised during R16 BC discussion.

10 – Ericsson LM

We support Nokia's proposal. The BC requirements in RRC inactive state become even more important with small data transmission.

11 – AT&T GNS Belgium SPRL

We support Nokia's proposal and agree that this item should be addressed in Rel-18.

12 – KDDI Corporation

We support the proposal from Nokia.

13 – Huawei Technologies France

We understand the motivation but not convinced to have this kind of study in Rel-18.

Firstly, 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.

Secondly, beam correspondence requirement is used to describe the UE ability to maintain the UL beam direction corresponding to DL beam selection, which is generally decided by UL and DL RF matching/-correspondence design. It actually has little relation with which RRC state the UE is in. It means one verification test under a typical configuration(RMC) is enough to cover other cases when UE is required to select Tx beam by Beam correspondence.

In addtion, for Random access SDT, there is no agreement in RAN1 on how UE decide the Tx beam for the msg1 and msg3(or msgA for 2 step RACH) as discussed before. And there is also no conclusion in RAN1 how UE decide the beam for DCI transfer and subsequent data transmission.

14 – Intel Deutschland GmbH

We are ok performing studies for this objective with a medium priority. Overall, additional clarification on specific issues during initial access would be encouraged.

Issue#1: Objectives proposed by Nokia can be used as a starting point. Also, this topic can be merged with "Spherical coverage enhancement for initial access." For initial access requirements, we suggest studying the potential impact on testability aspects (i.e., test time) to ensure reasonable testing efforts.

Issue#3: Our preference is a WI with a study phase on testability aspects. The objective can be a part of the FR2 evolution WI; we do not think a separate WI is required.

Issue#4: No impacts to other WGs are expected

15 – Samsung Electronics Co. Issue #1: Nokia's proposal can be used as starting point Issue #3: BC objective can be included in the FR2 UE RF umbrealla WI as one of high priority objective.
16 – LG Electronics Deutschland Similar view with some UE vendors that requirement and testing can be an issue for BC in RRC_INACTIVE and initial access
17 – ZTE Corporation We also have strong interest on this topic and are fine with Nokia proposed objectives. Since this should be one basic functionality for FR2 initial access and RRC Inactive mode, therefore this missing part should be done in Rel-18 FR2 UE RF enhancement.
18 – BT plc we support Nokia's proposal
19 – Sony Group Corporation We support this proposal. This is a missing piece of requirements for a critical feature, and no guarantee for the UE performances during the inactive model and initial access without it.

2.2.8 Spherical coverage enhancement for initial access

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- Spherical coverage enhancement for initial access
    - There is no spherical coverage requirement for PRACH msg1 transmission. It is important to enhance initial access performance.

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - Spherical coverage enhancement for initial access
        - **Specify** ~~There is no~~ spherical coverage requirement for PRACH msg1 transmission~~. It is important to enhance initial access performance.~~
- Justification:

- There is no spherical coverage requirement for PRACH msg1 transmission. It is important to enhance initial access performance.

- SI or WI (or WI with study phase) if approved:
  - WI?
  - Merged into UE RF FR2 enhancement WI including other objective
- Potential impact to other WG(s):
  - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved
- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 8:

1 – Guangdong OPPO Mobile Telecom. Similar comments as beam correspondence for initial access. We understand the motivation and agree with importance for UE to have good spherical coverage in the initial access, however, we are not convenced to introduce requirements and test cases for initial access just because of UE is tested in connected mode.
2 – MediaTek Inc. Similar comment as beam correspondence. We understand the motivation, however, we didn't see real problem while no specific additional requirement on initial access so far. In our understanding, if there is real problem, we shall know it from Rel-15 commercial devices.
3 – NTT DOCOMO INC. We are OK with this objective, but wonder if this objective is covered by "2.2.7 Beam correspondence requirements for RRC_INACTIVE and initial access" since beam correspondence is based on spherical coverage requirements.
4 – Nokia Corporation Issue#1: Objective is acceptable

Issue#2: Justification is very valid.

Issue#3: Could be coupled with Beam correspondence requirements for RRC_INACTIVE and initial access as a one objective under FR2 UE RF enhancement WI

5 – Apple (UK) Limited

See our comments above.

6 – Ericsson LM

We support this objective. We are fine with Nokia's proposal if this can be covered under the same bullet on beam correspondence for RRC inactive and initial access.

7 – AT&T GNS Belgium SPRL

We are OK with this objective and think that it can be taken with Beam correspondence requirements for RRC_INACTIVE and initial access.

8 – KDDI Corporation

We are OK with this objective. We also think that this could be coupled with Beam correspondence requirements as Nokia commented above.

9 – Huawei Technologies France

Similar comment as for beam correspondence.

10 – Intel Deutschland GmbH

We are ok with conducting studies in Rel-18. This topic shall be discussed jointly with "*Beam correspondence requirements for RRC_INACTIVE and initial access*" due to the strong coupling in beam correspondence and spherical coverage requirements.

11 – LG Electronics Deutschland

Similar comment as in BC that requirement and testing can be issues.

12 – ZTE Corporation

Similar as BC for RRC_INACTIVE and initial access, we also agree to specify the spherical coverage enhancement requirement for initial access.

13 – Sony Group Corporation

We support this proposal, but think it can be merged with Beam correspondence requirements for RRC_INACTIVE and initial access

2.2.9 Power-control tolerance

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- 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.

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - 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~~**both absolute and relative tolerances for power control in FR2** to enhance performance. ~~Several procedures reply on pathloss are impacted by the power control tolerance.~~
- Justification:
    - 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.
- SI or WI (or WI with study phase) if approved:
    - WI?
    - Merged into UE RF FR2 enhancement WI including other objective
- Potential impact to other WG(s):
    - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective
- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved

- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 9:

1 – Guangdong OPPO Mobile Telecom.

We understand the intention, but not clear how to improve the absolute and relative tolerance in FR2 in RAN4 and also in UE design? The power control tolerance is defined in RAN4 since Rel-15 based on UE Tx power control capabilities, is there some improvement today to support this enhancement? We would like to learn from companies on the approaches to improve UE performance.

2 – QUALCOMM JAPAN LLC.

There are very difficult implementation issues to be solved and it is not very clear if any meaningful gains can be achieved.

3 – MediaTek Inc.

Issue#2: Justification

1) We cannot agree with this statement ”Both absolute and relative tolerances for power control in FR2 are too coarse with **large margins**”.

2) Echo OPPO’s comment ”The power control tolerance is defined in RAN4 since Rel-15 based on UE Tx power control capabilities, is there some improvement today to support this enhancement?”

4 – Nokia Corporation

Issue#1: Proposed objectives are justified.

Issue#4: There should not be impact to other WG(s) except RAN5 needs to take into account improved tolerances.

Issues#5: If there are TUs available could be part of REL18 package. But this topic should not be considered as a top priority in RAN4.

5 – Apple (UK) Limited

It is unclear if there is indeed large margins in FR2. In our understanding, FR2 presents bigger implementation challenges than FR1 and the current requirement were specified as a result of considering such challenges.

6 – Ericsson LM

We support this objective. Power control tolerance is fundamental to several procedures.

7 – Huawei Technologies France

The issue had been discussed in previsous releases, but we didn’t see big improvement from implementation perspective. We also doubt the meaningful gain if no obvious implemenation assumptions have been changed.

8 – Intel Deutschland GmbH Clarification on how the tolerances will be improved is needed as there may not be significant updates/improvements to justify the enhancement. Compared to other objectives, we think this is a lower priority.
9 – TELECOM ITALIA S.p.A. We support Nokia and Ericsson view

2.3 Topic #14 Requirement for FR2 multi-Rx chain DL reception

2.3.1 Requirement for FR2 multi-Rx chain DL reception

Previous discussion

The summary for this objective captured in RP-212682 is as follow:

- 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 RX from different directions
        - 4 DL MIMO layers

Proposals for discussion

Based on the proposals and feedbacks in the previous discussions, the moderator provide the following proposals as the starting point for discussions.

- Objective:
    - 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 RX from different directions
            - 4 DL MIMO layers
- Justification:
    - TBD
- SI or WI (or WI with study phase) if approved:
    - WI?
    - Dedicated WI?
- Potential impact to other WG(s):
    - TBD

Comments and suggestion

Companies are encouraged to provide comments especially for the following issues:

- Issue#1: Objective

- Issue#2: Justification
- Issue#3: SI or WI (or WI with study phase) if approved
- Issue#4: Potential impact to other WG(s)
- Issue#5: Other (General comments)

Feedback Form 10:

1 – Guangdong OPPO Mobile Telecom.

For clarification, does the 4DL MIMO is for one CC from same BS, i.e. both panel connecting to same BS in the same directions and different direction scenarios?

2 – QUALCOMM JAPAN LLC.

Issue#1:

The list of objectives seems reasonable. It might be useful to clarify that a ”panel” is just an ”entity” that can create one analog beam, it is not necessarily a physical panel. RAN1 and RAN4 might have different understandings/definition of what is a ”panel”.

We would be fine to remove the part on improving the spherical coverage requirement, we believe that the current 50%-ile can be kept without any issues. What is needed are just new requirements for simultaneous receptions from different angles. The requirements for multiple angles should be discussed first, requirements for 4L should be added on top of these. Also, the RF requirements could be agnostic of the number of TCI states used.

For RRM, the list of objectives should be kept to a minimum, not so many changes are needed to enable this type of operation. Many enhancements are being proposed, however, these are not necessarily needed for this feature.

Issue#2:

The justification is relatively clear, most MIMO enhancements being discussed are based on some sort of simultaneous transmission/reception. The RAN4 requirements are clearly lagging in this area so there is a need to enable further MIMO enhancements/evolution. What is now being discussed are leftovers from previous releases.

Issue#3: This should be a WI, there is nothing to study for a feature already defined in the 3GPP specs for which just RAN4 reqs are missing.

3 – MediaTek Inc.

Issue#1: Objective

1)We propose to add **“necessary** & **“simultaneous** to make it clearer.

- Introduce **necessary** requirement**(s)** for enhanced FR2 UEs with multi-Rx chain DL **simultaneous** reception

2) We propose to discuss “**simultaneous** reception” firstly, and then “**4x4 MIMO**” as second step.

3) We propose to make it clearer:

- Identify and specify necessary RF requirements for devices with 2 **simultaneous reception**panels

4 – Nokia France

Issue#1: Objectives

The main bullet should state that the reception is "simultaneous from two directions". 4 DL MIMO layers are only relevant to the demod part, so this doesn't need to be stated in the main bullet.

For the RF requirements:

o the key requirement is the UE's ability to receive from two different directions simultaneously. It should be studied whether coherence between the directions can be assumed (coherence, if assumed, could either imply single-panel dual beam reception, or dual-panel reception with coherence between the panels).

o Spherical coverage requirements should be enhanced for simultaneous reception from two directions.

For RRM and demod, we list the key requirements below.

We propose the following detailed objectives:

- Introduce requirements for enhanced FR2 UEs with downlink reception simultaneously from two directions:
  - Enhanced RF requirements:
    - Specify RF requirements for reception from two different directions simultaneously.
    - Study whether coherence between the directions can be assumed.
    - Enhance spherical coverage requirements for simultaneous reception from two directions.
  - Enhanced RRM requirements:
    - TCI switching delay requirements for simultaneous dual TCI with different QCL-D source RS
    - L3- and L1-RSRP measurement requirements with simultaneous dual reception of different QCL-D source RS
    - Extend/reuse independent beam management (IBM) concept from inter-band CA to cover dual-TCI MIMO in the same CC.
    - Specify beam failure recovery requirement for mTRP with simultaneous dual-TCI reception
    - FFS : Specify radio link monitoring requirements with simultaneous dual-TCI reception

- UE demodulation requirements: Introduce demod and CSI performance requirements for 4-layer DL MIMO:
  - Conduct performance study with Rel-17 dual-TCI indicating different QCL-D type to enable 4-layer PDSCH reception from mTRP with single DCI, compared to Rel-15 single-TCI-enabled 4-layer PDSCH reception from single TRP
  - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI.
    - Demod requirements on 4 DL MIMO layers
    - CSI requirements to support 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook
  - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI
    - Demod requirements on 4 DL MIMO layers
    - CSI requirement to support 4-layer with single TCI and Rel-15 Type I codebook

Issue#2: Justification

We propose the following:

In FR2, 4-layer MIMO reception requires beam reception from at least two directions. Although this is supported by the MIMO features since Rel-15, no performance requirements have yet been specified. This is important for high-rate MIMO in FR2, as well as for FR2 HST scenarios.

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

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

The WI covers RF, RRM and demodulation requirements.

Issue#3: SI or WI

This should be a dedicated WI.

Issue#4: Potential impact to other WG(s)

No impacts to other WGs, but the OTA test setup would also need to be extended to 4 layers in order to complete the work. This should be part of the OTA test enhancement item.

5 – Apple (UK) Limited

Since it is unlikely to complete the related work in R17 FeMIMO, we support a R18 WI to address the R17 work as well as any potential new aspects.

As for RF requirement, a feasibility study is needed to study if and how to specify additional/new RF requirement for devices that are capable of simultaneous multi-panel reception, while keeping the existing requirements intact.

Our views on the scope of the WI:

Dual TCI assumption

For RF requirements, it does not matter much. For RRM/Demod, since this is a R18 WI, we should consider all relevant assumptions in previous release. As a result, both R16 and R17 are considered, and updates/decisions can be made during the course of the WI.

Enhanced RF requirements:

Study, and if necessary and feasible, specify additional/new EIS spherical coverage requirement, for devices that are capable of simultaneous multi-panel reception. Note that the current requirement of 50%-ile spherical coverage is kept intact

Enhanced RRM requirements

FFS details, with a focus on RRM measurement and beam management delay reduction and ease of scheduling restriction for devices that are capable of simultaneous multi-panel reception

UE demodulation requirements:

Simultaneous RX from different directions, including 4 DL MIMO layers

Testing

Develop a test setup/methodology that can support the RF, RRM and Demod requirements. Note that the conclusions and agreements in TR38.810/884 should be taken into account.

Given the amount of work involving RF, RRM, Demod, and testing, an independent WI can be considered instead of merging the work into the FR2 UE RF umbrella WI.

6 – Huawei Technologies France

For dual TCI assumption, we first would like to change the wording to ”two QCL TypeD assumption”. Rel-16 two QCL typeD is for PDSCH, while Rel-17 is for PDCCH to get diversity gain. In our view, Rel-16 two QCL type D functionality is more fundamental. Since we just start the work on this aspect, we prefer to use Rel-16 assupmtion as baseline for this RAN4 work. In Rel-18, the enhancement would focus on uplink, which seems irrelevant to this work.

For enhanced RRM requirements, the main intention of this work is to improve FR2 DL reception coverage and throughtput. Considering the limited time, we would like to focus on the enhancement for demodulation baseband rather RRM baseband processing. From RRM base band perspective, the processing is not expected to be changed although the Rx beam pattern may be changed. In our view, we prefer to reuse

all the existing FR2 RRM requirements rather having fundamental changes for RRM processing. So we propose to remove ”enhanced RRM requirements” objective.

For UE demodulation requirements, we would like to make it clear that the work focus on single carrier to ensure timely finalization of the work. We do not need to consider CA case in this item. Thus we propose

* UE demodulatoin requirements

* Simultaneous and Rx from different directions

* up to 4 DL MIMO layers

* Focus on the single carrier case.

In addtion, we also think that “simultaneous reception” should be studied firstly.

7 – China Telecommunications

We support this work to complete the leftover requirements from earlier release. Also, extending the MIMO layers from 2 to 4 is a very direct way for throughput improvement.

8 – Intel Deutschland GmbH

We support this work to introduce requirements for FR2 multi-Rx chain DL reception.

Issue #1: Objectives

The high-level set of objectives is fine. We suggest considering improving RF spherical coverage and RRM requirements. For the latter, different improvements/requirements can be considered. We suggest to at least consider a reduction in measurement delays, which can be enabled by advanced UEs with simultaneous RX capabilities. The work can be limited to UEs supporting the “simultaneousReceptionDiffTypeD-r16” UE capability.

The following updated objectives are proposed:

- *Define necessary requirements for FR2 UEs capable of multi-RX chain simultaneous DL reception on a single component carrier*

- *Enhanced RF requirements:*

- *Identify and specify necessary RF requirements for devices with 2 panels*

- *Spherical coverage requirements for devices with 2 panels with improved performance*

- *Enhanced RRM requirements*

- *Enhanced RRM requirements with reduced measurement delays*

- *Specify the necessary performance requirements for FR2 UEs capable of multi-RX chain simultaneous DL reception on a single component carrier:*

- *RRM performance requirements and test cases*
- *UE demodulation and CSI reporting requirements*
- *Requirements for simultaneous reception from different directions*
- *Requirements for 4 DL MIMO layers*
- *Notes:*
- *Focus on handheld UEs supporting "simultaneousReceptionDiffTypeD-r16" UE capability*
- *Focus on UEs supporting simultaneous reception of at 2 beams and with support of 4 DL MIMO layers*

Issue #2: Justification

The following justification text is proposed

The existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that UE is equipped with a single antenna panel and capable to perform DL reception using a single RX beam/chain reception. Furthermore, the UE performance requirements are limited for DL MIMO rank 1 and 2.

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

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

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

Issue#3: WI is preferred; work can be performed as part of the FR2 evolution work item

Issue#4: No impact on other WGs is expected

@OPPO, in our view 4DL MIMO can be from one CC from same TRP or from different TRPs.

9 – TELECOM ITALIA S.p.A.

We are supportive of the activity

10 – LG Electronics Deutschland

Since this objective includes RRM and demod on top of FR2 RF, considering comments from other companies, it would be more appropriate to take this as a separate WI or under RAN4 core part of existing RAN1-led MIMO WI.

11 – vivo Communication Technology

Issue#1: Objectives

Our understanding to this Topic #14 is to focus on the DL requirements enhancements considering 2 active UE panels. We also prefer to delay UL related discussion to future release. Therefore, regarding the 'dual TCI assumption',

1. TCIs would be more related to both DL and UL, at least for R17. Moreover, RRM measurements can be performed before TCI are activated, or even before TCIs are configured. Therefore, utilization of multi-Rx chain DL reception can be beneficial not only for activating TCIs but also for reducing RRM measurement latency in FR2, while the later one receives quite many supporting views in another thread.

2. Regarding the release for TCIs to be considered, we also think it would to more feasible to start from R16 TCIs as baseline, which are DL-only, and may reduce the workload in R18 significantly.

3. We agree to only consider single carrier case in R18

Based on above, it is proposed to **remove the 'Dual TCI assumption' bullet and its sub-bullets.** The assumption would be clearer if it is clarified in the main bullet. The detailed objective is as follows:

- Introduce requirements for enhanced FR2 UEs with multi-Rx chains **and capable of simultaneous** DL reception **from different directions (2-AoA)**~~ with 4 DL MIMO layers~~.

o **Focus on single carrier case.**

For RF part:

1. Study and, if necessary, specify new requirements for the 2-AoA scenario, based on UE architecture that capable of 2-panel simultaneous reception.

For RRM part,

1. Study timing difference from different directions, and if necessary, specify new Rx timing requirements (e.g. similar to MRTD) under certain conditions. For example, UE would be able to deal with larger timing difference based on more than 1 FFT windows.

2. Enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors. FFS impacted sections of RRM requirements.

3. TCI switching delay requirements for the dual TCI case i.e. simultaneous QCL-D reception, while R16 TCIs are considered.

4. BFR and RLM requirements enhancements, if necessary.

For demod part

Introduce DL 4-layer related requirements for FR2.

For OTA testing

Introduce OTA testing methods for 2 active DL AoAs. With the following objectives

- The test methods in TR38.810/884 for RF/RRM/Demod can be further extended to support multi-panel reception performance
- Focus on DL test cases with 2 AoAs simultaneously for RF/RRM/Demod test
- The test setup should enable testing of up to 4 Layers DL signal
- FFS whether Fading model should be updated
- The angel separation should consider typical UE implementation
- Test methods development can be started after core requirements finalized.
- The test procedure for Quality of the quiet zone validation should be further studied
- Given the antenna pattern has been changed from single beam to multi-beams, FFS whether the related Measurement Grids should be updated
- The preliminary MU assessment for the enhanced test methodology should be done in RAN4

Issue#3: SI or WI

This should be a dedicated WI.

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12 – Samsung Electronics Co.

#1 Objective:

Specifying the requirements for UE with capability of simultaneous receptions with different QCL Type-D RSs are discussing in Rel-17 FeMIMO WI. Given the remaining time in Rel-17, we think we shall consider to postpone the works to Rel-18.

UE feature (16-2c) ”Simultaneous reception with different Type-D” has been introduced in Rel-16 (TR 38.822). We agree with some companies that given the panel/Rx chain concept is not clear concept cross-WG, it is better to modify the objectives according the UE capability of ”simulationeous reception with different QCL Type-D RSs“, i.e.,

- Specify requirements for FR2 UEs with simulationeous reception with different QCL Type-D RSs

For RF requirements, it is our understanding the most FR2 requirements in RAN4 are specified can be reused for UE with multi-panels. In our WG paper (R4-2200925), we showed the UE spherical coverage performance does not quite rely on the number of panels in a UE. Therefore, we agere with the QC that at least the CDF %-tile of the current sphecial coverage requirements shall be kept for UE with multi-panels, i.e.,

- Identify and specify necessary RF requirements for UE with capability of simultaneous receptions with different QCL Type-D RSs

- 50%-tile CDF of the spherical coverage shall be kept unchanged. FFS for enhanced spherical coverage requirements if identified

For RRM requirements, expected RRM impact at least include but no necessarily limited to

- Handover to unknown FR2 cell
- Factor for FR2 RX beam sweeping
- Measuremetn restriction for CSI-RS based operation
- Scheduling restriction for CSI-RS based operation
- SCell activiation/deactivation delay
- Active TCI swithcing delay

We are open to discuss whether to list the detailed RRM requirements in the objective part but these RRM impact shall be considered once the WI is approved

For performance part (Demodulation and CSI), in our understanding, below two items may have impact (detailed analysis can be found in our WG paper (R4-22000924)

- Inter-cell multi-DCI based multi-TRP operation
- Enhancement on HST-SFN deployment

Again, we are open to discuss whether to list the detailed performance requirements in the objectives.

Furthermore, it is our understanding no discussion on more than 1 AoA test setup for RF testing until now in RAN4. Also, for RRM test, no conclusion on the feasibility of generating the testable side conditions made for 2AoA, simultaneous transmission of signals from 2 probels. Similar situation in Demod test case, it is not supported to verify demod performance with 2 simultaneous active AoAs. Therefore, we believe the objectives of test methods for RF, RRM and Performance requiremetns shall be also added in the same release as core requirements.

Issue #3: Given the above potential scope for RF, RRM and Performance, it is too large to be include in the FR2 UE RF WI. A dedicated WI is perferred to accomodate above objectives. Proper TU for both RF and RD session have to be reserved.

Issue

13 – Sony Group Corporation

We are supportive of this item.

2.4 Others

As mentioned in introduction section, although the template for initial round explicitly lists only topics discussed in October as per RAN chairman's guidance, new proposals and the contributions submitted after October, i.e., in RAN4#101-e, RAN#94-e, and RAN4#101-e-bis can be also treated. Companies can use

”Others” section to provide new proposals.

Any other comments would be appreciated.

Feedback Form 11:

1 – Apple (UK) Limited

In R17, UL gap for TX power management is being worked out in UE FR2 RF WI as a continued effort to help UE meet MPE requirements while achieving better FR2 coverage and/or performance, and good progress has been made. To continue this effort, we propose the following objectives for in R18, as shown in R4-2200287.

1) maxUplinkDutyCycle-FR2 reporting, dynamic or semi-static, which would provide the network timely update to assist scheduling

Justification: In R15/16, maxUplinkDutyCycle-FR2 is reported as part of UE RF capability. Once reported, there is no further update.

While dynamic max. UL duty cycle reporting was discussed in R15/R16, there was no consideration of the possible use of body proximity sensor (BPS) to detect if a human tissue is close-by and then decide if P-MPR is needed. With BPS, the use of dynamic maxUplinkDutyCycle-FR2 reporting is more targeted and useful. For instance, instead of incurring a large P-MPR, a UE at the cell edge can rely on a smaller duty cycle to transmit with a high power and still meet MPE requirements.

2) Better granularity of P-MPR reporting from UE

Justification: Optional P-MPR reporting was added in R16 so UE can inform gNB of the required P-MPR values for MPE compliance, but the granularity (3dB per notch) can be further improved.

3) Possible enhancements to R17 beam-specific P-MPR reporting

Justification: As discussed in R4-2200301, there are the following possible enhancements:

A) based on RAN1 agreements, it is not guaranteed that the L1-RSRP of the associated SSBRI/CRI is always reported. In this case, the value of per-beam PMRP reporting is questionable.

B) In RAN1 discussion, body proximity sensing capability is assumed when per-beam PMPR reporting is introduced. From UL performance perspective, for the same SSBRI/CRI, UE can have different strategy to report P-MPR depending on human body approximation. If there is no human target around, UE should select the beam with the best EIRP in UL or L1-RSRP in DL and the corresponding P-MPR is reported. When there is human body approximate, the beam with maximum (L1-RSRP-P-MPR) should be selected and reported. Obviously, reporting a single P-MPR per SSBRI/CRI are not sufficient for MPE and UL performance enhancement.

The above objectives can be included in R18 WI on FR2 enhancement.

2 – Nokia Corporation

Comments on Apple’s MPE related proposals above.

1) We do not support introduction of changing (dynamic or semi-static) maxUplinkDutyCycle-FR2 reporting as it limits network scheduling flexibility for different UEs and therefore, degrades system performance.

Dynamic maxUplinkDutyCycle-FR2 was considered already in Rel-15 and Rel-16 and also UE proximity sensing with methods that do not require UL gaps were also considered at the time and the conclusion was that other MPE methods like MPE P-MPR reporting to the network are better as the network can decide the right actions to help the UE while also considering other UEs that the network needs to serve.

2) We support to define better granularity for UE's MPE P-MPR reporting. The benefits of better granularity were also discussed during Rel-16 but due to device complexity reasons better granularity was not defined at the time. Thus, it would be good to enhance reporting granularity in Rel-18.

3) The proposed objective is related to the ongoing Rel-17 work on MIMO enhancements, which is not yet complete yet. Enhancements should only be considered once the Rel-17 work is complete. Furthermore, considering that this type of enhancement was done under the Rel-17 MIMO work item, it would also be better to consider related enhancements under the Rel-18 MIMO work item after the Rel-17 work is completed and enhancements can be assessed.

2.5 Summary for initial round

2.5.1 UL 256QAM

- Objective
  - Several companies support with study although some companies think gain is very limited.
  - Several companies suggests that devices types should be clarified. Several companies support CPE/DWA device types only.
  - Modifications are suggested from MTK and Samsung
    - *Investigate and if **feasible**, enable UL 256QAM for FR2*
    - *Study the gain, operating SNR, **phase noise model and** implementation aspects*
- Justification
  - Several inputs are provided. Several companies commented that study is needed.
    - We understand the intention of this work, however, we believe that the actual performance gains will be very limited considering the UE will require a large power backoff and the FR2 power dynamic range is already quite small. As such, this feature will only be usable in a very small range in actual network so the gains will be very limited. We believe other topics might bring more tangible system gains.
    - The maximum throughput we achieve from this work could be extremely useful for research and marketing purposes which can also give some guidance to UL performance KPI for 6G.
    - Improved data rates and accompanying capacity increase.
    - The intention of 256QAM is to improve the peak data rate. Especially in some industry use case, e.g., the machine transmits the photograph with super high resolution to the cloud, which needs Gbps data rate. In such case, we see the need for 256QAM. And in such scenario thanks to lower path loss, the possibility to use 256QAM would be higher.

- WI or SI if approved
    - Eight companies prefer WI with study phase. Three companies prefer SI. There companies are OK with either of ways
- Dedicated WI or merged WI if approved
    - Five companies prefer merged WI with other objective. Three companies prefer dedicated WI.
- Impact to other WGs
    - Several companies commented no impact to other WG(s). No different views.
- other
    - Samsung commented that proper TU in RD session has to be reserved.

2.5.2 RF enhancement in FR2-1 for 39GHz band

- Objective
    - Several companies commented that beam types, band, band combinations should be clarified. LG commented that n260 and IBM+UL CA are targets. LGU commented that n257+n260 is a target.
- Justification
    - Five companies support this objective:
        - We are struggling to find the use case for 39GHz and working on vehicular UE power class can lead us into finding a good use case for utilizing this spectrum.
        - The example use case should be found from something other than mobile phone. In this sense, the vehicular UE can be the potential use case for FR2.
        - Regarding the 39GHz, n260(above 37GHz(40GHz)) is in planning from government around 2025~2026. So, n257 and n260 are of interests. Considering that the completion of Rel-18 is the end of 2023, Rel-19 is late to meet this schedule in advance
    - Four companies have a question on the demand and necessity in Rel-18.
- WI or SI
    - WI
    - Two companies prefer dedicated WI, and two companies prefer merged into FR2 RF enhancements WI
- Dedicated WI or merged
    - Two companies prefer dedicated WI, and two companies prefer merged into FR2 RF enhancements WI
- Impact to other WG(s)
    - One company commented no impact to other WG(s). No different view.

2.5.3 Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1

- Objective
    - Several companies commented that it depends on operator's request.
    - MTK suggested modification on the objective, and pointed out a typo.
        - We suggest adding "study and if feasible" before define requirement. "Study and if feasible" define RF requirement(s) for support of inter-band UL CA in FR2-1 based on CBM
        - Further breakdown to "same frequency group" and "different frequency groups" could make objective be clearer.
    - Nokia and Docomo commented that Rel-17 leftover should be added if not finished in Rel-17.
    - LG and LGU commented that example band combination can be the same with Rel-17.
- Justification
    - CA is important feature for all 3GPP RATs
- WI or SI if approved
    - WI
- Dedicated WI or merged WI if approved
    - FR2 UE RF enhancement WI
- Impact to other WG(s)

Potential impact to WG2 unless Rel17 WI completes certain features which need new UE capabilities.

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

One company support this objective, and several companies prefer to deprioritize. "The work should be based on operator's request" seems to be a common understanding.

There are comments pointing out a typo.

2.5.5 Enhanced switching time (ON/ON transient time)

- Objective
    - OPPO suggest the following modification
        - Add sub-bullet saying "reuse the conclusions in FR1 transient period capability discussion as much as possible" to reduce workload.

    - Several companies commented that should wait the progress of Rel-17 discussion.
    - Five companies support this objective. Two companies do not support. One company do not recommend FR2-2 enhancement.

- Justification
    - Would be beneficial from network point of view.
    - Improved performance for higher SCS (480/960kHz).
    - ON/ON transient time has a significant impact on UL performance, especially for high SCS scenarios in FR2-2 and FR2-1. Improved UE capabilities to support up to 1us ON/ON transient period can be considered for FR2, similar to FR1.

- WI or SI if approved
    - Several companies commented it should be WI. No different view.

- Dedicated WI or merged WI if approved
    - One company prefer dedicated WI. Three companies prefer merged into FR2 RF enhancement WI.

- Impact to other WG(s)
    - One company commented that there is no impact. No different view.

2.5.6 UE antenna scaling

- Objective and justification
    - Several companies commented that this is UE implementation aspect. Several companies suggest to deprioritize this objective.
    - The following question is provided:
        - Current overheating assistance information, allows UE to indicate the reduced BW, CC number and MIMO layer. Does antenna scaling can be covered by these information or something new need to be introduced?
        - Not sure whether there is impact to RAN1 beam management and power control since reduce antenna elements may cause the beam changes?
        - What problem we are trying to solve? what is the benefit?
        - For the network side, what is the difference between a change in the number of elements used or a switch to a different UL Tx beam with less gain?
        - Would new requirements be defined for UEs who support this scaling?

- WI or SI if approved
    - Merged into FR2 RF enhancement WI

- Impact to other WG(s)
    - Potential impact to WG2 if new signalling is needed.

2.5.7 Beam correspondence requirements for RRC_INACTIVE and initial access

- Objective
  - Twelve companies support this objective. Seven companies have some concerns on this objective.
  - Nokia suggest the following modification
    - Specify UE beam correspondence requirements for initial access and RRC_INACTIVE state [RAN4 RF]
    - SSB-based without UL beam sweeping
    - For RRC_INACTIVE at least requirements for Random Access SDT and Configured Grant SDT
    - For initial access, verification of beam correspondence requirements based on msg1 spherical coverage (at least)
  - Several companies commented that they don't see the necessity to specify this requirement since no real issues are found so far, and this aspect is already covered by the existing requirements.
  - Apple has the following questions
    - It would be helpful to understand what requirements are being considered, RF requirements like the current R15/16 BC requirements or some RRM requirements with a delay constraint?
  - Intel suggests to study the potential impact on testability aspects. Apple and LG also have concerns on testing issue.
  - Huawei have the following comments on SDT:
    - In addtion, for Random access SDT, there is no agreement in RAN1 on how UE decide the Tx beam for the msg1 and msg3(or msgA for 2 step RACH) as discussed before. And there is also no conclusion in RAN1 how UE decide the beam for DCI transfer and subsequent data transmission.
- Justification: Nokia propose the following
  - UE beam correspondence functionality for RRCCONNECTED, RRCINACTIVE and initial access in IDLE is specified in the RAN1 and RAN2 specifications already in Release 15 but no FR2 UE beam correspondence requirements have been defined for RRCINACTIVE and initial access in IDLE yet. The current UE beam correspondence requirements are only defined for RRCCONNECTED. Without UE beam correspondence requirements for RRC_INACTIVE and initial access it is not possible to ensure good UE RACH and msg1 performance and UL coverage in FR2 deployments due to varying UE performances.
  - Rel-15 RRCINACTIVE and Rel-17 small data transmission (SDT) have a large potential in UE power efficiency, latency and signalling overhead reduction. RRCINACTIVE allows for reduced latency and UE power saving, while SDT further enhances this for small data sessions. Considering that 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 RRCINACTIVE and Small Data Transmissions for FR2 as well. Without well performing UE beam correspondence support wide usage of RRCINACTIVE and Small Data Transmission may not be feasible in practical FR2 deployments.

    - To enable efficient use of RRCINACTIVE and Small Data Transmission in FR2 deployments to save UE power with reasonable latencies we see it important to develop FR2 UE beam correspondence requirements for RRCINACTIVE in Rel-18.

- WI or SI if approved
    - One company prefer WI, and one company prefer WI with study phase.
- Dedicated WI or merged WI if approved
    - Merged WI intro FR2 RF enhancement WI. No different view.
- Impact to other WG(s)
    - No impact to RAN1 and RAN2. Additional test cases may be defined for the RAN5 test specifications.

2.5.8 Spherical coverage enhancement for initial access

Based on the companies' comments, it seems that this objective can be merged with "1.7 Beam correspondence requirements for RRC_INACTIVE and initial access".

Power-control tolerance

2.5.9 Power-control tolerance

- Objective and Justification
    - Three companies support this objective, and six companies doubt the performance gain and feasibility.
- WI or SI if approved
    - No input
- Impact to other WG(s)
    - No RAN1 and RAN2 impact. RAN5 may needs to take into account improved tolerances.

2.5.10 multi-Rx chain DL reception

- Objective
    - Several companies provide modification on objective. Common part is to clarify the objective as "requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs(angles/directions)"

- Justification
    - Exact sentences are proposed by Nokia and Intel.
- WI or SI if approved
    - Several companies prefer WI. No different view.
- Dedicated WI or merged WI if approved
    - One company prefer merged WI, and five companies prefer dedicated WI.
- Impact to other WG(s)
    - No impact to other WGs.
    - Potential impact on OTA enhancements.

2.5.11 Other

New proposals on achieving better FR2 coverage and/or performance, are provided by Apple:

1) maxUplinkDutyCycle-FR2 reporting, dynamic or semi-static, which would provide the network timely update to assist scheduling

2) Better granularity of P-MPR reporting from UE

3) Possible enhancements to R17 beam-specific P-MPR reporting

3 Intermediate round

3.1 General

Regarding handling of WI or SI, and dedicated WI or merged into FR2 RF enhancement WI, the views are still divided. Therefore, moderator continue to provide individual sections for each objective.

The moderator suggests the modified proposals for each objective based on initial round comments.

3.2 Topic #4 UE FR2 requirements evolution

3.2.1 UL 256QAM

Based on the discussion in initial round, the moderator suggests the modified proposals.

- Objective:
    - Investigate and if **feasible**, enable UL 256QAM for FR2 (RAN4)

        - Study the gain, operating SNR, **phase noise model and**implementation aspects
        - Specify the UE RF requirements
        - Specify the BS demodulation performance
        - **Targeted device types of UE are [CPE/FWA only].**

- Justification:
    - **The improved throughput and accompanying capacity increase achieved from UL 256QAM could be extremely useful for research and marketing purposes which can also give some guidance to UL performance KPI for 6G. Especially in some industry use case, e.g., the machine transmits the photograph with super high resolution to the cloud, which needs Gbps data rate. In such case, the need for 256QAM can be seen. And in such scenario thanks to lower path loss, the possibility to use 256QAM would be higher. However, the actual performance gain and implementation aspects need to be studied.**

- SI or WI (or WI with study phase) if approved:
    - **Suggestion is [WI study phase and merged into FR2 RF enhancement WI]**
        - **Option 1: WI study phase and merged into FR2 RF enhancement WI**
        - **Option 2: dedicated WI with study phase**
        - **Option 3: dedicated SI**

- Potential impact to other WG(s):
    - **No.**

Please provide further feedbacks on the above proposals:

Issue#1: For "Targeted device types of UE are [CPE/FWA only]", check any objection.

Issue#2: For [WI study phase and merged into FR2 RF enhancement WI], Suggestion is provided based on the initial round discussion, but the moderator sees the views are still divided. Companies are encouraged to show any compromise or detailed reasons.

Issue#3: Other (General comments)

Feedback Form 12:

1 – TELECOM ITALIA S.p.A.

We are ok to focus on CPE/FWA device types, but we would also like to add vehicular/industrial devices in the scope.

If this is agreed and smartphones are not in the scope, we believe the activity could be a Work Item, rather than a study (maybe a study phase followed by normative work)

Therefore we suggest the following modification:

~~Investigate and if **feasible**,~~ [Study and] specify enable UL 256QAM for FR2 (RAN4)

2 – Verizon UK Ltd

For SI or WI, it should be WI with study phase, same as Option 2.

We do not prefer both Option 1 and 3.

3 – Verizon UK Ltd

We support the objective of this work!

For either SI or WI, we support WI with study phase.

4 – AT&T GNS Belgium SPRL

Issue 1: We are OK with the moderator proposal but can also support the comments from Telecom Italia.

Issue 2: We are OK with Option 1 only if it is reworded as "**Merged into FR2 RF enhancement WI with study phase**". We are also OK with Option 2. The existing wording for Option 1 implies a study phase but it is not clear if there will be normative output for 256QAM in Rel-18.

5 – Guangdong OPPO Mobile Telecom.

Objectives are ok, and support to only consider CPE/FWA and other non smartphone types.

6 – China Telecommunications

Issue 1: We are OK with the moderator proposal and the comments from Telecom Italia.

Issue 2: We are OK with WI study phase and merged into FR2 RF enhancement WI.

7 – QUALCOMM JAPAN LLC.

Issue 1: We are ok.

Issue#2: Given the uncertainty of what gains can be achieved and the impementation difficulties, this should be a SI.

Issue#3: For the justification, it seems too early to talk about 6G.

8 – MediaTek Inc.

Thanks for Moderator's draft.

Issue#1: We are fine on make UE types clearly based on comments in initial round, [] can be further removed.

About TELECOM ITALIA S.p.A.'s modification proposal, we think study phase is needed. In this case, the follow-up would base on study result. Hence, we prefer to original statement. (i.e. Investigate and if feasible)

Issue#2: No strong view, and support study phase is needed.

9 – Apple (UK) Limited

We agree with moderator's proposed objectives. In particular, the targeted devices are CPE/FWA only. We are open to including vehicular UEs. For industry devices, since there is no clear definition in RAN4, more clarification is needed. With the objectives, a WI with study phase or a SI is OK.

10 – KDDI Corporation

Issue1: We are fine with only considering CPE/FWA only.

Issue2: Prefer option2, but option1 is also acceptable to us.

11 – Nokia Corporation

Issue 1: Ok with moderator proposal to focus CPE and FWA

Issues 2: Option 2 is our preference as commented in first round. Mainly as this involves both UE and BS.

12 – Samsung Electronics Co.

We support Moderator suggestions including "focus on CPE/FWA" and also "WI study phase and merged into FR2 RF enhancement WI"

13 – Huawei Technologies France

Issue 1: we support moderator proposal to focus on CPE and FWA, similar view as MediaTek, bracket is not needed then

Issue 2: we support moderator proposal that WI study phase and merged into FR2 RF enhancement WI

14 – vivo Communication Technology

Issue#1: We support moderator proposal to focus on CPE and FWA, with [ ] removed.

Issue#2: We support WI study phase and merged into FR2 RF enhancement WI

15 – ZTE Corporation

Issue #1: Ok to target CPE/FWA device only. We have a question for clarification, there are two power classes, i.e . PC1 and PC5 , defined for FWA type in the 38.101-2, which PC(s) should be considered?

Issue #2: For SI or WI with study item, although SI is preferred in the first round, also we can live with WI with study item.

16 – China Unicom

We support this work, and support moderator's proposal for both Issue 1 and Issue 2.

17 – LG Electronics Deutschland

Issue #1 : We are fine to add vehicle/indutrial devices in the scope.

Issue #2 : We prefer this to be merged into FR2 RF enhancement

18 – Sony Group Corporation

We support this item. We think a WI with study phase is a more proper way to go.

19 – Ericsson LM Issue #1: we are fine with moderator suggestion. Issue #2: we prefer option 2. This will require significant work on BS demodulation. It is therefore more appropriate to have this as dedicated WI with study phase.
20 – China Mobile Group Device Co. issue #2: it's suggested to be merged into UE RF FR2 enhancement WI instead of a dedicated WI
21 – NTT DOCOMO INC. Issue#1: Regarding UE device types, we would like to study the feasibility for smart phone as well at this moment. As we commented in initial round, we think FR2 full beneficial use case basically assumes LOS and relatively small coverage than that of FR1, and thus there may be performance gain for even smart phone device type. Issue#2: Our preference is option2, but we can accept option 1 and 3.
22 – Intel Corporation SAS Current objectives are ok for us. We do not see a strong need to limit to certain device types and it can be a part of studies. WI with study stage merged into FR2 RF enhancement WI is preferred (Option 2)

3.2.2 RF enhancement in FR2-1 for 39GHz band

Based on the discussion in initial round, the moderator suggests the modified proposals.

- Objective:
  - RF enhancement in FR2-1 for 39GHz band (RAN4)
    - Vehicular UE requirements for power class in 39GHz. **[Targeted band is n260].**
    - Vehicular UE requirements for inter-band DL/UL CA, e.g., 28+39GHz. **[Targeted band combination is UL CA n257+n260 with IBM]**
- Justification:
  - **the vehicular UE can be the potential use case for FR2.**
  - **Regarding the 39GHz, n260(above 37GHz(40GHz)) is in planning from government around 2025~2026. Considering that the completion of Rel-18 is the end of 2023, Rel-19 is late to meet this schedule in advance.**
- SI or WI (or WI with study phase) if approved:

- WI
- Dedicated WI or merged into UE RF FR2 enhancement WI including other objectives?

- Potential impact to other WG(s):
  - **No**

Please provide further feedbacks on the above proposals:

Issue#1: Check if the targeted band and band combination is correctly captured, and collect further comments on the demands.

Issue#2: For "Dedicated WI or merged into UE RF FR2 enhancement WI including other objectives?", the moderator sees the views are still divided. Companies are encouraged to show any compromise or detailed reasons.

Issue#3: Other (General comments)

Feedback Form 13:

1 – Verizon UK Ltd

1. The objective is fine for us. And, the case of UL CA n260+n261 should be in the target of this work.
2. The justification is fine also. Mainly, this work should be in Rel-18.
3. For either SI or WI, in our view a separate WI could be considered.

2 – QUALCOMM JAPAN LLC.

Issue#3: given that 28GHz is already available but there are no devices, the justification that this will be needed for 2 bands in a few years seems very weak to us.

Issue#2: no strong vew from us.

3 – MediaTek Inc.

If justification is strong enough, we'd like to make objective be more precise/direct and align prior wording in FR2 enhancement WI, and also further consider Verizon's band combination demand input:

Issue#1: modification suggestion:

- RF enhancement in FR2-1 for **PC2 (Vehicular UE) n260 (39GHz)** (RAN4)
  - requirements for power class in **n260 (39GHz)**.
  - **requirements for inter-band UL CA with IBM between different frequency groups**
    - **n257+n260**

- **n261+n260**

4 – Nokia Corporation

Issue 2: Dedicated WI if approved

Issue 3: We do not see urgent need for this in REL18

5 – ZTE Corporation

It was mentioned inter-band DL/UL CA, however, it seems it is still unclear the BM type in inter-band DL CA

6 – LG Uplus

Thanks moderator for organizing nicely, some comments for band range and commercial interests as follows :

-From justification section, ”n260(above 37GHz(40GHz))” should be ”n260(above 37GHz(37-40GHz))” where maybe dash(-)is removed. Anyway the wording can be improved later.

-For commercial interest, clearly this is not such topic that solve existing or expected problem like MSD, NBC CR, SIB read fail issue and intra-band non-collocation issue. However if the problem and use case is just ahead and you want to solve by 3GPP standard, the timeline will not meet the situation. You will be late and the window is more than a year at least where we consider the time gap between 3GPP spec and commercial.

-Anyway, from the practicality point of view raised from Vali(Qualcomm) and many companies which I want to admire always, I also wonder the views from the operators who have already 39GHz. (Verizon already shared the view)

-No strong view either FR2 or separated one, but slight more prefer separated item

7 – LG Electronics Deutschland

Issue #1 : Fine with MediaTek’s proposal with following small modification where n260 is proposed to be changed to n259 for the alignment with Rel-17 UL CA n257+n259 with IBM

- RF enhancement in FR2-1 for PC2 (Vehicular UE) **n259 (39GHz)** (RAN4)
  - requirements for power class **2** in **n259 (39GHz)**.
  - requirements for inter-band UL CA with IBM between different frequency groups
    - n257+**n259**
    - n261+n260

Issue #2: Prefer to merge this objective into FR2 RF enhancement considering the required amount of work is not that high and dedicated WI can increase the project management effort from RAN4 workload perspective

8 – Sony Group Corporation

We are fine with this item, and think it is more feasible to merged into FR2 RF enhancement

9 – Samsung Electronics Co. We support Moderator proposal on objectives and justifications. We do not have strong view on either including in FR2 UE RF or dedicated WI.
10 – China Mobile Group Device Co. issue #2: it's suggested to be merged into UE RF FR2 enhancement WI instead of a dedicated WI
11 – Intel Corporation SAS Taking into consideration KT and LG Uplus comments we are ok with this work. The proposed updates from MTK look fine for us.

3.2.3 Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1

Based on the discussion in initial round, the moderator suggests the modified proposals.

- Objective:
  - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators'requests (RAN4)
    - **Study and if feasible,** define RF requirement(s) for support of inter-band UL CA **for same frequency group and different frequency groups** 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 CB**M** is available
    - **[NOTE: Rel-17 leftover should be added if not finished in Rel-17. Potential leftovers are DL CA with CBM. DL CA within same frequency group with IBM. UL CA with IBM.]**
- Justification:
  - **CA is important feature for all 3GPP RATs**
- SI or WI (or WI with study phase) if approved:
  - **WI**
  - **Merged into UE RF FR2 enhancement WI including other objectives**
- Potential impact to other WG(s):
  - **[For Rel-17 leftover topics, potential impact to WG2 unless Rel17 WI completes certain features which need new UE capabilities.]**

Please provide further feedbacks on the above proposals:

- Issue#1: Other (General comments)

Feedback Form 14:

1 – Guangdong OPPO Mobile Telecom.

Example band combinations should be clear in the objective part to justify that there is demand at least. If no demands there is no need for RAN4 to consider it.

2 – QUALCOMM JAPAN LLC.

As commented before, there should be band combination proposals to do this work.

3 – MediaTek Inc.

In general, we still advocate exact band combination **demand** is needed before do requirement discussion in RAN4, and we don't prefer define requirement for **example** band combination, because it's not practical demand. We think current first bullet "*depending on operators' requests*" can reflect this wish/thought.

Furthermore, we'd like to rephrase **potentialRel-17 leftover** part to make it clearer:

- ***[****NOTE: Rel-17 leftover should be added if not finished in Rel-17. Potential leftovers are:*
  - *DL CA with IBM within same frequency group*
  - *DL CA with CBM for same frequency group and different frequency groups*
  - *UL CA with IBM for different frequency groups****]***

Moreover, we'd like to further raise a higher-level open issue for discussion about "***within same frequency group***" demand, no matter DL/UL with IBM/CBM. In Rel-17 period, no demand is shown, even if we tried to get input from operators couple of times. We are curiously about do we really need to still leave the **possibility** in Rel-18 WID objective?

4 – Apple (UK) Limited

The proposed objectives are OK. However, we'd like to note if there is no operator requests on band combinations for inter-band UL CA based on CBM, this objective should be removed.

5 – Nokia Corporation

We agree that for REL18 we need to have operator request before RAN4 starts the work, this is lessons learned from REL17. If there are many left overs from REL17 then we could consider even dropping the the UL CA with CBM objective as UL CA with IBM should be prioritized.

6 – Huawei Technologies France In general we are of with the objectives. Example band combinations or specific requests are both fine for us.
7 – ZTE Corporation Band combination and the coresponding power class should be clear first.
8 – LG Electronics Deutschland We are fine with the objectives and as commented in the first round, there is already an existing band combo of n257+n259 in Rel-17 inter-band UL CA. IBM or CBM is not the scope of band combo request, from our perspective.
9 – Sony Group Corporation our understanding is that IBM/CBM is not part of band combo request, but it is a UE capability.
10 – Ericsson LM If there is no request from any operator then this should be down prioritized.
11 – China Mobile Group Device Co. it's suggested to be merged into UE RF FR2 enhancement WI instead of a dedicated WI
12 – NTT DOCOMO INC. As we commented in initial round, our interests are on UL CA different frequency group of n257+n259 with IBM which is being discussed in Rel-17.
13 – Intel Corporation SAS We share other companies views that there should be explicit BC request for inter-band UL CBM and we prefer to remove it. With respect to leftover issues – we think that RAN4 should strive to complete the work in Rel-17 and avoid prolonging the discussion to the next release. It is premature to discuss the leftovers.

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

Based on the discussion in initial round, the moderator suggests the modified proposals.

- Objective:
  - 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 **inter**-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

NOTE: This work should be based on band combination proposals from operators. If there are no proposals then there is no need to discuss this further for the time being.

The moderator think we can close this discussion at least this week. The feedback form is provided just in case.

Feedback Form 15:

1 – TELECOM ITALIA S.p.A. In our understanding there were a lot of concerns on this proposal and no input from operators. We strongly suggest to drop the feature
2 – Guangdong OPPO Mobile Telecom. Example band combinations should be clear in the objective part to justify that there is demand at least. If no demands there is no need for RAN4 to consider it.
3 – MediaTek Inc. We do support this ”**NOTE: This work should be based on band combination proposals from operators. If there are no proposals then there is no need to discuss this further for the time being.**” If there is no exact operator’s demand shared, we are fine to drop this quite open objective directly.
4 – Nokia Corporation We support dropping this topic from REL18.
5 – ZTE Corporation Band combination and the power class should be clear first. If no demands for now, we also support to drop this topic in Rel-18
6 – Ericsson LM We also suggest to drop this objective especially due to lack of interest from operators so far
7 – vivo Communication Technology We also support to drop this item.
8 – Intel Corporation SAS We are ok with moderator proposal

3.2.5 Enhanced switching time (ON/ON transient time)

Based on the discussion in initial round, the moderator suggests the modified proposals.

- Objective:
  - Enhanced switching time (ON/ON transient time)
    - Investigate (gain) and if possible, enhance FR2-1 and FR2-2 switching time (ON/ON transient time)
    - **[reuse the conclusions in FR1 transient period capability discussion as much as possible]**
- Justification:
  - **Enhanced switching time (ON/ON transient time) would be beneficial from network point of view. ON/ON transient time has a significant impact on UL performance, especially for high SCS (480/960kHz) scenarios in FR2-2 and FR2-1. Improved UE capabilities to support up to 1us ON/ON transient period can be considered for FR2, similar to FR1.**
- SI or WI (or WI with study phase) if approved:
  - **WI with study phase**
  - **[Merged into UE RF FR2 enhancement WI including other objectives]**
- Potential impact to other WG(s):
  - **No**

[NOTE: Further updated may be needed based on the outcome of Rel-17 discussion.]

Please provide further feedbacks on the above proposals:

- Issue#1: For "[Merged into UE RF FR2 enhancement WI including other objectives]", the moderator sees the views are still divided. Companies are encouraged to show any compromise or detailed reasons.
- Issue#2: Is there any feedback to question from OPPO
  - For clarification, is the same enhancement as FR1 transient period capability? If it is, what is the target enhanced switching time?
- Issue#3: Other (General comments)

Feedback Form 16:

1 – TELECOM ITALIA S.p.A.

Due to the overall workload and the lack of real use cases, we strongly suggest to drop FR2-2. In General, no issue if the all features is dropped out of Rel 18.

If no agreement in Rel 17, we strongly doubt it could be easy to reach consensus in rel 18 (therefore leading to a lot of discussion and in general a waste of resources)

2 – AT&T GNS Belgium SPRL

Issue #1: We support the proposal.

Issue #2: We prefer to investigate the gain associated with a range of enhanced switching time (1us to 3us) to determine the appropriate value as part of the objective first sub-bullet.

Issue #3: We would prefer to update the objective second sub-bullet as follows, ”[consider the conclusions in FR1 transient period capability discussion as much as possible]”

3 – Guangdong OPPO Mobile Telecom.

Not clear how much gain can be achieved, in FR1 it is improved from 10us to 2us at most and the benefit is understood, but for FR2 how much can be improved from current 5us is unknown. Thus we suggest to deprioritize this work in Rel-18.

4 – Apple (UK) Limited

It is better to wait until R17 discussions conclude. If R17 reaches no agreement on improved switching time, a study can be opened in R18. However, we wonder if FR2-1 needs to considered, since the discussion came up during the FR2-2 480/960kHz SCS discussion.

5 – MediaTek Inc.

Issue#2

”Consider” (proposed by AT&T) would be better than ”**Reuse**”

Issue#3

1) ”Wait for Rel-17 discussion conclusion” is made sense for us.

2) Based on the justification *”ON/ON transient time has a significant impact on UL performance, especially for **high SCS (480/960kHz)** scenarios in FR2-2 and FR2-1”, we are curious about do we really also need to consider FR2-1.*

6 – Nokia Corporation

We should wait REL17 discussion outcome and come back to this in RAN#95e.

7 – ZTE Corporation

Waiting for the Rel-17 discussion outcome is fine to us. If it is not done in Rel-17, then we support this work should be done in Rel-18.

8 – Huawei Technologies France

We are also ok to wait for the Rel-17 discussion conclusion. In our understanding, the implemenation for FR2 has no big change from previous release.

9 – Ericsson LM We also fine to wait for the R17 conclusion. If this is not done in R17 then it can be included in R18
10 – Intel Corporation SAS **Issue #1:** Overall we do not see much need to discuss the WI structure at the moment or split the FR2 discussion into many different items. Once the objectives are stable further decision on a WI structure can be made. **Issue #2:** The focus is to improve ON/ON transient period and introduce an optional UE capability. The target enhanced switching time is up to 1us **Issue #3:** We are ok with proposed objectives. With respect to reusing FR1 conclusions – we think that the wording can cause some ambiguity during WI discussion. If companies insist, we can accept such wording as a Note.

3.2.6 UE antenna scaling

Based on the discussion in initial round, the moderator suggests the modified proposals.

- Objective:
  - 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
- Justification:
  - TBD
- SI or WI (or WI with study phase) if approved:
  - **WI**
  - **Merged into UE RF FR2 enhancement WI including other objectives**
- Potential impact to other WG(s):
  - **Potential impact to WG2 if new signalling is needed.**

Please provide further feedbacks on the above proposals:

Issue#1: Any feedback to question in initial round?

- Current overheating assistance information, allows UE to indicate the reduced BW, CC number and MIMO layer. Does antenna scaling can be covered by these information or something new need to be introduced?

- Not sure whether there is impact to RAN1 beam management and power control since reduce antenna elements may cause the beam changes?
- What problem we are trying to solve? what is the benefit?
- For the network side, what is the difference between a change in the number of elements used or a switch to a different UL Tx beam with less gain?
- Would new requirements be defined for UEs who support this scaling?

Issue#2: Other (General comments)

Feedback Form 17:

1 – TELECOM ITALIA S.p.A.

Looking to the feedbacks provided in the initial round most companies believe there is no need to specify this feature (several companies indicate it is implementation dependent).

We recommend to drop it from Rel 18 to optimize the workload in RAN4

2 – Guangdong OPPO Mobile Telecom.

Ok with majority view to deprioritize this topic and leave it to UE implementation.

3 – QUALCOMM JAPAN LLC.

Issue#1: Overheating is a different issue, we do not think this should be merged. So far, it wasn't shown what real issue is being solved. Power changes can happen for multiple reasons, especially in FR2 where beams can be switched very often and the power difference between different beams can be quite large.

4 – Apple (UK) Limited

Many thanks for the comments in the first round. Please see our clarification below.

Issue 1 (objective):

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

- Quantify the impact on network performance by the UE performing antenna scaling
- Identify potential solutions to mitigate the impact of autonomous UE antenna scaling on NW performance
- Identify the impact of UE antenna scaling on UE RF requirements (e.g. TPC, max input level) and the associated testability
- Identify the potential impact on other WGs

Issue 2 (justification):

Any UE implementation can enable and disable tx/rx chains driving the corresponding FR2 antenna elements transparently to the network, and we do observe this behavior in the field. The motivation for this study is rooted in the observation that when the UE performs this scaling autonomously, there is a delay until the network knows by receiving UE measurement report or PHR report. The cause for performance degradation is how fast the UE can inform the network of its scaling with such reports. Before the network

receives such updates, the network would rely on previous reports and there is a mismatch between what the network assumes and what the UE uses, which leads to performance degradation. The major questions here are how much degradation in system performance does transparent antenna scaling involve, and how this degradation can be mitigated.

Issue 3 (SI or WI)

study objective in the UE RF FR2 enhancement WI

Issue 4 (Potential impact to other WG(s))

include in the study objective

Issue 5

We set up some preliminary system level simulations to quantify the gain loss resulting from autonomous antenna scaling in two scenarios: when the UE scales the number of antenna elements down (e.g. 4 -> 2) and when the UE scales the number of antenna elements up (e.g. 2 -> 4). When the UE performs this scaling, it must rely on a fixed beam mapping to select a beam in the new codebook, and this leads to suboptimal beam selection. In the 4->2 case, we observe coupling gain loss <0.5 dB for 60% of the users, and in the 2->4 case, we observe coupling gain loss >1.0 dB for 20% of the users. We also focused on the 2->4 case by performing a preliminary analysis of throughput. In the case of scaling without beam refinment, each UE follows these steps: (1) select best beam based on 2-element codebook, (2) select a beam in the 4-element codebook according to a predetermined mapping from the selected beam from the 2-element codebook, (3) scale Pout down by 3 dB. In this simulation the %TPT loss for average (50th %-tile) users and cell edge (5%-tile) users is >45%. We think a more rigorous study of network performance with such UEs is beneficial, and a discussion of possible solutions to mitigate such performance loss can be helpful.

To answer the questions:

Regarding UE assistance information: we think that extension of UE assistance information can be one possible solution to let the UE inform the network about antenna scaling, and such a discussion should be possible within the proposed study objectives

Regarding possible impact on beam management/power control: as part of the study, we should quantify how these procedures are impacted; in our understanding, if the network becomes aware of the UE antenna scaling operation, then it can apply existing procedures to maintain beam management and power control.

Regarding problem/benefit: based on our preliminary study, we understand that network performance is not optimal when the UE performs antenna scaling autonomously; the problem statement is to quantify by the overall performance degradation and to determine whether a solution is feasible.

Regarding ”what is the difference between a change in the number of elements used or a switch to a different UL Tx beam with less gain,” it is the correct understanding that the network has no way to distinguish antenna scaling from different (perhaps, suboptimal) UL beam selection. The aim is to quantify this difference and to determine whether a solution is feasible to ”give back” this performance delta to the network.

Regarding ”would new requirements be defined for UEs who support this scaling?” we are currently suggesting a study to quantify the performance impact and to determine feasible solutions. If this process concludes with a positive outcome well within the Rel-18 timeline, then we could come back to RAN with a proposal for a WI. But the study by itself would not impact requirements.

5 – Nokia Corporation From our perspective it is ok to drop this from REL18. There seems not to be much interest for the feature.
6 – Ericsson LM We also suggest to drop this objective.
7 – ZTE Corporation Ok with majority view to deprioritize/drop this topic and leave it to UE implementation.
8 – China Mobile Group Device Co. it's suggested to be merged into UE RF FR2 enhancement WI instead of a dedicated WI

3.2.7 Beam correspondence requirements for RRC_INACTIVE and initial access

Based on the discussion in initial round, the moderator suggests the modified proposals.

- Objective:
  - Beam correspondence requirements for RRC_INACTIVE and initial access
    - **[Specify UE beam correspondence requirements for initial access and RRC_INACTIVE state [RAN4 RF]**
    - **SSB-based without UL beam sweeping**
    - **For RRC_INACTIVE at least requirements for Random Access SDT and Configured Grant SDT**
    - **For initial access, verification of beam correspondence requirements based on msg1 spherical coverag**e (at least)
    - **Study the potential impact on testability aspects (i.e., test time).]**
- Justification:
  - **[UE beam correspondence functionality for RRCCONNECTED, RRCINACTIVE and initial access in IDLE is specified in the RAN1 and RAN2 specifications already in Release 15 but no FR2 UE beam correspondence requirements have been defined for RRCINACTIVE and initial access in IDLE yet. The current UE beam correspondence requirements are only defined for RRCCONNECTED. Without UE beam correspondence requirements for RRC_INACTIVE and initial access it is not possible to ensure good UE RACH and msg1 performance and UL coverage in FR2 deployments due to varying UE performances.**
  - **Rel-15 RRCINACTIVE and Rel-17 small data transmission (SDT) have a large potential in UE power efficiency, latency and signalling overhead reduction. RRCINACTIVE allows for reduced latency and UE power saving, while SDT further enhances this for small data sessions. Considering that 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 RRCINACTIVE and Small Data Transmissions for FR2 as well. Without well performing UE beam correspondence support wide usage of RRCINACTIVE and Small Data Transmission may not be feasible in practical FR2 deployments.

  - **To enable efficient use of RRCINACTIVE and Small Data Transmission in FR2 deployments to save UE power with reasonable latencies we see it important to develop FR2 UE beam correspondence requirements for RRCINACTIVE in Rel-18.]**

- SI or WI (or WI with study phase) if approved:
  - **[WI with study phase]**
  - **Merged into UE RF FR2 enhancement WI including other objectives**
- Potential impact to other WG(s):
  - **No impact to RAN1 and RAN2. Additional test cases may be defined for the RAN5 test specifications.**
  -

Please provide further feedbacks on the above proposals:

- Issue#1: Other (General comments)
- Issue#2: Any feedback to question from Apple?
  - It would be helpful to understand what requirements are being considered, RF requirements like the current R15/16 BC requirements or some RRM requirements with a delay constraint?
  -

Feedback Form 18:

1 – TELECOM ITALIA S.p.A. We are ok with the proposed objective, and therefore are ok with removing the square brackets
2 – Verizon UK Ltd We support the objective (even without brackets) and are okay with the justification of this item. For either SI or WI, we agree to marge this to the UE RF FR2 enhancement WI.
3 – AT&T GNS Belgium SPRL Issue #1: We support the proposed justification and objective. Please remove the brackets. We are OK with either ”WI with study phase” or ”Merged into UE RF FR2 enhancement WI including other objectives” with a preference for the latter option.
4 – Guangdong OPPO Mobile Telecom. In our view it is not justified to specified addtional requirements for beam correspondence in initial access stage. As commented in 1st round, we understand the motivation and agree with importance for UE to do

fast beam management in the initial access, however, we are not convenced to introduce requirements and test cases for initial access.

The beam correspondence is very basic behavior for UE to do beam selection and the process is straight forward that UE measure DL RS to select the best Rx beam then mapping to Tx beam. This process has already been verified in connected mode we don't see the reason to re-introduce requirements for initial access. Beam correspondence is introduced since R15, if there is problem in the initial access then the UEs on the market already suffers from that, but we didn't notice that in the field.

Therefore, in our view, this is over defining requirements in RAN4.

5 – QUALCOMM JAPAN LLC.

Issue#1: we agree with the proposed objectives.

Issue#2: in our understanding, this is just about defining RF requirements similarly to earlier releases. RRM requirements/tests are separate.

6 – Apple (UK) Limited

We would like to get direct responses for our comments below in the first round before discussing the detailed objectives.

1) it is unclear if the UE will exhibit a different behavior in RRC*CONNECTED vs. RRC*INACTIVE and initial access. It is also not clear whether additional requirements are needed. Some field data on different UE behaviors in RRC*CONNECTED vs. RRC*INACTIVE and initial access would be useful.

2) We would also like to understand if testability is an issue, since it was raised during R16 BC discussion (especially if the discussion proceeds on a path toward new spherical coverage requirements for RACH, for example).

In addition, we would like to ask the proponent companies to help clarify further the concern stated in the justification, i.e. UE's RACH transmissions being potentially lost. In the past, we have seen this proposal in RAN4 appear in the context of mandatory/optional discussions related to Rel-16 beam correspondence enhancements as well as in the context of transmit power control enhancements. If the problem statement can be summarized in these terms (e.g. mandatory beam correspondence based on SSB can help to alleviate the concern with RACH transmissions being potentially lost, or the large tolerance of open loop power control raises the concern that RACH transmissions may not have sufficient power to be received by the network reliably), then this could help us find a technical solution.

7 – SoftBank Corp.

We are fine with the modified proposals.

8 – KDDI Corporation

Issue1: We are fine with the proposed objectives/justification.

Issue2: We share the view with Qualcomm, just about defining RF requirements similarly to earlier releases.

9 – Nokia Corporation

#Issue 1: We support with the moderator's proposal for the objectives, justification and WI with study phase where the BC work is merged into UE RF FR2 enhancement WI. In our view the square brackets can be removed both from the objectives and justification text.

#Issue 2: We agree with Qualcomm's view thatthis work is intended for defining RF requirements similarly as in the earlier releases. This is also mentioned in the objective proposal as follows "[RAN4 RF]"

To Apple: 1) The intention is to define UE requirements for RRC*INACTIVE and initial access based on technical work in RAN4. The proposed objectives do not say whether the requirements for RRC*INACTIVE and Initial access should be the same or different from the current RRC_CONNECTED state BC requirements. This is up to RAN4 work and discussions. 2) Testability aspect is already indicated in the proposed objective as study phase and this is also technical work and discussion for RAN4. The last comment/question from Apple is not clear to us. The intention is to first define requirements and not discuss mandatory/optional aspects especially as unfortunately these requirements are only defined in Rel-18 rather than in Rel-15, which means that there are likely to be legacy UEs, which may not perform optimally.

10 – MediaTek Inc.

As commented in initial round, we actually not so not worry on this potential issue because of observation by commercial case, but worry the extra benefit versus test loading.

If the justification is strong enough, we still would like to propose below modifications:

- **[Study and specify necessary** beam correspondence requirements**/verification** for RRC_INACTIVE and initial access
  - Specify UE beam correspondence requirements for initial access and RRC_INACTIVE state, **for the UE support SSB-based without UL beam sweeping** [RAN4 RF]
    - For initial access, at least **necessary** verification of beam correspondence requirements based on msg1 spherical coverage
    - For RRC_INACTIVE at least **necessary** requirements for Random Access SDT and Configured Grant SDT
  - Study the potential impact on testability aspects (i.e., test time).**]**

Moreover, we have one clarification question on what's the difference between "verification" and "requirement":

- **verification** based on msg1 spherical coverage
- **requirement** for SDT

Be more specific,

- Does **verification** imply the spherical EIRP requirement **value** would be same as normal test case, but just different test condition?
- Does **requirement** imply potential **new requirement framework/value** would be needed?

Further modification based on clarification would be needed.

11 – Ericsson LM

We are also fine with the objective and OK to remove the brackets. It should an objective in the FR2 enhancement WI.

12 – ZTE Corporation

We are ok with the proposed objective and ok to remove the [ ].

13 – Huawei Technologies France

We have similar concern as Apple for the issues related to RRC_inactive and initial access. And seems our comments are not reflected in the revised proposals at all. Thus we recopy our first round comments as below:

Firstly, 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.

Secondly, beam correspondence requirement is used to describe the UE ability to maintain the UL beam direction corresponding to DL beam selection, which is generally decided by UL and DL RF matching/-correspondence design. It actually has little relation with which RRC state the UE is in. It means one verification test under a typical configuration(RMC) is enough to cover other cases when UE is required to select Tx beam by Beam correspondence.

In addtion, for Random access SDT, there is no agreement in RAN1 on how UE decide the Tx beam for the msg1 and msg3(or msgA for 2 step RACH) as discussed before. And there is also no conclusion in RAN1 how UE decide the beam for DCI transfer and subsequent data transmission.

14 – LG Electronics Deutschland

As commented in the 1st round, the issues of whether additional requirement and testing for BC in initial access and RRC_INACTIVE are necessary or bring benefit, are not clear to us. And extra effort for test&verification can bring additional cost to vendors. In this respect, we share the similar view with Apple, Oppo and MediaTek.

15 – LG Uplus

We are fine with the proposed objectives.

16 – Sony Group Corporation

We support this item. As we mentioned in the first round, the current beam correspondence for initial access and idle mode is dependent on UE implementation. However, from the specification wise, we have no requirement to ensure the UE performance in such a scenario. Therefore, this missing piece should be filled as soon as possible.

Also, in RRC connected mode, UE can rely on uplink beam sweeping but not in initial access, which makes the beam correspondence become more critical for initial access.

Moreover, the current beam correspondence test in connected mode can not ensure the similarity between the Tx and Rx beam, but only the Tx power level towards a given direction. So it may not sufficient to verify the beam correspondence during initial access.

17 – Samsung Electronics Co.

We support moderator proposals

18 – NTT DOCOMO INC.

We support the proposal, and agree that the work should be merged into FR2 RF enhancement WI with study phase.

19 – China Mobile Group Device Co.

it's suggested to be merged into UE RF FR2 enhancement WI instead of a dedicated WI

20 – Intel Corporation SAS

Issue #1: Based on the 1st round conclusions for "Spherical coverage topic" moderator concluded that objective can be merged with "1.7 Beam correspondence requirements for RRC_INACTIVE and initial access". In this case we suggest clarifying that the objective shall aim to "Define Beam correspondence and spherical coverage requirements for RRC_INACTIVE and initial access"

Issue #2: We think that the focus shall be on RF requirements and no impact to RRM

21 – ZTE Corporation

Sorry to revert the previous comments.

Basically, we are fine with most of the objectives except for this one 'For RRC*INACTIVE at least requirements for Random Access SDT and Configured Grant SDT', we think the RRC*INACTIVE can not specific only to SDT transmission. So we suggest to not specific only to SDT transmission, which is both Random Access SDT and Configured Grant SDT are considered, other transmission with inactive mode are not precluded.

3.2.8 Power-control tolerance

Based on the discussion in initial round, the moderator suggests the modified proposals.

- Objective:

- Power-control tolerance
  - **Investigate and if possible,** improve both absolute and relative tolerances for power control in FR2 to enhance performance.

- Justification:
  - ~~**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.

- SI or WI (or WI with study phase) if approved:
  - **WI**
  - **Merged into UE RF FR2 enhancement WI including other objectives**

- Potential impact to other WG(s):
  - **No RAN1 and RAN2 impact. RAN5 may needs to take into account improved tolerances.**

Please provide further feedbacks on the above proposals:

- Issue#1: Other (General comments)
-

Feedback Form 19:

1 – TELECOM ITALIA S.p.A. We are ok with the proposal
2 – Verizon UK Ltd We support this both objective and justification considering the power tolerance is a fundamental requirement for the performance
3 – Guangdong OPPO Mobile Telecom. In our view there is no much improvements for UE in FR2 power control comparing to Rel-15, and don't see how this can be improved in implementation. Without UE improvements it is not justified to further tighten UE requirements. Therefore, suggest to drop this topic comparing to other real demands in NW.
4 – Apple (UK) Limited We have seen this proposal in RAN4 during the Rel-16 discussions, and we understand that it is related to the previous proposal for beam correspondence for RACH. On the other hand, this issue presents a more focused problem statement. While it is true that in FR2 we have defined open loop power control tolerance to be a larger value than in FR1; however, this requirement was derived and well justified by practical implementation constraints, such as greater RSRP accuracy tolerance in FR2 vs FR1 and greater output power accuracy tolerance. Together, these parameters have yielded the requirement as it has been defined

since Rel-15. As we had described in R4-2106909 and R4-2112384 (with FR2 field data), open loop power control for PRACH can be replaced by a requirement for the UE to transmit with Pcmax (i.e. removing OL TPC from PRACH). This would immediately reduce the output power tolerance for PRACH. We would like to propose this solution as an alternative way forward for both this issue and the previous one.

5 – QUALCOMM JAPAN LLC.

It doesn't seem like signficant improvements are possible, we should in general avoid such "investigate and if possible" objectives such that we do not waste time

6 – Nokia Corporation

If TU are available this could be considered. However may be difficult to achieve agreements for notable improvement.

7 – MediaTek Inc.

Thanks for Moderator's draft. We don't have large expectation on the final potential contribution. Compared to other new feature objectives, drop this improvement objective would be preferred.

Just a slight comment, change "**possible"** to "**feasible"** would be preferred as other objectives' wording.

- *"Investigate and if **feasible**"*

8 – Ericsson LM

We support this objective. Updated wording by Mediatek is fine for us.

9 – Huawei Technologies France

Since there is no obvious improvement for the UE implemenation from previous releases, we dont expect any new conclusion could be made for the objective. Prefer to drop the topic in Rel-18.

10 – China Mobile Group Device Co.

it's suggested to be merged into UE RF FR2 enhancement WI instead of a dedicated WI

11 – Intel Corporation SAS

As commented in the initial round we think this objective has a low priority and needs to be dropped to allow sufficient capacity to proceed with the work on other topics.

3.2.9 New proposals on achieving better FR2 coverage and/or performance

In initial round, the following new proposals are provided. The moderator tries to collect companies' comment on this objective in intermediate round.

- Objective(R4-2200287)
  - 1) maxUplinkDutyCycle-FR2 reporting, dynamic or semi-static, which would provide the network timely update to assist scheduling

- 2) Better granularity of P-MPR reporting from UE
- 3) Possible enhancements to R17 beam-specific P-MPR reporting

- Justification
  - 1)In R15/16, maxUplinkDutyCycle-FR2 is reported as part of UE RF capability. Once reported, there is no further update. While dynamic max. UL duty cycle reporting was discussed in R15/R16, there was no consideration of the possible use of body proximity sensor (BPS) to detect if a human tissue is close-by and then decide if P-MPR is needed. With BPS, the use of dynamic maxUplinkDutyCycle-FR2 reporting is more targeted and useful. For instance, instead of incurring a large P-MPR, a UE at the cell edge can rely on a smaller duty cycle to transmit with a high power and still meet MPE requirements.
  - 2)Optional P-MPR reporting was added in R16 so UE can inform gNB of the required P-MPR values for MPE compliance, but the granularity (3dB per notch) can be further improved.
  - 3)
    - A) based on RAN1 agreements, it is not guaranteed that the L1-RSRP of the associated SSBRI/CRI is always reported. In this case, the value of per-beam PMRP reporting is questionable.
    - B) In RAN1 discussion, body proximity sensing capability is assumed when per-beam PMPR reporting is introduced. From UL performance perspective, for the same SSBRI/CRI, UE can have different strategy to report P-MPR depending on human body approximation. If there is no human target around, UE should select the beam with the best EIRP in UL or L1-RSRP in DL and the corresponding P-MPR is reported. When there is human body approximate, the beam with maximum (L1-RSRP-P-MPR) should be selected and reported. Obviously, reporting a single P-MPR per SSBRI/CRI are not sufficient for MPE and UL performance enhancement.

- WI or SI
  - Merged into FR2 RF enhancement WI

- Impact to other WG(s)
  - TBD
  -

Feedback Form 20:

1 – Guangdong OPPO Mobile Telecom.

1. For the maxUplinkdutycycle-FR2 capability, the dyanmic reporting was considered and discussed widely in Rel-15/16 although at that time is in FR1. However, FR1 UE at that time people brought out the case that sensors are implemented in many UEs to detect the human body (similar as BPS) and then UE can dynamicly change the duty cycle capability, but unfortunately this discussion fallen into dilemma and no conclusion can be reached. If re-initiate the discussion in FR2 R18, these situations needs to be avoided.

2. Better granularity PMPR reporting is no need in our view, this has been discussed from the beginning of PMPR reporting signaling design in Rel-16.

3. Rel-17 beam specific PMPR reporting seems also been discussed in Rel-17 FeMIMO, but no conclusion what will be changed comparing to current PMPR reporting and how UE actaully will report in the NW. More discussion might be needed.

2 – Apple (UK) Limited

Thanks for the comments from Nokia. Below is our response:

1) We do not support introduction of changing (dynamic or semi-static) maxUplinkDutyCycle-FR2 reporting as it limits network scheduling flexibility for different UEs and therefore, degrades system performance…

Response: We understand the possible impact on network scheduling. For networks that consider the static maxUplinkDutyCycle-FR2 reporting in scheduling, we believe the increased overhead is manageable. However, the gain is significant for cell edge UEs because they may lose the coverage with a large P-MPR. To evaluate the pros and cons, we are open to have some study phase first.

2) The proposed objective is related to the ongoing Rel-17 work on MIMO enhancements, which is not yet complete yet. Enhancements should only be considered once the Rel-17 work is complete. Furthermore, considering that this type of enhancement was done under the Rel-17 MIMO work item, it would also be better to consider related enhancements under the Rel-18 MIMO work item after the Rel-17 work is completed and enhancements can be assessed.

Response: As this objective is related to UE MPE compliance, we thought it is better to lump relevant objectives together. In addition, it is unclear if we can add it to the R18 MIMO WI, which is a RAN1-led WI and has no MPE-targeted objective.

To OPPO, thanks for your comments and we agree some details can be discussed during the WI.

3 – QUALCOMM JAPAN LLC.

All these proposals are minor improvements to what has been done so far, the performance gains are not clear. The objectives are also not very clear, we should not venture do to ”possible improvements”.

4 – Nokia Corporation

Our views on the new proposals 1), 2) and 3)

- we do not support to define objectives maxUplinkDutyCycle-FR2 reporting, dynamic or semi-static. Dynamic or semi-static maxUplinkDutyCycle-FR2 would limit network scheduling flexibility for different UEs and therefore, degrades system performance. Furthermore, change in maxUplinkDutyCycle-FR2 is not the only way of reducing UE’s P-MPRs. The network has already multiple ways to to reduce date rates in UL if UE’s UL performance like UL power is reducing. Therefore, Dynamic or semi-static maxUplinkDutyCycle-FR2 is not needed for UL coverage reasons.
- it is ok for us to improve granularity of P-MPR reporting from UE and if this is agreed to be done, it can be included to the FR2 RF enhancement WI
- The proposed objective is related to the ongoing Rel-17 work on MIMO enhancements, which is not yet complete yet. Enhancements should only be considered once the Rel-17 work is complete. Furthermore, considering that this type of enhancement was done under the Rel-17 MIMO work item, it would also be better to consider related enhancements under the Rel-18 MIMO work item after the

Rel-17 work is completed and enhancements can be assessed. Therefore, at this point of time we do not support this proposal.

5 – MediaTek Inc.

We'd like to share our views on each objective:

- No strong view. From UE performance perspective, we understand the motivation. However, network mechanism's view (shared by Nokia) is also important.
- Okay to improve granularity of P-MPR reporting.
- We understand the motivation, but just would like to clarify whether UEs already can report different P-MPR values based on beam etc like UE implementation.

6 – Sony Group Corporation

We don't see the need the of introducing dynamic uplink duty cycle as we already have dynamic PMPR reporting, and the network can derive feasible uplink duty cycle from the reported PMPR values and the existing static UE capability maxUplinkDutyCycle-FR2 since MPE (e.g. power density), power level and uplink duty cycle are in linear relations.

it is also questionable to us how much practical gain we can expect from increase the PMPR report granularity considering the current UE power control tolerance is so large in FR2.

It is unclear to us what kind of enhancements to R17 beam-specific P-MPR reporting, clarification is needed.

7 – Ericsson LM

On item 1) we do not see much benefit of dynamic or semi-static maxUplinkDutyCycle-FR2.

On item 2), the main problem is that power control tolerance is quite course. So defining signaling with granularity less than 3 dB will not be very useful. It is better to first improve the power control tolerance and revisit granularity of P-MPR reporting at later stage.

On item 3) It is not needed since it is related to ongoing FeMIMO WI.

3.3 Topic #14 Requirement for FR2 multi-Rx chain DL reception

3.3.1 multi-Rx chain DL reception

Based on the discussion in initial round, the moderator suggests the modified proposals.

The moderator tries to reflect the proposals provided from different companies, but some proposals may be conflicted. Companies are encouraged to check the following proposals, and give any feedback to converge the objectives.

- Objective:
  - Introduce necessary requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier

- Enhanced RF requirements:
  - Study, and if necessary and feasible, specify RF requirements for devices with simultaneous reception with different QCL TypeD RSs
  - Study whether coherence between the directions can be assumed.
  - Enhance spherical coverage requirements for simultaneous reception from two directions.
    - Note that the current requirement of 50%-ile spherical coverage is kept intact
- [FFS Enhanced RRM requirements
  - TCI switching delay requirements for simultaneous dual TCI with different QCL-D source RS
  - L3- and L1-RSRP measurement requirements with simultaneous dual reception of different QCL-D source RS
  - Extend/reuse independent beam management (IBM) concept from inter-band CA to cover dual-TCI MIMO in the same CC.
  - Specify beam failure recovery requirement for mTRP with simultaneous dual-TCI reception
  - FFS : Specify radio link monitoring requirements with simultaneous dual-TCI reception
  - Study timing difference from different directions, and if necessary, specify new Rx timing requirements (e.g. similar to MRTD) under certain conditions. For example, UE would be able to deal with larger timing difference based on more than 1 FFT windows
  - Enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors. FFS impacted sections of RRM requirements.
  - BFR and RLM requirements enhancements, if necessary.
  - Handover to unknown FR2 cell
  - Factor for FR2 RX beam sweeping
  - Measuremetn restriction for CSI-RS based operation
  - Scheduling restriction for CSI-RS based operation
  - SCell activiation/deactivation delay]
- UE demodulation requirements:
  - Introduce demod and CSI performance requirements for 4-layer DL MIMO
    - Conduct performance study with Rel-17 dual-TCI indicating different QCL-D type to enable 4-layer PDSCH reception from mTRP with single DCI, compared to Rel-15 single-TCIenabled 4-layer PDSCH reception from single TRP
    - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI.

        - Demod requirements on 4 DL MIMO layers
        - CSI requirements to support 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook
    - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI
        - Demod requirements on 4 DL MIMO layers
        - CSI requirement to support 4-layer with single TCI and Rel-15 Type I codebook
    - Inter-cell multi-DCI based multi-TRP operation
    - Enhancement on HST-SFN deployment
  - Notes:
    - Focus on handheld UEs supporting “simultaneousReceptionDiffTypeD-r16” UE capability
    - Focus on UEs supporting simultaneous reception of at 2 beams and with support of 4 DL MIMO layers
- Justification:
  - Two input from Nokia and intel
  - #There were not enough time to merge them. The moderator will try after intermediate round. It would be appreciated if companies could suggest how to merge them.
- SI or WI (or WI with study phase) if approved:
  - Dedicated WI
- Potential impact to other WG(s):
  - No

Feedback Form 21:

1 – Verizon UK Ltd

We support this item!

One suggestion is for the objective. It would be fine to add a clear statement in the objective for introducing requirements to enhance FR2 UEs with multi-Rx chain DL simultaneous reception with 4 DL MIMO layers.

Also, we prefer work in dedicated WI.

2 – China Telecommunications

We support this work as a dedicated WI. Meanwhile, we share other companies’ comments in initial round that we first focus on the most fundamental requirements to ensure efficient completion of this feature.

3 – Apple (UK) Limited

First, we are OK with the use of "FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier".

Second, we have the following comments regarding the objective:

1) We don't quite understand the term "coherence between the directions". It can be considered when requirements are discussed in the WI if needed.

2) It is better to reword the objectives as follows:

- Enhanced RF requirements:

Study, and if necessary and feasible, specify RF requirements, mainly spherical coverage requirements, for devices with simultaneous reception with different QCL TypeD RSs.

Note that the current requirement of 50%-ile spherical coverage is kept intact

- Enhanced RRM requirements, focusing on

TCI switching delay requirements

Enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors.

Scheduling restriction

- UE demodulation and CSI reporting requirements

Requirements for simultaneous reception from different directions, including the support of 4 DL MIMO layers and inter-cell multi-TRP operation

4 – QUALCOMM JAPAN LLC.

Regarding the objectives, please see our comments below. AS of now there are too many subobjectives that are not justified and will make this item much bigger than it should be.

RF requirements:

- first bullet should be just "Specify RF requirements", there is no need for any study or feasibility study. This feature already exists, if feasibility is an issue companies should stop any other MIMO enhancements assuming multi-panel Tx/RX.
- Why is there a need for coherence between the directions? This feature is also for mTRP, seems unlikely that coherence can be assumed.
- Last subbullet should be just spherical coverage requirements for simultaneous reception. enhance means we are adding something on top but as of now there are no requirements for this scenario.

RRM requirements

- What is really needed are: L1-RSRP measurements to apply for m-TRP, simultaneous reception impact on scheduling restrictions and TCI state switching delays, BFD/CBD/BFR to cover multiple TRPs.

- All other proposals are enhancements that are not needed to enable this feature. Many of them are just brought here from the RRM enhancement discussion but they should be taken out.

demod requirements

- Why is there a need for a performance study ? what is needed are just new demod tests with simultaneous reception (start with 2 layer, one layer from each direction) and 4L DL MIMO, and CAI requirements for these scenarios.

- It seems other enhancements like HST-SFN or inter-cell multi DCI are brought here for no good reason. These are not needed for this feature to work, in our understanding

Dedicated WI is ok for us.

Overall we should limit this item to only objectives that are clearly needed to enable this feature, not merge all sorts of enhancements just because UE capable of simultaneous reception could in theory enable other enhancements.

5 – Samsung Electronics Co.

Thanks for moderator proposal. On the RF requirements, it may not so necessary to seperate the sphercial coverage from other RF requirements. Our proposal in 1st round is to keep the value of 50%-tile unchanged but open to discuss the spherical coverage requirements if necessary/identified. With abvoe, we think Apple's proposal on RF requirements is better descriptions. We are fine with that.

For RRM and Demod/CSI requirements, we also think having the generic descriptions shall be sufficent and leave the detailed impact to existing requirements to the WI phase.

6 – LG Electronics Deutschland

We support this as a dedicated WI, not part of FR2 RF enhancement.

7 – Nokia France

Thank you for the updates.

Objectives

For the **RF enhancements**, in response to Apple:

The second sub-bullet could be modified as follows:

"Study whether coherence between the simultaneous receptions with different QCL TypeD~~directions~~ can be assumed."

Also the third sub-bullet could be modified to "Specify enhanced spherical coverage requirements for UEs capable of simultaneous receptions with different QCL TypeD ~~from two directions~~". (Note that support of these enhanced requirements could be a separate optional UE capability.)

For the RRM enhancements:

In response to Huawei: this work should cover all the benefits of simultaneous reception from multiple directions, which are not only related to coverage and throughput, but also enabling improved measurements from being able to measure in multiple directions simultaneously. It is important for operators that this aspect is included. But we do agree with Qualcomm that we need to limit the number of RRM objectives. We propose here a merged and prioritised shorter list, where the top 3 are the highest priority and others, although interesting, are not essential and could be downscoped due to TU limitation if desired.

So the **top priority objectives for RRM** would be:

- TCI switching delay requirements for simultaneous dual TCI with different QCL-D source RS
- L3- and L1-RSRP measurement requirements with reduced beam sweeping enabled by simultaneous dual reception of different QCL-D source RS
- Extend/reuse independent beam management (IBM) concept from inter-band CA to cover dual-TCI MIMO in the same CC.

Among the other mentioned potential RRM objectives with lower priority which could be downscoped, there was anyway some duplication in the list (L3/L1 measurements are already covered, RLM appears twice in the list, SCell (de)activation delay is covered in the RRM thread 03...)

For the demod enhancements:

We agree with Qualcomm that the performance study could be omitted.

We propose the following modifications:

- Introduce demod and CSI performance requirements for 4-layer DL MIMO
    - ~~Conduct performance study with Rel-17 dual-TCI indicating different QCL-D type to enable 4-layer PDSCH reception from mTRP with single DCI, compared to Rel-15 single-TCIenabled 4-layer PDSCH reception from single TRP~~
    - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI with different QCL typeD.
        - Demod requirements on 4 DL MIMO layers
        - CSI requirements to support 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook
    - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI
        - Demod requirements on 4 DL MIMO layers
        - CSI requirement to support 4-layer with single TCI and Rel-15 Type I codebook

- ~~Inter-cell multi-DCI based multi-TRP operation~~ [As the focus is on the reception of 4-layer DL MIMO, single DCI should be sufficient.]
- ~~Enhancement on HST-SFN deployment~~ [This would be covered by the separate HST item]

For the notes, the following clarifications would be helpful:

- For the dual-TCI case, focus on handheld UEs supporting "simultaneousReceptionDiffTypeD-r16" UE capability, and for the 4-layer downlink MIMO reception, focus on UEs supporting the basic mTRP CSI reporting capability (FG 23-7-1 of NR FeMIMO).
- ~~Focus on UEs supporting simultaneous reception of at 2 beams and with support of 4 DL MIMO layers~~ [already covered above]

8 – Nokia France

For the **Justification**, we propose a merge of the original Nokia and Intel proposals:

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

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

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

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

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

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

9 – MediaTek Inc.

About **Enhanced RF requirements**":

1) Clarification on "coherence between the directions" for DL is needed. It would be also fine to further consider it in RAN4 for this technical detail, and make the objective simpler.

- ~~*Study whether coherence between the directions can be assumed.*~~

2) For other 2 sub-bullets, we prefer Apple's proposal as below:

- *"Study, and if* ***necessary*** *and feasible, specify RF requirements, mainly spherical coverage requirements, for devices with simultaneous reception with different QCL TypeD RSs."*
    - *Note that the current requirement of 50%-ile spherical coverage is kept intact*

About **Enhanced RRM requirements**":

In [RAN95e-RAN4-R18Prep-04], there is a parallel discussion on the FR2 enhancement, which also considers potential delay reduction for SCell activation or measurement. We need to make a decision on which WI we should have this objective.

The list is very long. The expected RRM workload will be huge. It would be very helpful if some prioritization can be done first. So that the RAN4 can focus on the more important items. For some examples, RAN4 can work on the basic Rel-15 functionality before moving to Rel-16/17 advanced features.

Handover to unknown FR2 cell is not related to this issue. It should be removed.

About **UE demodulation requirements**

Similar comment as RRM part. There are too many objectives. We suggest focusing on the Rel-15 basic functionality first. Some selective Rel-16/17 can also be considered if there is a strong support.

About **Note**":

Our modification proposal is as below, in our understanding, it could be 2DL MIMO for multi-Rx chain DL reception. Discuss it step-by-step would be better.

- *Focus on UEs supporting simultaneous reception of at 2 beams*
    - *stage1: 2DL MIMO layers*
    - *stage2: 4DL MIMO layers*

10 – vivo Communication Technology

We support this work as a dedicated WI.

For RF part, given this is DL requirements, currently we are not sure whether the coherence between the directions should be considered or not.

For RRM part, we share similar view with other companies, the RRM bullets should be merged, we suggest the following objective:

• Specify TCI switching delay requirements for simultaneous dual TCI with different QCL-D source RS

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

n Note: For example, UE would be able to deal with larger timing difference based on more than 1 FFT windows

• Identify enhancements to RRM requirements related L3 and/or L1 measurements considering reduced beam sweeping factors.

• Identify enhancements BFR and RLM requirements, if necessary, for mTRP with simultaneous dual-TCI reception.

11 – Ericsson LM

- We agree to remove the following objectives as suggested by Nokia (to remove them):
    - Inter-cell multi-DCI based multi-TRP operation
    - Enhancement on HST-SFN deployment
- We suggest to modify the following objective s to avoid any confusion since 'extend' may cause some confusion and reusing the concept will also save RAN4 time.
    - ~~Extend~~/Reuse independent beam management (IBM) concept from inter-band CA to cover dual-TCI MIMO in the same CC
- Furthermore, RAN4 needs to discuss the following and needs to be included in the objectives:
    - Rx antenna model supporting 4 DL MIMO layers with dual TCI (RF)and
    - Channel model for 4 DL MIMO layers with dual TCI (Demodulation)

12 – Intel Corporation SAS

For RF requirements:

- For spherical coverage we prefer not to preclude possible enhancements. We are ok to keep 50%-tile point but think that some possible improvement on the actual EIRP/EIS can be considered. So, we suggest removing "~~*Note that the current requirement of 50%-ile spherical coverage is kept intact*~~""
- We are not clear on the scope of "coherence" studies. Our assumption is that the focus shall be on dual-panel reception use case, while we are open to study single panel. For dual-panel case the concept of coherence is not very clear. Is the intention that UE combines the signals from same TRP using 2 panel reception?

For RRM requirements:

- In our understanding the support of simultaneous Rx may have impact on multiple RRM requirements including at least
  - TCI switching delay requirements
  - L3- and L1-RSRP measurement requirements
  - Handover
  - SCell activation/deactivation delay
- It may be challenging to converge on a complete set of objectives and we suggest an alternative approach capturing high-level objectives, while leaving detailed discussion up to RAN4
  - *Identify and specify enhanced RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier including at least*
    - *TCI switching delay requirements*
    - *L3- and L1-RSRP measurement requirements*

For Demod requirements:

- The requirements may not necessarily be limited to 4 MIMO layers and shall cover other scenarios including 2 MIMO layers
- We are not clear on the intention to "*Conduct performance study…"* and think that RAN4 can discuss requirements directly
- For HST-SFN requirements – we would like to understand more motivation. Is the intention to define requirements for FR2 HST CPE devices with multi-panel simultaneous Rx?
- The objectives can be revised as

- *Specify UE demodulation and CSI performance requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier*
  - *Demodulation requirements with up to 4 DL MIMO layers*
  - *CSI reporting requirement to support up to 4 DL MIMO layers*
  - *Requirements for simultaneous reception from different directions for inter-cell multi-DCI based multi-TRP operation*
  - *[Requirements for FR2 HST multi-panel operation for train roof-mounted FR2 high power devices]*
  - *Note: requirements shall cover the scenarios with [single and] dual TCI*

For the justification part the text proposed by Nokia seems a good starting point.

13 – Huawei Technologies France

For the RRM requirements enhancements, as commented in the 1st round,we do not think it is necessary to go through all existing RRM requirements for this feature, the RRM processing is not expected to be changed although the Rx beam pattern may be changed. In our view, we prefer to reuse all the existing RRM requirements rather than having fundamental changes for RRM processing,we would like to focus on the enhancement for demodulation baseband.

For UE demodulation requirements, it is not needed to conduct any study to compared to the Rel-15 performance, we just need to specify performance requirements for demodulation and CSI requirements for this feature. The basic inter-cell m-DCI based m-TRP reception is under discussion in Rel-17, we prefer not to discuss in this WI; HST-SFN enhancements can be covered in FR2 HST enhancements WI to avoid duplicated discussion.

3.4 Other

Please provides any feedbacks and comments.

Feedback Form 22:

3.5 Summary for intermediate round

3.5.1 UL 256QAM

Summary

For device types, 7 companies OK to focus CPE/FWA device types. 4 company prefer to focus CPE/FWA.

1 company want to add vehicular/industrial devices in the scope. 3 companies accept this. Apple require the clarification on the definition of “industrial devices”.

Question from ZTE is what PC is assumed for CPE/FWA, i.e., PC1 or PC5.

For WI/SI handling, 12 companies prefer option 1, 7 companies prefer option 2, 1 company prefer option 3.

Option 1 is updated as suggest by AT&T.

Based on the companies input, moderator suggest to focus on option 1 or option 2.

- Option 1: ~~WI study phase and merged into FR2 RF enhancement WI~~ Merged into FR2 RF enhancement WI with study phase
- Option 2: dedicated WI with study phase
- Option 3: dedicated SI

There are suggestions on modification from Telecom Italia, AT &T and Qualcomm.

MediaTek prefers to still keep "if feasible", the moderator suggest to keep it with [].

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
    - **Investigate and [if feasible],** enable UL 256QAM for FR2 (RAN4)
        - Study the gain, operating SNR, phase noise model andimplementation aspects
        - Specify the UE RF requirements
        - Specify the BS demodulation performance
        - Targeted device types of UE are ~~[~~CPE/FWA [only].
- Justification:
    - The improved throughput and accompanying capacity increase achieved from UL 256QAM could be extremely useful for research and marketing purposes ~~**which can also give some guidance to UL performance KPI for 6G**~~. Especially in some industry use case, e.g., the machine transmits the photograph with super high resolution to the cloud, which needs Gbps data rate. In such case, the need for 256QAM can be seen. And in such scenario thanks to lower path loss, the possibility to use 256QAM would be higher. However, the actual performance gain and implementation aspects need to be studied.
- SI or WI (or WI with study phase) if approved:

- ~~**Suggestion is [Merged into FR2 RF enhancement WI with study phase]**~~ **FFS option 1 or 2**
    - Option 1: Merged into FR2 RF enhancement WI with study phase
    - Option 2: dedicated WI with study phase
    - ~~Option 3: dedicated SI~~

- Potential impact to other WG(s):
    - No.

NOTE:

FFS to include vehicular, industrial devices, and smart phone as target devices. FSS the definition of industrial devices.

FFS power class for CPE/FWA is PC1 or PC5 or both PC1 and 5.

3.5.2 RF enhancement in FR2-1 for 39GHz band

Summary

For WI/SI handling, 3 company prefer a dedicated WI. 3 company prefer to merge it into FR2 FR enhancement WI.

For targeted band and band combination, 1 company request to include UL CA n260+n261.

There are modification suggestions from MediaTek, LG Uplus, LG.

LG suggested that n260 is changed to n259, but n260 was also proposed by LG Uplus in initial round. The moderator describes n260 with [] just in case.

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
    - RF enhancement in FR2-1 for PC2**(Vehiculat UE) n259 [and n260] (39GHz)** band (RAN4)
        - Vehicular UE requirements for power class **2** in **n259 [and n260]** (39GHz). ~~[Targeted band is n260].~~

        - Vehicular UE requirements for inter-band UL **[and DL]** CA with IBM
            - **n257+n259 [and n257+n260]**
            - **n261+n260**

- Justification:
    - the vehicular UE can be the potential use case for FR2.
    - Regarding the 39GHz, n260(above 37GHz(**37-**40GHz)) is in planning from government around 2025~2026. Considering that the completion of Rel-18 is the end of 2023, Rel-19 is late to meet this schedule in advance.

- SI or WI (or WI with study phase) if approved:
    - WI
    - Dedicated WI or merged into UE RF FR2 enhancement WI including other objectives?

- Potential impact to other WG(s):
    - No

NOTE:

FFS "n259 [and n260]" and "n257+n259 [and n257+n260]"

#LG suggested that n260 is changed to n259, but n260 was also proposed by LG Uplus in initial round. The moderator describes n260 with [] just in case, and would like to check.

FFS [DL CA] can be removed. And if DL CA is included, beam management type should be clarified.

3.5.3 Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1

Summary

7 company commented band combination request is needed firstly. 1 company commented that UL CA n257+n259 is requested in Rel-17, and this should be based on both IBM and CBM. 1 operator commented they have interest on UL CA n257+n259 with IBM which is being discussed in Rel-17. I company commented that it is premature to discuss Rel-17 leftover at this moment.

MTK have a question if RAN4 work on CA for within same frequency group is really needed since there seems no demand so far.

For WI handling, 1 company prefer to merge this objective into FR2 RF enhancement WI.

There are modification suggestions from MediaTek on Rel-17 left over description.

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
    - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators'requests (RAN4)
        - Study and if feasible, define RF requirement(s) for support of inter-band UL CA for same frequency group and different frequency groups 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 CBM is available
- Justification:
    - CA is important feature for all 3GPP RATs
- SI or WI (or WI with study phase) if approved:
    - WI
    - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
    - FFS

NOTE:

If there are no band combination request, the objective of inter-band UL CA for same frequency group and different frequency groups in FR2-1 based on CBM should be deprioritized.

FSS to include CA within same frequency group in Rel-18 work.

Rel-17 leftover should be added in Rel-18 work item if not finished in Rel-17. Potential leftovers are:

- **[DL CA with IBM for same frequency group]**
- **DL CA with CBM for [same frequency group] and different frequency groups**
- **UL CA with IBM for different frequency groups**

For Rel-17 leftover topics, potential impact to WG2 unless Rel17 WI completes certain features which need new UE capabilities.

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

Summary

8 companies prefer to drop this objective from Rel-18 work. No objections are seen.

3.5.5 Enhanced switching time (ON/ON transient time)

Summary

1 company commented FR2-2 part should be dropped from Rel-18 work.

3 company support this objective. 1 company suggest to deprioritize it. 6 company commented that it is better to wait until Rel-17 discussion conclude.

For targeted enhanced switching time, 1 company commented that it is 1 us to 3us and it should be studied as a part of WI. 1 company commented that it is 1us with optional capability.

There are modification suggestions from AT&T, and MediaTek agree with it.

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
  - Enhanced switching time (ON/ON transient time)
    - Investigate (gain) and if possible, enhance FR2-1 and FR2-2 switching time (ON/ON transient time)
- Justification:
  - Enhanced switching time (ON/ON transient time) would be beneficial from network point of view. ON/ON transient time has a significant impact on UL performance, especially for high SCS (480/960kHz) scenarios in FR2-2 and FR2-1. Improved UE capabilities to support up to 1us ON/ON transient period can be considered for FR2, similar to FR1.
- SI or WI (or WI with study phase) if approved:
  - WI with study phase
  - [Merged into UE RF FR2 enhancement WI including other objectives]
- Potential impact to other WG(s):

- No

NOTE:

Further discuss based on the outcome of Rel-17 discussion.

~~reuse~~ Consider the conclusions in FR1 transient period capability discussion as much as possible

3.5.6 UE antenna scaling

Summary

5 company suggest to deprioritize or drop this objective.

Proponent provide details of objective and justification.

For WI handling, one company suggest to merge it into UR FR2 RF enhancement WI.

Based on the discussion in intermediate round, the moderator updates the objective and justification for reference.

- Objective:
  - UE antenna scaling
    - **As a technique to reduce FR2-1/FR2-2 power consumption, study to enable/disable antenna elements & RF chains (antenna scaling) by UE**
      - **Quantify the impact on network performance by the UE performing antenna scaling**
      - **Identify potential solutions to mitigate the impact of autonomous UE antenna scaling on NW performance**
      - **Identify the impact of UE antenna scaling on UE RF requirements (e.g. TPC, max input level) and the associated testability**
      - **dentify the potential impact on other WGs**
- Justification:
  - **Any UE implementation can enable and disable tx/rx chains driving the corresponding FR2 antenna elements transparently to the network, and we do observe this behavior in the field. The motivation for this study is rooted in the observation that when the UE performs this scaling autonomously, there is a delay until the network knows by receiving UE measurement report or PHR report. The cause for performance degradation is how fast the UE can inform the network of its scaling with such reports. Before the network receives such**

updates, the network would rely on previous reports and there is a mismatch between what the network assumes and what the UE uses, which leads to performance degradation. The major questions here are how much degradation in system performance does transparent antenna scaling involve, and how this degradation can be mitigated.

  -

- SI or WI (or WI with study phase) if approved:
  - WI
  - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
  - **Part of the study objective.**

3.5.7 Beam correspondence requirements for RRC_INACTIVE and initial access

Summary

7 company support this objective. 6 company are OK with the objective.

5 company commented that they are not convinced to introduce the requirements. 1 company have commented that if UE will exhibit a different behavior in RRCCONNECTED vs. RRCINACTIVE and initial access, and that it is unclear if testability is an issue, and that further clarify the concern stated in justification. 1 company commented that all most all RF requirements are verified under RRC_connected state now, and that the current RF requirements is enough to cover, and that for random access SDT, there are no RAN1 agreement on how to decide UE Tx beam for the msg 1 and msg 3 and how to decide beam for DCI transfer and subsequent data transmission.

1 company commented that the current beam correspondence for initial access and idle mode is dependent on UE implementation and thus it should be defined, and that UE in initial access cannot rely on UL beam sweeping.

For WI/SI handling, 6 company agree to merge it inro FR2 RF enhancement WI. 3 company agree WI with study phase.

3 company commented that RRM requirements/tests are separately discussed from defining RF requirements.

1company commented requirements for other transmissions with RRC_INACTIVE state should not be precluded.

Modification suggestion is provided from MediaTek and Intel.

For adding “and spherical coverage” in the objective suggested by intel, the moderator’s understanding is that “For initial access, [necessary] verification of beam correspondence requirements based on msg1 spherical coverage (at least)” already covers this aspect.

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
  - **[Study and specify necessary]** beam correspondence requirements**[/verification]** for RRC_INACTIVE and initial access
    - ┤Specify UE beam correspondence requirements for initial access and RRC_INACTIVE state**, for the UE support SSB-based without UL beam sweeping** [RAN4 RF]
    - ~~**SSB-based without UL beam sweeping**~~
      - For RRC_INACTIVE at least **[necessary]** requirements for Random Access SDT and Configured Grant SDT
        - **FFS requirements for other transmissions with RRC_INACTIVE state**
      - For initial access, **[necessary]** verification of beam correspondence requirements based on msg1 spherical coverage (at least)
    - Study the potential impact on testability aspects (i.e., test time).┤
- Justification:
  - ┤UE beam correspondence functionality for RRCCONNECTED, RRCINACTIVE and initial access in IDLE is specified in the RAN1 and RAN2 specifications already in Release 15 but no FR2 UE beam correspondence requirements have been defined for RRCINACTIVE and initial access in IDLE yet. The current UE beam correspondence requirements are only defined for RRCCONNECTED. Without UE beam correspondence requirements for RRC_INACTIVE and initial access it is not possible to ensure good UE RACH and msg1 performance and UL coverage in FR2 deployments due to varying UE performances.
  - Rel-15 RRCINACTIVE and Rel-17 small data transmission (SDT) have a large potential in UE power efficiency, latency and signalling overhead reduction. RRCINACTIVE allows for reduced latency and UE power saving, while SDT further enhances this for small data sessions. Considering that 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 RRCINACTIVE and Small Data Transmissions for FR2 as well. Without well performing UE beam correspondence support wide usage of RRCINACTIVE and Small Data Transmission may not be feasible in practical FR2 deployments.
  - To enable efficient use of RRCINACTIVE and Small Data Transmission in FR2 deployments to save UE power with reasonable latencies we see it important to develop FR2 UE beam correspondence requirements for RRCINACTIVE in Rel-18.┤
- SI or WI (or WI with study phase) if approved:
  - ┤WI with study phase┤
  - Merged into UE RF FR2 enhancement WI including other objectives

- Potential impact to other WG(s):
    - No impact to RAN1 and RAN2. Additional test cases may be defined for the RAN5 test specifications.

NOTE:

Check if there is a difference between "requirements" and "verification" mentioned in objective.

3.5.8 Power-control tolerance

Summary

2 companies support this objective. 2 companies are OK with the objective.

4 companies prefer to drop or deprioritize this objective.

1 company suggests an alternative that open loop power control for PRACH can be replaced by a requirement for the UE to transmit with Pcmax (R4-2106909 and R4-2112384).

1company prefers to merge it inro UE RF FR2 enhancements.

Modification suggestion are provided from MediaTek.

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
    - Power-control tolerance
        - Investigate and if ~~**possible**~~ **feasible**, improve both absolute and relative tolerances for power control in FR2 to enhance performance.
- Justification:
    - There is potential to improve them to enhance performance. Several procedures reply on pathloss are impacted by the power control tolerance.
- SI or WI (or WI with study phase) if approved:

- WI
- Merged into UE RF FR2 enhancement WI including other objectives

- Potential impact to other WG(s):
  - No RAN1 and RAN2 impact. RAN5 may needs to take into account improved tolerances.

3.5.9 New proposals on achieving better FR2 coverage and/or performance

Summary

For 1), 1 company commented that the similar discussion happened in past and no conclusion at that time. 4 companies prefer to deprioritize this objective.

For 2), 3 company think it is not needed. 2 company is OK with the objective. 1 company has a question how much practical gain.

For 3), 1 company is OK to discuss further. 3 company prefer to deprioritize this objective. 1 company commented that it should be discussed in MIMO WI, and should be discussed after conclusion of Rel-17 MIMO WI. 1 company has a question what kind of enhancements to R-17 beam specific P-MPR reporting.

MediaTek has a question whether UEs already can report different P-MPR values based on beam etc like UE implementation.

- Objective(R4-2200287)
  - 1) maxUplinkDutyCycle-FR2 reporting, dynamic or semi-static, which would provide the network timely update to assist scheduling
  - 2) Better granularity of P-MPR reporting from UE
  - 3) Possible enhancements to R17 beam-specific P-MPR reporting
- Justification
  - 1)In R15/16, maxUplinkDutyCycle-FR2 is reported as part of UE RF capability. Once reported, there is no further update. While dynamic max. UL duty cycle reporting was discussed in R15/R16, there was no consideration of the possible use of body proximity sensor (BPS) to detect if a human tissue is close-by and then decide if P-MPR is needed. With BPS, the use of dynamic maxUplinkDutyCycle-FR2 reporting is more targeted and useful. For instance, instead of incurring a large P-MPR, a UE at the cell edge can rely on a smaller duty cycle to transmit with a high power and still meet MPE requirements.
  - 2)Optional P-MPR reporting was added in R16 so UE can inform gNB of the required P-MPR values for MPE compliance, but the granularity (3dB per notch) can be further improved.

- 3)
    - A) based on RAN1 agreements, it is not guaranteed that the L1-RSRP of the associated SSBRI/CRI is always reported. In this case, the value of per-beam PMRP reporting is questionable.
    - B) In RAN1 discussion, body proximity sensing capability is assumed when per-beam PMPR reporting is introduced. From UL performance perspective, for the same SSBRI/CRI, UE can have different strategy to report P-MPR depending on human body approximation. If there is no human target around, UE should select the beam with the best EIRP in UL or L1-RSRP in DL and the corresponding P-MPR is reported. When there is human body approximate, the beam with maximum (L1-RSRP-P-MPR) should be selected and reported. Obviously, reporting a single P-MPR per SSBRI/CRI are not sufficient for MPE and UL performance enhancement.

- WI or SI
    - Merged into FR2 RF enhancement WI
- Impact to other WG(s)
    - TBD

3.5.10 multi-Rx chain DL reception

Summary

For WI handling, 5 companies prefer a dedicated WI.

1 company provided the merged version of summary for justification.

Several companies suggest to focus on the most fundamental requirements. The moderator tries to accommodate the all suggestion in the modified proposal, but the objective may be still too large. For RRM objective, 1 company suggested high level objective, and it may be better to check if we can go with the modified proposals or the high-level objective.

1 company has a question whether “potential delay reduction for SCell activation or measurement” should be discussed in this WI or WI for RRM enhancements.

Clean version of objective is provided in final round section. This section describes it with change remarks for reference.

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

- ~~**Study, and if necessary and feasible,**~~ Specify RF requirements**, mainly spherical coverage requirements,** for devices with simultaneous reception with different QCL TypeD RSs
  - [Note that the current requirement of 50%-ile spherical coverage is kept intact]
  - **Note that support of these enhanced requirements could be a separate optional UE capability**
- **Rx antenna model supporting 4 DL MIMO layers with dual TCI**
- ~~Study whether coherence between the simultaneous receptions with different QCL TypeD can be assumed.~~
- ~~Enhance spherical coverage requirements for simultaneous reception from two directions.~~

■ [~~FFS~~ Enhanced RRM requirements

- **TCI switching delay requirements for simultaneous dual TCI with different QCL-D source RS**
- **Simultaneous reception impact on scheduling restrictions and TCI state switching delays,**
- **BFD/CBD/BFR/RLM requirements if necessary, for mTRP with simultaneous dual-TCI reception.**
- **L3- and L1-RSRP measurement requirements with reduced beam sweeping enabled by simultaneous dual reception of different QCL-D source RS**
- ~~**Extend/**~~**Reuse independent beam management (IBM) concept from inter-band CA to cover dual-TCI MIMO in the same CC.**
- **Handover**
- ~~Specify beam failure recovery requirement for mTRP with simultaneous dual-TCI reception~~
- ~~FFS : Specify radio link monitoring requirements with simultaneous dual-TCI reception~~]
- Study timing difference from different directions, and if necessary, specify new Rx timing requirements (e.g. similar to MRTD) under certain conditions.
  - For example, UE would be able to deal with larger timing difference based on more than 1 FFT windows
- **Enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors. FFS impacted sections of RRM requirements.**
- ~~BFR and RLM requirements enhancements, if necessary.~~
- ~~Handover to unknown FR2 cell~~
- ~~Factor for FR2 RX beam sweeping~~
- ~~Measuremetn restriction for CSI-RS based operation~~

- SCell activiation/deactivation delay
-

- UE demodulation requirements:
  - **Specify UE demodulation and CSI performance requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier** ~~Introduce demod and CSI performance requirements for 4-layer DL MIMO~~
  - ~~**Requirements for simultaneous reception from different directions, including the support of 4 DL MIMO layers and inter-cell multi-TRP operation**~~
    - ~~Conduct performance study with Rel-17 dual-TCI indicating different QCL-D type to enable 4-layer PDSCH reception from mTRP with single DCI, compared to Rel-15 single-TCIenabled 4-layer PDSCH reception from single TRP~~
    - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI **with different QCL typeD**.
      - Demod requirements ~~on~~**up to** 4 DL MIMO layers
      - CSI requirements to support **up to** 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook
    - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI
      - Demod requirements on 4 DL MIMO layers
      - CSI requirement to support 4-layer with single TCI and Rel-15 Type I codebook
    - **Channel model for 4 DL MIMO layers with dual TCI**
    - **[Requirements for simultaneous reception from different directions for** Inter-cell multi-DCI based multi-TRP operation]
    - **[Requirements for FR2 HST multi-panel operation for train roof-mounted FR2 high power**

      devices] ~~Enhancement on HST-SFN deployment~~
    - **Note: requirements shall cover the scenarios with [single and] dual TCI**

Notes:

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

- **stage 2: 4 layers downlink MIMO**

- **FFS "Study whether coherence between the simultaneous receptions with different QCL TypeD can be assumed." should be included in objective**

-

- ~~Focus on handheld UEs supporting "simultaneousReceptionDiffTypeD-r16 UE capability~~

- ~~Focus on UEs supporting simultaneous reception of at 2 beams and with support of 4 DL MIMO layers~~

- Justification:

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

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

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

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

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

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

- SI or WI (or WI with study phase) if approved:
  - Dedicated WI
- Potential impact to other WG(s):
  - No

4 Final round

4.1 General

4.2 Topic #4 UE FR2 requirements evolution

4.2.1 UL 256QAM

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
  - **Investigate and [if feasible],** enable UL 256QAM for FR2 (RAN4)
    - Study the gain, operating SNR, phase noise model andimplementation aspects
    - Specify the UE RF requirements
    - Specify the BS demodulation performance
    - Targeted device types of UE are ~~[~~CPE/FWA [only].
- Justification:
  - The improved throughput and accompanying capacity increase achieved from UL 256QAM could be extremely useful for research and marketing purposes ~~**which can also give some guidance to UL performance KPI for 6G**~~. Especially in some industry use case, e.g., the machine transmits the photograph with super high resolution to the cloud, which needs Gbps data rate. In such case, the need for 256QAM can be seen. And in such scenario thanks to lower path loss, the possibility to use 256QAM would be higher. However, the actual performance gain and implementation aspects need to be studied.
- SI or WI (or WI with study phase) if approved:

- ~~**Suggestion is [Merged into FR2 RF enhancement WI with study phase]**~~ **FFS option 1 or 2**
    - Option 1: Merged into FR2 RF enhancement WI with study phase
    - Option 2: dedicated WI with study phase
    - ~~Option 3: dedicated SI~~

- Potential impact to other WG(s):
    - No.

NOTE:

FFS to include vehicular, industrial devices, and smart phone as target devices. FSS the definition of industrial devices.

FFS power class for CPE/FWA is PC1 or PC5 or both PC1 and 5.

Please provide further feedbacks on the above proposals.

Feedback Form 23:

1 – QUALCOMM JAPAN LLC. Given the uncertainty it would be better to have this as a SI. merging it into the ”bucket” item already hints at a work item. This should be just a study and whether to continue or not with the work should be decided based on the conclusion of the study.
2 – Guangdong OPPO Mobile Telecom. Suggest to focus on the FWA/CPE, and not consider smartphone considering the challenges in implementation.
3 – Huawei Technologies France We think it should be a WI with study phase rather than a SI. To avoid too many WI/SIs in RAN4, prefer to be included in the FR2 enhance WI. Focus on FWA/CPE is ok for us.
4 – MediaTek Inc. 1) We are okay for moderator’s proposal, while ”**if feasible**” and ”**CPE/FWA only**” are kept. 2) Because there are many FFS target devices, we suggest to use **power class (PC)** instead of **device type** to discuss/clarify objective, especially that TS38.101-2 framework are based on PC.

Table 6.2.1.0-1 (Assumption of UE Types) of TS38.101-2

- PC1: Fixed wireless access (FWA) UE
- PC2: Vehicular UE
- PC3: Handheld UE
- PC4: High power non-handheld UE
- PC5: Fixed wireless access (FWA) UE

5 – KDDI Corporation

We prefer a dedicated WI with study phase. For target devices, we share the view with MediaTek, when it comes to identifying objectives, using power class makes sense.

6 – Apple (UK) Limited

The proposed scope is reasonable, and we would like to target the work toward CPE/FWA devices only. In terms of WI or SI, all three options are OK.

7 – TELECOM ITALIA S.p.A.

We prefer a WI (dedicated or under the general umbrella) with a study phase.

Just a note: in RAN1 they used CPE/FWA/vehicular and industrial devices (format used in RP-213598, WI on MIMO enhancements). But I agree with Mediatek that it would be better to focus on power classes (as far as ”industrial devices”, however you want to define them, are not precluded :-))

8 – Nokia Corporation

Should focus on CPE and FWA including PC1 and possibly PC5. If smartphones are kept in objectives that would slowdown the progress or stall it completely. Do not prefer SI instead of dedicated WI should be selected. If RAN4 focuses to CPE and FWA there is no need to SI.

9 – LG Electronics Deutschland

We support the proposal from the moderator.

We prefer this merged into FR2 RF enhancement WI. Prefer WI with the study phase. We are open to the inclusion of vehicular UE in the scope of device type.

10 – ZTE Corporation

Ok to target CPE/FWA device only.

For the power class, we agree with Mediatek to use specfic power class in the objectives.

11 – China Unicom

We support this work, and it is fine for us whether it is a dedicated WI or merging into the FR2 RF enhancement WI.

12 – Sony Group Corporation we are fine with this proposal and also prefer to focus on CPE/FWA devices.
13 – AT&T GNS Belgium SPRL We are OK with the moderator proposal and to focus on CPE/FWA devices. We are OK with either Option 1 or Option 2.
14 – SoftBank Corp. We are fine with the moderator's proposal.
15 – Intel Corporation SAS For how to handle the work, our preference is Option 1 (merge into FR2 WI with study phase). Including additional device types is ok for us.
16 – Samsung Electronics Co. We support to merge into FR2 UE RF WI. We also support to focus on CPE/FWA

4.2.2 RF enhancement in FR2-1 for 39GHz band

Summary

For WI/SI handling, 3 company prefer a dedicated WI. 3 company prefer to merge it into FR2 FR enhancement WI.

For targeted band and band combination, 1 company request to include UL CA n260+n261.

There are modification suggestions from MediaTek, LG Uplus, LG.

LG suggested that n260 is changed to n259, but n260 was also proposed by LG Uplus in initial round. The moderator describes n260 with [] just in case.

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
  - RF enhancement in FR2-1 for PC2**(Vehiculat UE) n259 [and n260] (39GHz)** band (RAN4)
    - Vehicular UE requirements for power class **2** in **n259 [and n260]** (39GHz). ~~[Targeted band is n260].~~

- Vehicular UE requirements for inter-band UL **[and DL]** CA with IBM
  - **n257+n259 [and n257+n260]**
  - **n261+n260**

- Justification:
  - the vehicular UE can be the potential use case for FR2.
  - Regarding the 39GHz, n260(above 37GHz(**37-**40GHz)) is in planning from government around 2025~2026. Considering that the completion of Rel-18 is the end of 2023, Rel-19 is late to meet this schedule in advance.
- SI or WI (or WI with study phase) if approved:
  - WI
  - Dedicated WI or merged into UE RF FR2 enhancement WI including other objectives?
- Potential impact to other WG(s):
  - No

NOTE:

FFS "n259 [and n260]" and "n257+n259 [and n257+n260]"

#LG suggested that n260 is changed to n259, but n260 was also proposed by LG Uplus in initial round. The moderator describes n260 with [] just in case, and would like to check.

FFS [DL CA] can be removed. And if DL CA is included, beam management type should be clarified.

Please provide further feedbacks on the above proposals:

Feedback Form 24:

1 – Guangdong OPPO Mobile Telecom. If no demands on DL CA, suggest to remove it and be more focus. Many FR2 topics are on the table and discussion is hard, should be focus and precise in the WID discussion.
2 – LG Uplus Regarding band combinations, please see below : [Background until Rel-17]

For handheld UE, We have following spec with IBM in TS38.101-2 Rel-17 :

-CA__n257_n259

-CA_n258_n260

-CA_n260_n261

-n257 26.5-29.5

-n258 24.25-27.5

-n259 39.5-43.5

-n260 37-40

-n261 27.5-28.35

[Opinion for each option]

Op1)Go with ”n259” for band and ”n257+n259” for band combination only

-(+): It can leverage the CA_n257_n259 works for handheld UE completed in Rel-17 so that can reduce the workload.

-(-): A bit of worry not to meet the government plan.

->However, when I checked again the government document and the wording is just ’above 37GHz’ so which part from 37GHz to 43.5GHz(n260 to n261)is unclear yet. I guess anyway it is OK to go with this for the sake of reduced workload.

Op2)Go with ”n260” for band and ”n257+n260” for band combination only

-(+): I guess it will be fit for government planning with high probability since the wording is ”above 37GHz” where it does not clearly say which part from 37 to 43.5GHz.

-(-): It cannot leverage the CA_n257_n259 works for handheld UE completed in Rel-17

->So if we go with Op2, maybe it should be checked whether we start the works from handheld UE. Also if we go with Op1, how we can add other band combination around 39GHz later should be addressed after the completion of example band combination. For example, as usual business, basket WI, etc.

Op3)Go without square brackets :

”n259 and n260” and ” ’n257+n259’ and ’n257+n260’ ”

-(+): Fit to the government planning and also some band combination can leverage the previous works for handheld UE in Rel-17.

-(-): Workload

->It can satisfy all the proposed bands and band combinations, but having in mind the concerns from many companies about workload, not the most preferable option.

3 – MediaTek Inc.

Why exact demand have options? Why exact demand need to consider other devices? We are a little confused. Please proponent just clarify the exact demand firstly. If it’s still not clear so far, maybe we could discuss it later.

Moreover, for inter-band CA, please consider clarify all below components for **each demand**:

- Power Class?
- band combination?
- UL/DL?
- IBM/CBM?”

4 – SK Telecom

We support this work in R18. Vehicular UE with FR2 is under consideration and PC2 in vehicular UE is inevitable.

5 – Nokia Corporation

Objectives are very confusing.

How there can be UL CA if there is not DL CA? Moreover there is no UL CA defined for FR2 yet and may not be in REL17. So is the proposal to define UL CA under vehicular PC2 WI? In reality we need to wait and see the outcome of Rel17 UL CA for IBM before deciding whether to add DL and UL CA objective.

Perhaps better to focus on just single band requirements if really needed now.

Should be dedicated WI if any.

6 – LG Electronics Deutschland

Thank you very much moderator for the hard work and good final proposal. We support the proposal with the following comment and proposal:

On the band combo, n257+n259 can exploit the existing requirement for handheld as much as possible and also can accommodate the potential spectrum plan in Korea as explained by Uplus. With this understanding and comment from Uplus, this n257+n259 band combo should be fine to Uplus. Please let us know if this is not the case.

On DL CA, we support removing this from the objective as proposed by the moderator.

And we still prefer this to be merged into FR2 RF enhancement considering the workload would not be high.

So we propose the objective as

Objectives:

- RF enhancement in FR2-1 for PC2 (Vehicular UE) n259 (39GHz) (RAN4)
    - Vehicular UE requirements for **power class 2** in **n259** (39GHz).
    - Vehicular UE requirements for inter-band **UL CA with IBM**
        - **n257+n259**

▪ n261+n260 **@MediaTek** Please see our following response that are reflected in the above proposed Objectives - Power Class? –> **PC2** - band combination? –> **n257+n259, n261+n260** - UL/DL? –> **UL** - IBM/CBM?" –> **IBM**
7 – Sony Group Corporation We also prefer to focus on single band. If there would be a strong demand for CA, then we think it is more reasonable to include both UL and DL rather than just UL.
8 – Intel Corporation SAS Between n260 or n259… no strong view

4.2.3 Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
  - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators'requests (RAN4)
    - Study and if feasible, define RF requirement(s) for support of inter-band UL CA for same frequency group and different frequency groups 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 CBM is available
- Justification:
  - CA is important feature for all 3GPP RATs
- SI or WI (or WI with study phase) if approved:
  - WI
  - Merged into UE RF FR2 enhancement WI including other objectives

- Potential impact to other WG(s):
    - FFS

NOTE:

If there are no band combination request, the objective of inter-band UL CA for same frequency group and different frequency groups in FR2-1 based on CBM should be deprioritized.

FSS to include CA within same frequency group in Rel-18 work.

Rel-17 leftover should be added in Rel-18 work item if not finished in Rel-17. Potential leftovers are:

- **[DL CA with IBM for same frequency group]**
- **DL CA with CBM for [same frequency group] and different frequency groups**
- **UL CA with IBM for different frequency groups**

For Rel-17 leftover topics, potential impact to WG2 unless Rel17 WI completes certain features which need new UE capabilities.

Please provide further feedbacks on the above proposals:

Feedback Form 25:

1 – QUALCOMM JAPAN LLC. We support the proposal
2 – Guangdong OPPO Mobile Telecom. Ok with objectives, but should list the tartgeted band combination no matter from operator demands or part of already introduced band combination with IBM.
3 – Huawei Technologies France If the work is based on requests from operators, we think there is no need to keep the wording ”study and if feasible”, and it also clarifies that the beam manangement capability is aligned with DL. ~~Study and if feasible,~~ define RF requirement(s) for support of inter-band UL CA for same frequency group and different frequency groups in FR2-1 based on CBM
4 – MediaTek Inc. 1) We are fine for moderator’s proposal 2) We don’t prefer to remove ”study and if feasible” 3) We don’t prefer example band in objective, because it’s not exact demand.

5 – Apple (UK) Limited The proposal is OK. It should be merged into UE RF FR2 enhancement WI. The list of Rel-17 leftover items is helpful, and upon the conclusion of the February RAN4 meeting it will be clear which of these will need to be transferred over to Rel-18.
6 – Nokia Corporation Potential REL17 left overs already have a specific band combination(s) which should be transferred onto REL18 if not completed in REL17. UL CA with CBM must be a band combination which already have DL CA defined. UE RF FR2 enhancement WI would be natural place for this work.
7 – LG Electronics Deutschland Support the objective from moderator. Not sure why operators request for inter-band DL/UL CA/DC RF is important for working priority reminding we already have similar inter-band CA/DC combo in Rel-17 as mentioned in 1st and 2nd round. Prefer this to be merged into UE RF FR2 enhancement. Leftover from Rel-17 should be discussed further after Feb. RAN4 meeting.
8 – ZTE Corporation Ok with objectives. It should avoid RAN4 to spent time to study/discuss the band combination without operator's demands/specfic band combination, otherwise company may argue the necessity of the work in RAN4 meeting...
9 – Sony Group Corporation We understand that the urgent of the work will depends on the operator request, which is fine for us. However, we just want to clarify that CBM is a UE capability but not part of band combination request.
10 – Intel Corporation SAS With respect to leftover issues – we think that RAN4 should strive to complete the work in Rel-17 and avoid prolonging the discussion to the next release. It is premature to discuss the leftovers. We prefer postponing this discussion.
11 – Samsung Electronics Co. We support moderator proposal on objectives.

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

Based on the discussion in intermediate round, it seems we can reach consensus, and thus **the moderator suggests to drop the following objective from Rel-18 work.**

- ~~Objective:~~
    - ~~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 **inter-**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~~

~~**NOTE: This work should be based on band combination proposals from operators. If there are no proposals then there is no need to discuss this further for the time being.**~~

Feedback Form 26:

1 – QUALCOMM JAPAN LLC. We are fine to drop this for now.
2 – Guangdong OPPO Mobile Telecom. Ok with drop.
3 – Huawei Technologies France We are ok with the moderator proposal.
4 – MediaTek Inc. We are fine for moderator's proposal.
5 – Apple (UK) Limited The proposal to not consider it is OK.
6 – TELECOM ITALIA S.p.A. ok with the moderator's proposal
7 – Nokia Corporation We are ok with the moderator proposal.
8 – ZTE Corporation We are ok with the moderator's proposal
9 – Ericsson LM We support moderator's proposal

10 – Intel Corporation SAS Ok to drop and prioritize other objectives

4.2.5 Enhanced switching time (ON/ON transient time)

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
  - Enhanced switching time (ON/ON transient time)
    - Investigate (gain) and if possible, enhance FR2-1 and FR2-2 switching time (ON/ON transient time)
- Justification:
  - Enhanced switching time (ON/ON transient time) would be beneficial from network point of view. ON/ON transient time has a significant impact on UL performance, especially for high SCS (480/960kHz) scenarios in FR2-2 and FR2-1. Improved UE capabilities to support up to 1us ON/ON transient period can be considered for FR2, similar to FR1.
- SI or WI (or WI with study phase) if approved:
  - WI with study phase
  - [Merged into UE RF FR2 enhancement WI including other objectives]
- Potential impact to other WG(s):
  - No

NOTE:

Further discuss based on the outcome of Rel-17 discussion.

~~reuse~~ Consider the conclusions in FR1 transient period capability discussion as much as possible

Feedback Form 27:

1 – QUALCOMM JAPAN LLC. We are fine with the objectives, this item should be lower priority
2 – Guangdong OPPO Mobile Telecom. Sugget to derioritized from Rel-18 comparing to other items and no justification of benefits on the improvement by 1-2 us transient time.

3 – Huawei Technologies France

We also think the topic should be deprioritied in Rel-18.

In addtion, if some work can be done in Rel-18 based on discussion, as the justification is mainly for high SCS (480/960kHz), we think FR2-1 should not be included.

- Investigate (gain) and if possible, enhance ~~FR2-1 and~~ FR2-2 switching time (ON/ON transient time)

4 – MediaTek Inc.

1) We share similar view on ”as the justification is mainly for high SCS (480/960kHz), we think FR2-1 should not be included. ”

2) We also think the topic should be deprioritized in Rel-18.

5 – Apple (UK) Limited

The proposal to further discuss based on the outcome of Rel-17 discussion is OK. In addition, as we commented in the intermediate round, FR2-1 should not be included in the consideration.

6 – TELECOM ITALIA S.p.A.

we propose to remove the topic from Rel 18, especially if the focus is now only on FR2-2 (see OPPO: and no justification of benefits on the improvement by 1-2 us transient time.)

7 – Nokia Corporation

Comeback in RAN#95 when REL17 outcome is clear. Based on REL17 outcome make a decision if there are enough benefits to consider also FR2-1 as those discussion would take a lot of RAN4 time.

8 – ZTE Corporation

Fine to wait for the outcomes in Rel-17 and comeback to RAN#95.

9 – AT&T GNS Belgium SPRL

We are OK with the justification. We are OK with the objectives but support to remove FR2-1 since the target is higher SCSs. We prefer to merge this topic into UE RF FR2 enhancement WI including other objectives. We are OK to wait for Rel-17 outcome with the understanding that this item will be discussed with other Rel-18 items if needed.

10 – Intel Corporation SAS

We are fine with moderator proposal. Prefer to merge into UE RF FR2 enhancement WI including other objectives. Focus shall be on both FR2-1 and FR2-2. The enhancements can be applicable and beneficial for lower SCS as well.

4.2.6 UE antenna scaling

Based on the discussion in intermediate round, the moderator updates the objective and justification for reference.

- Objective:
    - UE antenna scaling
        - **As a technique to reduce FR2-1/FR2-2 power consumption, study to enable/disable antenna elements & RF chains (antenna scaling) by UE**
            - **Quantify the impact on network performance by the UE performing antenna scaling**
            - **Identify potential solutions to mitigate the impact of autonomous UE antenna scaling on NW performance**
            - **Identify the impact of UE antenna scaling on UE RF requirements (e.g. TPC, max input level) and the associated testability**
            - **dentify the potential impact on other WGs**
- Justification:
    - **Any UE implementation can enable and disable tx/rx chains driving the corresponding FR2 antenna elements transparently to the network, and we do observe this behavior in the field. The motivation for this study is rooted in the observation that when the UE performs this scaling autonomously, there is a delay until the network knows by receiving UE measurement report or PHR report. The cause for performance degradation is how fast the UE can inform the network of its scaling with such reports. Before the network receives such updates, the network would rely on previous reports and there is a mismatch between what the network assumes and what the UE uses, which leads to performance degradation. The major questions here are how much degradation in system performance does transparent antenna scaling involve, and how this degradation can be mitigated.**
    -
- SI or WI (or WI with study phase) if approved:
    - WI
    - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
    - **Part of the study objective.**

NOTE:

5 company suggest to deprioritize or drop it. No supports in intermediate round.

Based on the intermediate round, the moderator would like to check if the objective can be drop, or still be kept for future discussion.

Feedback Form 28:

1 – QUALCOMM JAPAN LLC. We support to drop this item from the discussion
2 – Guangdong OPPO Mobile Telecom. In our view it is UE implementation issue, can be deprioritized.
3 – MediaTek Inc. Drop this item is our preference, it's mainly up to UE implementation.
4 – Apple (UK) Limited We appreciate all of the companies' feedback to this proposal during the discussion and also the moderator's effort.
5 – Nokia Corporation Should be de-prioritized.
6 – Ericsson LM We also suggest to drop it from R18
7 – Intel Corporation SAS If approved, prefer to merge into FR2 UE RF WI; we are ok to drop

4.2.7 Beam correspondence requirements for RRC_INACTIVE and initial access

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
  - **[Study and specify necessary]** beam correspondence requirements**[/verification]** for RRC_INACTIVE and initial access
    - ~~[~~Specify UE beam correspondence requirements for initial access and RRC_INACTIVE state**, for the UE support SSB-based without UL beam sweeping** [RAN4 RF]
    - ~~**SSB-based without UL beam sweeping**~~
      - For RRC_INACTIVE at least **[necessary]** requirements for Random Access SDT and Configured Grant SDT
        - **FFS requirements for other transmissions with RRC_INACTIVE state**
      - For initial access, **[necessary]** verification of beam correspondence requirements based on msg1 spherical coverage (at least)

    - Study the potential impact on testability aspects (i.e., test time).]

- Justification:

  - [UE beam correspondence functionality for RRCCONNECTED, RRCINACTIVE and initial access in IDLE is specified in the RAN1 and RAN2 specifications already in Release 15 but no FR2 UE beam correspondence requirements have been defined for RRCINACTIVE and initial access in IDLE yet. The current UE beam correspondence requirements are only defined for RRCCONNECTED. Without UE beam correspondence requirements for RRC_INACTIVE and initial access it is not possible to ensure good UE RACH and msg1 performance and UL coverage in FR2 deployments due to varying UE performances.
  - Rel-15 RRCINACTIVE and Rel-17 small data transmission (SDT) have a large potential in UE power efficiency, latency and signalling overhead reduction. RRCINACTIVE allows for reduced latency and UE power saving, while SDT further enhances this for small data sessions. Considering that 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 RRCINACTIVE and Small Data Transmissions for FR2 as well. Without well performing UE beam correspondence support wide usage of RRCINACTIVE and Small Data Transmission may not be feasible in practical FR2 deployments.
  - To enable efficient use of RRCINACTIVE and Small Data Transmission in FR2 deployments to save UE power with reasonable latencies we see it important to develop FR2 UE beam correspondence requirements for RRCINACTIVE in Rel-18.]

- SI or WI (or WI with study phase) if approved:

  - [WI with study phase]
  - Merged into UE RF FR2 enhancement WI including other objectives

- Potential impact to other WG(s):

  - No impact to RAN1 and RAN2. Additional test cases may be defined for the RAN5 test specifications.

NOTE:

Check if there is a difference between “requirements” and “verification” mentioned in objective.

<u>Discussion points:</u>

In intermediate round discussion, while 7 companies support and 6 companies are OK with the objective, 5 companies still are not convinced to include it in Rel-18 work. In moderator understanding, the main concern is the necessity to introduce the requirements. 1 company suggests to add [Study and specify necessary] in the objective. The moderator wonder if this can address the concern. Any other suggestion on rewarding would be appreciated.

In addition to this, 1 company commented that "for Random access SDT, there is no agreement in RAN1 on how UE decide the Tx beam for the msg1 and msg3(or msgA for 2 step RACH) as discussed before. And there is also no conclusion in RAN1 how UE decide the beam for DCI transfer and subsequent data transmission." Feedbacks would be appreciated.

Any other feedbacks would be also appreciated

Feedback Form 29:

1 – QUALCOMM JAPAN LLC.

We support the moderator proposal

2 – Guangdong OPPO Mobile Telecom.

There are many FR2 topics on the table, and this initial access discussion has last for a long time since Rel-16, and no justification which can get consensus in RAN4 up to now. It is unclear which real issue to be solved, and discuss in Rel-18 again about the necessity or study what to be defined, or whether it is testable is redundant in our view. It can only consume valuable RAN4 times to debating on the necessity...Therefore, this should be dropped in our view and focus on other topics with more supports.

3 – Huawei Technologies France

The RF requirements are verified under RRC_connected state, it does not preclude these RF requirements can be used for other RRC states and configurations. We are not convined by the benefit for spending more time to rediscuss the issue in Rel-18. The fundermental question asked by Apple is not well addressed as well. We agree with OPPO this topic should be dropped in Rel-18.

4 – Nokia Corporation

We support the moderator proposal.

Regarding the question related to requirement and verification in our view it is important to mention 're-quirements' in the start of the objectives to make clear that the aim is to define requirements so that there is no misunderstanding in RAN4. Additionally verification can also be mentioned.

5 – MediaTek Inc.

Drop or **deprioritize** is still our basic view, because of consideration on additional potential benefit and TU. If "**study and specify necessary**" can be kept, it would be okay for us generally while TU is enough.

About detailed objective, thanks Moderator treats this open issue. Please proponent clarify ***"if there is a difference between "requirements" and "verification" mentioned in objective."***, we shall make the objective be clearer, to avoid potential chaos in WG meeting.

6 – KDDI Corporation

We are fine with the moderator proposal.

7 – SoftBank Corp.

We support the moderator's proposal.

8 – Apple (UK) Limited

We are still not convinced without seeing our comments in the first and intermediate rounds being adequately addressed. If there is RAN4 TU and companies really want to study it, the scope of the study should be more open:

· Study the need and how to specify beam correspondence requirements for RRC_INACTIVE and initial access

o For RRC_INACTIVE, consider requirements for Random Access SDT and Configured Grant SDT, and FFS other transmissions

o For initial access, consider requirements based on msg1 spherical coverage

o Study the potential impact on testability aspects (i.e., test time)

9 – TELECOM ITALIA S.p.A.

We are fine with the moderator's proposal

10 – LG Electronics Deutschland

Not clear whether this is necessary in Rel-18 FR2 RF enhancement WI. Similar views with Apple, Oppo, Huawei and MediaTek on the necessity and methodology aspects.

11 – ZTE Corporation

Generally we are fine with the moderator's proposal.

For this sub bullet, we suggest to modify it as:

For RRC_INACTIVE at least [necessary] requirements for Random Access SDT and Configured Grant SDT

- ~~FFS requirements for other transmissions with RRC_INACTIVE state I~~t's not precluded for other transmission within RRC_INACTIVE state

12 – Sony Group Corporation

We are fine with the proposal and support it.

We think one potential way to test the BC in initial access is to verify the similarity between Tx and Rx beams instead of just Tx powers, and this is might be more feasible if there would be different beams patterns would be used during initial access. But this is technical discussion and can be left to RAN4 in Rel-18.

13 – Ericsson LM

We support moderator proposal.

14 – AT&T GNS Belgium SPRL We support the moderator proposal.
15 – Intel Corporation SAS We are ok with adding a study and specifying IF NECESSARY

4.2.8 Power-control tolerance

Based on the discussion in intermediate round, the moderator suggests the modified proposals.

- Objective:
  - Power-control tolerance
    - Investigate and if ~~possible~~ **feasible**, improve both absolute and relative tolerances for power control in FR2 to enhance performance.
- Justification:
  - There is potential to improve them to enhance performance. Several procedures reply on pathloss are impacted by the power control tolerance.
- SI or WI (or WI with study phase) if approved:
  - WI
  - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
  - No RAN1 and RAN2 impact. RAN5 may needs to take into account improved tolerances.

Discussion points:

In intermediate round discussion, while 2 companies support and 2 companies are OK with the objective, 4 companies suggest to deprioritize or drop this objective. Please provide further feedbacks on the above proposals.

One suggestion is provided in intermediate round by Apple. "As we had described in R4-2106909 and R4-2112384 (with FR2 field data), open loop power control for PRACH can be replaced by a requirement for the UE to transmit with Pcmax (i.e. removing OL TPC from PRACH). Feedbacks would be appreciated.

Feedback Form 30:

1 – QUALCOMM JAPAN LLC. We supporting deprioritizing this objective. IT would be good to see some analysis from proponents that this is a real problem in the field. To Apple, why not use open loop power control? transmitting all the time at max power could lead to interference issues.
2 – Guangdong OPPO Mobile Telecom. Suggest to deprioritize this topic since not clear how UE can improve the power control tolerance.
3 – MediaTek Inc. Prefer to deprioritize this topic since not clear how UE can improve the power control tolerance.
4 – Apple (UK) Limited We are OK to de-prioritize this item. If there is a strong desire to initiate the study, then we prefer to update the objective as follows: Investigate and if feasible, improve both absolute and relative tolerances for power control in FR2 to enhance performance; this includes the consideration of replacing OL TPC by setting Tx power to Pcmax for PRACH transmissions.
5 – TELECOM ITALIA S.p.A. We support the moderator's proposal.
6 – Nokia Corporation Objective are good and smaller tolerance is beneficial but we fear that this topic would take a lot of RAN4 time and it is unlikely that substantial gains are achieved.
7 – Ericsson LM We support moderator's proposal.
8 – Intel Corporation SAS We prefer to deprioritize this objective (it is still unclear)

4.2.9 New proposals on achieving better FR2 coverage and/or performance

- Objective(R4-2200287)
  - 1) maxUplinkDutyCycle-FR2 reporting, dynamic or semi-static, which would provide the network timely update to assist scheduling
  - 2) Better granularity of P-MPR reporting from UE

- 3) Possible enhancements to R17 beam-specific P-MPR reporting

- Justification
  - 1)In R15/16, maxUplinkDutyCycle-FR2 is reported as part of UE RF capability. Once reported, there is no further update. While dynamic max. UL duty cycle reporting was discussed in R15/R16, there was no consideration of the possible use of body proximity sensor (BPS) to detect if a human tissue is close-by and then decide if P-MPR is needed. With BPS, the use of dynamic maxUplinkDutyCycle-FR2 reporting is more targeted and useful. For instance, instead of incurring a large P-MPR, a UE at the cell edge can rely on a smaller duty cycle to transmit with a high power and still meet MPE requirements.
  - 2)Optional P-MPR reporting was added in R16 so UE can inform gNB of the required P-MPR values for MPE compliance, but the granularity (3dB per notch) can be further improved.
  - 3)
    - A) based on RAN1 agreements, it is not guaranteed that the L1-RSRP of the associated SSBRI/CRI is always reported. In this case, the value of per-beam PMRP reporting is questionable.
    - B) In RAN1 discussion, body proximity sensing capability is assumed when per-beam PMPR reporting is introduced. From UL performance perspective, for the same SSBRI/CRI, UE can have different strategy to report P-MPR depending on human body approximation. If there is no human target around, UE should select the beam with the best EIRP in UL or L1-RSRP in DL and the corresponding P-MPR is reported. When there is human body approximate, the beam with maximum (L1-RSRP-P-MPR) should be selected and reported. Obviously, reporting a single P-MPR per SSBRI/CRI are not sufficient for MPE and UL performance enhancement.

- WI or SI
  - Merged into FR2 RF enhancement WI

- Impact to other WG(s)
  - TBD

- **Discussion points:**

For 2) and 3), some companies seem OK to discuss, but other companies have questions on the necessity and practical gain. Further clarification on objective and justification may be needed. Please provide further feedbacks on the above proposals.

Questions in intermediate round:

For 3), whether UEs already can report different P-MPR values based on beam etc like UE implementation.

For 3), what kind of enhancements to R17 beam-specific P-MPR reporting, clarification is needed.

Feedback Form 31:

1 – Guangdong OPPO Mobile Telecom.

Sugget to further discuss in next RAN with more detailed explaination/information on the proposals.

2 – MediaTek Inc.

3) Please proponent clarify the clarification question for **3**. In our understanding, it's up to UE implementation, however, we are fine to confirm whether our understanding is correct or not.

3 – Apple (UK) Limited

We believe we have shared the justifications in the intermediate round. Below is our response to the two questions below.

For 3), whether UEs already can report different P-MPR values based on beam etc like UE implementation.

Response: If the question is whether UE can report two or more P-MPR values for a beam, the answer is No. More specifically, RAN1 made the following agreements:

· The gNB can configure a list of SSBs/CSI-RSs for P-MPR report by RRC

· UE can report up to 4 P-MPRs and up to 4 SSBRIs/CRIs by MAC CE

· The P-MPR and SSBRI/CRI are one-to-one associated

· UE can report the capability of maximum number of P-MPRs to be reported in a MAC CE

For 3), what kind of enhancements to R17 beam-specific P-MPR reporting, clarification is needed.

Response: as shared in the justification, we see a need to improve the RAN1 design by looking at the possible linkage between L1-RSRP report and per-beam P-MRP reporting for the same beam in order to aid the network in UL beam selection. Furthermore, how does the UE report P-MPR per SSBRI/CRI can be further discussed and improved.

4 – Nokia Corporation

In our view it would be best to see how the Rel-17 work is finalized and then discuss if and what kind of further enhancements may be needed.

5 – Sony Group Corporation

As we commented in the intermediate round, we are not convinced by the gain from the first two objectives for now. For the third objective, it seems this is mainly RAN1 issue rather than RAN4.

6 – Ericsson LM

We do not think they will bring any major benefit. As commented in previous round that P-MPR granularity improvement in signaling will not be beneficial unless power control tolerance is improved (reduced).

7 – Intel Corporation SAS

Agree with OPPO, it is best to discuss in greater detail in the next RAN meeting

4.3 Topic #14 Requirement for FR2 multi-Rx chain DL reception

4.3.1 multi-Rx chain DL reception

- Objective:
  - Introduce necessary requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier **with up to 4DL MIMO**
    - Enhanced RF requirements:
      - Specify RF requirements**, mainly spherical coverage requirements,** for devices with simultaneous reception with different QCL TypeD RSs
        - [Note that the current requirement of 50%-ile spherical coverage is kept intact]
        - **Note that support of these enhanced requirements could be a separate optional UE capability**
      - **Rx antenna model supporting 4 DL MIMO layers with dual TCI**
    - Enhanced RRM requirements
      - **TCI switching delay requirements for simultaneous dual TCI with different QCL-D source RS**
      - **Simultaneous reception impact on scheduling restrictions and TCI state switching delays,**
      - **BFD/CBD/BFR/RLM requirements, if necessary, for mTRP with simultaneous dual-TCI reception.**
      - **L3- and L1-RSRP measurement requirements with reduced beam sweeping enabled by simultaneous dual reception of different QCL-D source RS**
      - **Reuse independent beam management (IBM) concept from inter-band CA to cover dual-TCI MIMO in the same CC.**
      - **Handover**
      - Study timing difference from different directions, and if necessary, specify new Rx timing requirements (e.g. similar to MRTD) under certain conditions.
        - For example, UE would be able to deal with larger timing difference based on more than 1 FFT windows
      - **Enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors. FFS impacted sections of RRM requirements.**
      - SCell activiation/deactivation delay
      -
    - UE demodulation requirements:

- **Specify UE demodulation and CSI performance requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier**
  - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI **with different QCL typeD**.
    - Demod requirements ~~on~~**up to** 4 DL MIMO layers
    - CSI requirements to support **up to** 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook
  - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI
    - Demod requirements on 4 DL MIMO layers
    - CSI requirement to support 4-layer with single TCI and Rel-15 Type I codebook
  - **Channel model for 4 DL MIMO layers with dual TCI**
  - **[Requirements for simultaneous reception from different directions for** Inter-cell multi-DCI based multi-TRP operation]
  - **[Requirements for FR2 HST multi-panel operation for train roof-mounted FR2 high power**

    devices]
  - **Note: requirements shall cover the scenarios with [single and] dual TCI**

Notes:

- **For the dual-TCI case, focus on handheld UEs supporting "simultaneousReceptionDiffTypeD-r16" UE capability, and for the 2 or 4 layer downlink MIMO reception, focus on UEs supporting the basic mTRP CSI reporting capability (FG 23-7-1 of NR FeMIMO).**
  - **stage 1: 2 layers downlink MIMO**
  - **stage 2: 4 layers downlink MIMO**
- **FFS "Study whether coherence between the simultaneous receptions with different QCL TypeD can be assumed." should be included in objective**

- Justification:

- **The existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that UE is equipped with a single antenna panel and capable to perform DL reception using a single RX beam/chain reception. Furthermore, the UE performance requirements are limited for DL MIMO rank 1 and 2. In FR2, 4-layer MIMO reception requires beam reception from at least two directions. Although this is supported by the MIMO features since Rel-15, no performance requirements have yet been specified. This is important for high-rate MIMO in FR2, as well as for FR2 HST scenarios.**
- **During Rel-16 and Rel-17, the support of NR FR2 CA with IBM (Independent Beam Management) and CBM (Common Beam Management) with simultaneous DL reception on different component carriers from the co-located and non-col-located TRPs was defined. The IBM concept implies a UE is capable of DL simultaneous reception on different UE panels/chains using separate beams on different component carriers and requires improved UE baseband and RF capabilities (multiple baseband chains and support of multiple antenna panels).**
- **Several enhancements to enable efficient and robust DL multi-TRP/panel operation were introduced in the Rel-16 NR eMIMO WI. For instance, DL transmission schemes with simultaneous and non-simultaneous multi-beam reception from multiple TRPs/panels were introduced. The simultaneous reception may require support of simultaneous multi-panel operation with several independent RX beams/chains at the UE side. As part of this item, a new FR2 UE capability for simultaneous multi-beam reception was introduced (simultaneousReceptionDiffTypeD-r16). However, no RF, RRM or performance requirements were defined in Rel-16 and Rel-17 for FR2 UEs with simultaneousReceptionDiffTypeD-r16 capability.**
- **Enhanced NR FR2 UEs with multi-beam simultaneous reception and multiple RX chains can provide a meaningful performance improvement in FR2 improving both demodulation performance (4-layer DL MIMO), RRM performance and improve RF spherical coverage. This work item aims to introduce the requirements for UEs capable of multi-beam/chain simultaneous DL reception on a single component carrier to achieve improved RF, RRM and UE demodulation performance.**
- **Different implementation scenarios could be considered at the UE. Single-TCI reception on different beams has been supported since Rel-15 via the Type I codebook, requiring coherent reception at the UE from at least two directions, which could be achieved with either a single panel or multiple coherent panels. Alternatively, dual TCI operation can work with or without the assumption of coherence at the UE, and can be combined with the Rel-17 mTRP framework even if the base station is actually deployed as a single TRP. Dual TCI operation is therefore the most flexible assumption allowing a variety of actual implementations.**
- **This WI therefore provides the requirements for both single and dual TCI assumptions to specify requirements for reception of 4-layer downlink MIMO with simultaneous reception at the UE from two different directions.**

- SI or WI (or WI with study phase) if approved:
  - Dedicated WI
- Potential impact to other WG(s):
  - No

NOTE:

FFS Whether "potential delay reduction for SCell activation or measurement" should be discussed in this WI or WI for RRM enhancements.

For RRM objective, discuss

Option 1: Use above objective as baseline for future discussion with modification

Option 2: Use high level objective suggested by Intel

- **Identify and specify enhanced RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier including at least**
  - **TCI switching delay requirements**
  - **L3- and L1-RSRP measurement requirements**

Feedback Form 32:

1 – QUALCOMM JAPAN LLC.

What is the intention with the bullet in the RF requirements on **model supporting 4 DL MIMO layers with dual TCI?** what does dual TCI have to do with the antennas? Requirements for UEs with simultaneous receive should not be optional so the subbullet should be removed.

The following objectives from RRM are not needed, these are just enhancements. There is no clear justification to have them in this work since they are not needed for this feature to work:

L3- and L1-RSRP measurement requirements with reduced beam sweeping enabled by simultaneous dual reception of different QCL-D source RS-

Enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors. FFS impacted sections of RRM require

measurements also have a baseband processing component, if a UE has simultaneous reception it does not necessarily mean it can also do measurements simultaneously. Also, no need for such enhancements was shown. Mobility requirements are still the same and beams do not change faster.

Handover - why is this needed? simultaneous reception does not mean UE can connect to different cells at the same time.

SCell activation/deactivation - there should be no change to this, no justification

We should capture clear objectives, not have high level objectives that would lead ot a long discussion in RAN4.

2 – Samsung Electronics Co.

For RF requirements, we agreed with QC's comments on the needs of 2nd sub-bullet, i.e., "**Rx antenna model supporting 4 DL MIMO layers with dual TCI"**. The intension of such bullet is not clear. Also,

the requirement will be specified based on the UE capability ”**simultaneousReceptionDiffTypeD-r16”** which has been already optional capability. In our understanding, the requirements shall be mandatory for such UE. Therefore, we also agree to remove the 2nd note

For detailed RRM requirements, we suggest to follow the exisitng RAN4 approach, i.e., leave the detailed analysis of impact to existing requirements to the WI phase. It is premature to list the detailed impacted requirements in the objective parts without further analysis. On the other hand, listing the detailed requirements will prevent RAN4 to check whether other requirements will be impacted due to introducation of simultaneous reception capability. Therefore, we prefer to leave the high level descriptions (even higher level comparing with Intel’s option 2) for RRM in the objective part, i.e.,

- Specify RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier

For demod and CSI requirements for FR2 HST CPE, in e-mail thread #6 final round, moderator suggest to following notes:

- NOTE: Focus on FR2 HST specific requirements, and avoid the overlap with the scope of FR2 multi-Rx DL reception

With such above notes, the sub-bullet for FR2 HST CPE can be removed in this e-mail thread.

Also, we recognize the test method to verify the performance of UE with simultaneous reception capability was also discussed in e-mail thread #5. To enable this feature properly in Rel-18, it is desired to merge the core part and test methods into single WI to guarantee the core requirements are specified in the testable manner and test is designed to fulfill the core requirements demand. Also, such merging can prevent core requirements and test methods are specified in the different release (due to WI progress if both of WI were approved or even two WIs may not be approved together due to RAN4 workload)

3 – Apple (UK) Limited

For RF scope, moderator’s proposal is mostly OK. ”Rx antenna model supporting 4 DL MIMO layers with dual TCI” is not clear. We also prefer to remove the square brackets around ”Note that the current requirement of 50%-ile spherical coverage is kept intact”

For RRM scope, Intel’s suggestion is OK as a starting point. We believe some RRM requirements should be improved for such UEs. Since support of this feature is a UE capability, companies have the option of not supporting it.

For Demod, we propose the following high-level objective:

Specify UE demodulation and CSI performance requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier, including the support of 4 DL MIMO layers

4 – MediaTek Inc.

1) RF

- Clarification on “*Rx antenna model supporting 4 DL MIMO layers with dual TCI*” is needed, remove it directly is also fine.

2) RRM

- Clarification on "*Reuse independent beam management (IBM) concept from inter-band CA to cover dual-TCI MIMO in the same CC.*" is needed. For example, what requirement(s) will be enhanced?
- The below two seems same in practically?
  - *"L3- and L1-RSRP measurement requirements with reduced beam sweeping enabled by simultaneous dual reception of different QCL-D source RS"*
  - *"Enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors. FFS impacted sections of RRM requirements."*

3) Demodulation

- Not sure this one *"[Requirements for FR2 HST multi-panel operation for train roof-mounted FR2 high power devices]"* shall be handled here or [RAN95e-RAN4-R18Prep-06].

5 – LG Electronics Deutschland

Support RF objective proposed by the moderator. No strong view on RRM/Demod objectives

6 – vivo Communication Technology

For RF scope

- The square brackets for "Note that the current requirement of 50%-ile spherical coverage is kept intact" can be removed.

For RRM scope

- The high-level scope from Intel is OK for us. However, as we proposed in intermediate round, we prefer study timing difference from different directions, and if necessary, specify new Rx timing requirements (e.g. similar to MRTD) under certain conditions (For example, UE would be able to deal with larger timing difference based on more than 1 FFT windows), therefore we suggest to add one sub-bullet in the objectives:

Identify and specify enhanced RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier including at least

- *TCI switching delay requirements*
- *L3- and L1-RSRP measurement requirements*
- ***Rx timing difference requirement***

For Demod Scope

- Suggest to remove FR2 HST related objectives

For Testability scope (in thread #5)

- We share similar view with Samsung, if a dedicated WI is planned for this topic, then merging core part and test methods into single WI is preferred. The update of the test methods defined in TR38.810/884 to support this feature verification is highly dependent on how the requirements defined.

7 – Huawei Technologies France

For RF part:

We also cannot understand "Rx antenna model supporting 4 DL MIO layers with dual TCI", justification is needed.

For RRM, there is no fundamental change in Rel-16 compared to Rel-15. The measurements per panel for L1-RSRP, BFD/CBD/BFR, CSI are supported in Rel-17, which is different from Rel-15/16. But the RRM/RLM measurements are not changed in our understanding.

The more detailed comments for each RRM tentative objectives are as follows:

n For 1st bullet, it should be clarified whether simultaneous dual TCI switching is applied for R16 TCI framework or R17 TCI framework. The TCI switching delay requirements are separately defined for R16 TCI framework and R17 TCI framework.

n It should be clarified the difference of TCI switching delay part between 1st bullet and 2nd bullet.

n For the front 4 bullets, it should be firstly studied whether/how to have RRM impacts due to simultaneous dual receptions with different QCL-D.

n For 5th bullet, UE capable of independent beam management for FR2 inter-band CA is still assumed to perform common beam management for FR2 intra-band CA, which means that independent beam management assumptions cannot be reused from inter-band CA scenario to intra-band CA scenario. Hence, independent beam management assumptions could not be directly reused to a single CC scenario.

n For 6th bullet, the timing difference assumption will be impacted by both beam assumption and BB assumption.

n For 7th bullet, the change of assumption on beam sweeping factors will have significant impact on the whole RRM specification, not only L1/L3 measurements requirements.

In our view, RAN4 should focus on the critical requirements rather including optimizations when working on the first version of multi-Rx chain DL reception requirements. In our view, the simultaneous TCI switching delay requirements, L1-RSRP requirements, BFD/CBD/BFR requirements should be investigated and if needed the new requirements would be needed. For other requirements or requirement enhancement like L3-RSRP measurement handover, IBM capability covering dual TCI MIMO in the same CC are unnecessary.

Due to limited TU for RRM, we should be careful not to introduce two many objectives. The same principle for RRM email thread to have a cap on the number of objectives should also be applied here.

So basically we support Option 2 by Intel but would like to make modification. We do not need to list detailed objective at the current stage.

Option 2: Use high level objectives suggested by Intel

- Identify and if necessary specify enhanced RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCl TypeD RSs on a single component carrier ~~including at least~~

~~* TCI switching delay requirements~~

~~* L3- and L1-RSRP measurement requirements~~

For the UE demodulation requirements part:

1: The first sub-bullet: we understand that ”PDSCH with 4 DL MIMO layers with dual TCI” refer to m-DCI and s-DCI based multi-TRP transmission defined in Rel-16 eMIMO WI? How to understand ”Rel-17 mTRP Type I codebook”? what is difference from Rel-15 multi-panel Type I codebook?

2: The 2nd sub-bullet: How to understand the scenario with single TCI? it refers to single-TRP transmission or SFN transmission?

3: How to understand the ”Channel model for 4 DL MIMO layers with dual TCI”, justification is needed. Based on the discussion for FR1, we understand it is just test setup, no need to be listed in the WID.

4: We just start to discuss the requirements for multi-TRP transmission for FR2 UE with simultaneous DL reception with different QCL TypeD, we prefer to focus on multi-TRPs within one cell. Also RAN4 haven’t agreed to define requirements for inter-cell m-DCI based m-TRP transmission for FR1 yet, it is still under discussion in RAN4.

5: We agree with Samsung. FR2 HST multi-panel reception is agreed to cover in FR2 HST enhancements WI, no duplicated discussion is needed.

6: We cannot understand the ”**Note: requirements shall cover the scenarios with [single and] dual TCI** ”. What is the scenario and motivation for single TCI, clarification is needed.

In a summary, considering too much detail for clarification and discussion, we suggest to just keep the highest level objective and leave the discussion on details in the WI stage.

- Specify UE demodulation and CSI performance requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier.

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8 – Nokia France

RF enhancements: we are fine with the proposed objectives.

RRM enhancements:

Option 1 is OK with the following modifications:

- The 2nd bullet (“Simultaneous reception impact on scheduling restrictions and TCI state switching delays”) could be deleted. It is covered by the 1st bullet.
- The bullets from the 6th bullet (“Handover”) onwards are not necessary (e.g. bullet 8 is covered by bullet 4)
- “SCell activiation/deactivation delay” for FR2 is being included separately in the RRM enhancements thread, and therefore does not need to be included here.

We could also accept option 2.

We disagree with QC that L3/L1 measurement enhancements are not needed. A clear potential benefit of being able to receive from multiple directions is enabling improvements in the measurements. To say ”these are just enhancements” seems a rather strange argument not to do the work, as the whole topic is about making enhancements! Currently, RRM measurements add overhead/loss in FR2 due to the assumed sweeping needed in the UE with the current 1Rx direction assumption for RRM, and it is important to consider if these degradations can be ameliorated with multi-directional reception.

Demod enhancements:

The new extension of the main bullet is not necessary. We propose modifying as follows:

UE demodulation requirements

- Specify UE demodulation and CSI performance requirements as follows:~~for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier~~
    - Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI with different QCL typeD on a single component carrier
    - ...

The two bullets in square brackets can be deleted.

The note “Note: requirements shall cover the scenarios with [single and] dual TCI” is already covered by the bullets above and can be deleted.

9 – Ericsson LM

Generally we are fine with the objectives.

Regarding RRM scope:

All link recovery requirements (BFD/CBD/L1-RSRP) are needed for dual TCI to ensure that the UE maintains good link performance on both links.

On L3 neighbor cell RRM measurements we do not have strong view and it might be ok to skip it.

But RRM requirements for serving cell procedures like SCell activation needs to be defined. In RRM enhancement, there will be improvement of FR2 requirements including SCell activation requirements. But this is related to legacy UE in R18 i.e. not for UE capable of multi-RX chain in FR2.

Quest6ions where raised regarding following suggested by us:

”Rx antenna model supporting 4 DL MIMO layers with dual TCI”

The purpose of, ”**Rx antenna model supporting 4 DL MIMO layers with dual TCI**” is that there will be a condition that UE requirements are defined under the assumption that the UE is able to receive XPOL signals from two directions (TRPs) simultaneously.

If this is clear from objective and clear understanding then it is ok to skip.

10 – Intel Corporation SAS

- RF requirements:
  - For spherical coverage we suggest removing “~~*Note that the current requirement of 50%-ile spherical coverage is kept intact*~~”
  - The purpose and spec impact of “**Rx antenna model supporting 4 DL MIMO layers with dual TCI**” is unclear. Suggest removing.
- RRM requirements:
  - Agree with Samsung that details can be left up to RAN4 discussion and out preference is
  - *Identify and Specify RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier*
  - We are ok to list certain sub-topics if there is convergence but it seem quite challenging based on current discussion
- Demod requirements:
  - Requirements for simultaneous reception from different directions for Inter-cell multi-DCI based multi-TRP operation shall be a part of requirements for “UEs supporting 4 DL MIMO layers with dual TCI with different QCL typeD.” Multi-TRP operation is one of the key use cases for multi-panel reception UEs and shall be a part of the scope.
  - For “For demod and CSI requirements for FR2 HST CPE” we are ok to remove it under Samsung’s clarification that it is included in the FR2 HST WI scope
- Test methods: In our view the test methods for multi-chain reception shall be considered jointly as a package. There is a parallel discussion in 05 and we are ok to have it as a separate SI.
- Proposed staged approach for 2 and 4 MIMO layers is unclear and we do not see value in such prioritization.
- WI structure: we prefer to keep it open whether a separate item is needed or whether it can be merged into FR2 RF WI.

4.4 Summary for final round

4.4.1 UL 256QAM

Summary

For SI/WI handling, 1 company prefers to use SI. 6 companies prefer to use WI with study phase.3 companies prefer to merge it into FR2 RF enhancement WI. 2 companies prefer to use dedicated WI.

The moderator suggests to keep option 1 and 2.

For device type, 6 companies prefer to focus FWA/CPE. 4 companies are OK to focus GWA/CPE. 2 companies suggest not to consider smart phone. 1 company is OK to include additional device types. 4 companies comment that the PC definition should be used instead of device type.

The moderator suggests to use PC definition.

1 company prefer to keep "if feasible".

The moderator thinks that 1 company comment that they prefer SI, and it is the common understanding that RAN4 needs a study anyway, and "if feasible" means that RAN4 work will start based on the outcome of the study. So, this part should be kept.

Based on the discussion in final round, the moderator suggests the modified proposals.

- Objective:
  - Investigate and ~~[~~if feasible~~]~~, enable UL 256QAM for FR2 (RAN4)
    - Study the gain, operating SNR, phase noise model andimplementation aspects
    - Specify the UE RF requirements
    - Specify the BS demodulation performance
    - Targeted power classes are **PC1 and PC5** ~~**device types of UE are CPE/FWA [only]**~~**.**
- Justification:
  - The improved throughput and accompanying capacity increase achieved from UL 256QAM could be extremely useful for research and marketing purposes. Especially in some industry use case, e.g., the machine transmits the photograph with super high resolution to the cloud, which needs Gbps data rate. In such case, the need for 256QAM can be seen. And in such scenario thanks to lower path loss, the possibility to use 256QAM would be higher. However, the actual performance gain and implementation aspects need to be studied.

- SI or WI (or WI with study phase) if approved:
    - **WI with study phase.** FFS option 1 or 2
        - Option 1: Merged into FR2 RF enhancement WI with study phase
        - Option 2: dedicated WI with study phase
- Potential impact to other WG(s):
    - No.

NOTE: FFS to include other Power classes.

4.4.2 RF enhancement in FR2-1 for 39GHz band

Summary

For bands and band combinations, 1 company prefers to remove DL CA part if there is no demand. 1 company prefers to clarify the demand. 1 company comments that since the exact spectrum plan is TBD, there are pros and cons to define the targeted bands and band combinations. 1 company comments that DL CA is needed before UL CA introduced, and that FR2 inter-band UL CA is still discussed in Rel-17 and not yet completed and thus wait for the Rel-17 conclusion for CA. 2 company suggest to focus on single band. 1 company comments that target is n259 and UL CA n257+n259 with IBM, and UL CA n261+n260 with IBM.

The moderator's understanding is that DL CA n257+n259 with IBM and DL CA n260+n261 with IBM are completed, and that UL CA with IBM is still not finished in Rel-17. The moderator wonder if RAN4 work for DL CA for vehicular UE is needed, considering that requirements for DL CA seems power class agnostic, but power class is also associated with refsens and n259 and n260 is not defined for PC2 so far. Anyway, UL CA part should wait for the outcome of Rel-17 discussion.

And n260 should be needed if CA n260+n261 is a targeted band combination.

Based on the discussion in final round, the moderator suggests the modified proposals.

- Objective:
    - RF enhancement in FR2-1 for PC2(Vehicular UE) n259 [and n260] (39GHz) band (RAN4)
        - Vehicular UE requirements for power class 2 in n259 [and n260] (39GHz).
        - **[**Vehicular UE requirements for inter-band UL **[and DL]** CA with IBM
            - n257+n259 ~~**[and n257+n260]**~~

□ n260+n261**]**

■ **NOTE: FFS CA parts should be included based on the outcome of Rel-17 discussion.**

- Justification:
  - the vehicular UE can be the potential use case for FR2.
  - Regarding the 39GHz, n260(above 37GHz(37-40GHz)) is in planning from government around 2025~2026. Considering that the completion of Rel-18 is the end of 2023, Rel-19 is late to meet this schedule in advance.
- SI or WI (or WI with study phase) if approved:
  - WI
  - **FFS** Dedicated WI or merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
  - No

4.4.3 Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1

Summary

For targeted band combinations, 2 companies comment that example band combination is needed no matter from operator demand. 2 companies prefer not to include example band combination without request. 1 company comment that CBM is a part of capability.

The moderator thinks there are no consensus, and suggest to keep the current description.

For Rel-17 leftover, 1 company comments that it is premature to discuss. 2 companies agree the description on Rel-17 leftover.

The moderator suggests to add the description saying “Further discuss handling of Rel-17 leftover based on the outcome of Rel-17 discussion”.

For “study if feasible” part, 1 company prefers to remove, and 1 company prefers not.

The moderator suggests to add [].

For WI handling, 3 companies prefer to merge it into FR2 RF enhancement WI.

Based on the discussion in final round, the moderator suggests the modified proposals.

- Objective:
    - Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1 depending on operators'requests (RAN4)
        - **[**Study and if feasible,**]** define RF requirement(s) for support of inter-band UL CA for same frequency group and different frequency groups 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 CBM is available
- Justification:
    - CA is important feature for all 3GPP RATs
- SI or WI (or WI with study phase) if approved:
    - WI
    - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
    - FFS

NOTE:

If there are no band combination request, the objective of inter-band UL CA for same frequency group and different frequency groups in FR2-1 based on CBM should be deprioritized.

FSS to include CA within same frequency group in Rel-18 work.

Further discuss handling of Rel-17 leftover based on the outcome of Rel-17 discussion.

- Rel-17 leftover should be added in Rel-18 work item if not finished in Rel-17. Potential leftovers are:
    - [DL CA with IBM for same frequency group]
    - DL CA with CBM for [same frequency group] and different frequency groups

- UL CA with IBM for different frequency groups

- For Rel-17 leftover topics, potential impact to WG2 unless Rel17 WI completes certain features which need new UE capabilities.

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

Summary

Based on the discussion in intermediate round and final round, the moderator suggests to drop the following objective from Rel-18 work.

- ~~Objective:~~
  - ~~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 **inter**-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~~

~~**NOTE: This work should be based on band combination proposals from operators. If there are no proposals then there is no need to discuss this further for the time being.**~~

4.4.5 Enhanced switching time (ON/ON transient time)

Summary

5 companies prefer to deprioritize this objective.

4 companies suggest to wait for Rel-17 conclusion.

4 companies suggest to remove FR2-1 since the target is high SCS (480/960kHz). 2 company prefer to consider both FR2-1 and FR2-2.

2 companies prefer to merge it intro FR2 RF enhancement WI.

The moderator suggests to add [] for “FR2-1”. And remove [] for “Merged into UE RF FR2 enhancement WI including other objectives”.

Based on the discussion in final round, the moderator suggests the modified proposals.

- Objective:
  - Enhanced switching time (ON/ON transient time)
    - Investigate (gain) and if possible, enhance **[**FR2-1**]** and FR2-2 switching time (ON/ON transient time)
- Justification:
  - Enhanced switching time (ON/ON transient time) would be beneficial from network point of view. ON/ON transient time has a significant impact on UL performance, especially for high SCS (480/960kHz) scenarios in FR2-2 and **[**FR2-1**]**. Improved UE capabilities to support up to 1us ON/ON transient period can be considered for FR2, similar to FR1.
- SI or WI (or WI with study phase) if approved:
  - WI with study phase
  - ~~[~~Merged into UE RF FR2 enhancement WI including other objectives~~]~~
- Potential impact to other WG(s):
  - No

NOTE:

Further discuss based on the outcome of Rel-17 discussion.

Consider the conclusions in FR1 transient period capability discussion as much as possible

4.4.6 UE antenna scaling

Summary

6 companies suggest to reprioritize or drop this objective. No support. It seems that proponent can accept to deprioritize or drop.

So, the moderator suggests to deprioritize this objective.

No updates on the following description.

- Objective:
    - UE antenna scaling
        - As a technique to reduce FR2-1/FR2-2 power consumption, study to enable/disable antenna elements & RF chains (antenna scaling) by UE
            - Quantify the impact on network performance by the UE performing antenna scaling
            - Identify potential solutions to mitigate the impact of autonomous UE antenna scaling on NW performance
            - Identify the impact of UE antenna scaling on UE RF requirements (e.g. TPC, max input level) and the associated testability
            - dentify the potential impact on other WGs
- Justification:
    - Any UE implementation can enable and disable tx/rx chains driving the corresponding FR2 antenna elements transparently to the network, and we do observe this behavior in the field. The motivation for this study is rooted in the observation that when the UE performs this scaling autonomously, there is a delay until the network knows by receiving UE measurement report or PHR report. The cause for performance degradation is how fast the UE can inform the network of its scaling with such reports. Before the network receives such updates, the network would rely on previous reports and there is a mismatch between what the network assumes and what the UE uses, which leads to performance degradation. The major questions here are how much degradation in system performance does transparent antenna scaling involve, and how this degradation can be mitigated.
    -
- SI or WI (or WI with study phase) if approved:
    - WI
    - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
    - Part of the study objective.

4.4.7 Beam correspondence requirements for RRC_INACTIVE and initial access

Summary

7 companies support this objective.

5 companies suggest to deprioritize or drop.

For the difference between “requirements” and “verification”, 1 company comment that it is important to mention “requirements” in the start of objective, and on top of that, “verification” is additionally mentioned. 1 company suggest to replace “verification” with “requirements”

The moderator feels that no clear differences are shown. Therefore, to avoid any misunderstanding, the moderator suggests to replace “verification” with requirements, as 1 company suggested.

1 company suggests to add “study the need and how to specify beam correspondence requirements for RRC_INACTIVE and initial access.”

The moderator thinks the suggestion is rewording of “[Study and specify necessary]”, so suggest to replace it with the proposed sentence with [].

1 company suggest to modify as “It’s not precluded for other transmission within RRC_INACTIVE state”.

The moderator suggests to apply the rewording.

As one potential way to test the BC in initial access, 1 company comment that “verify the similarity between Tx and Rx beams instead of just Tx powers, and this is might be more feasible if there would be different beams patterns would be used during initial access. But this is technical discussion and can be left to RAN4 in Rel-18.”

Based on the discussion in final round, the moderator suggests the modified proposals.

- Objective:
    - ~~**[Study and specify necessary] [**~~**Study the need and how to specify** beam correspondence requirements~~**[/verification]**~~ for RRC_INACTIVE and initial access]
    - Specify UE beam correspondence requirements for initial access and RRC_INACTIVE state, for the UE support SSB-based without UL beam sweeping [RAN4 RF]
        - For RRC_INACTIVE at least [necessary] requirements for Random Access SDT and Configured Grant SDT
            - ~~**FFS requirements for other transmissions with RRC_INACTIVE state**~~ **It’s not precluded for other transmission within RRC_INACTIVE state**
        - For initial access, [necessary] **requirements** ~~**verification**~~of beam correspondence requirements based on msg1 spherical coverage (at least)
    - Study the potential impact on testability aspects (i.e., test time).

- Justification:
    - UE beam correspondence functionality for RRCCONNECTED, RRCINACTIVE and initial access in IDLE is specified in the RAN1 and RAN2 specifications already in Release 15 but no FR2 UE beam correspondence requirements have been defined for RRCINACTIVE and initial access in IDLE yet. The current UE beam correspondence requirements are only defined for RRCCONNECTED. Without UE beam correspondence requirements for RRC_INACTIVE and initial access it is not possible to ensure good UE RACH and msg1 performance and UL coverage in FR2 deployments due to varying UE performances.
    - Rel-15 RRCINACTIVE and Rel-17 small data transmission (SDT) have a large potential in UE power efficiency, latency and signalling overhead reduction. RRCINACTIVE allows for reduced latency and UE power saving, while SDT further enhances this for small data sessions. Considering that 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 RRCINACTIVE and Small Data Transmissions for FR2 as well. Without well performing UE beam correspondence support wide usage of RRCINACTIVE and Small Data Transmission may not be feasible in practical FR2 deployments.
    - To enable efficient use of RRCINACTIVE and Small Data Transmission in FR2 deployments to save UE power with reasonable latencies we see it important to develop FR2 UE beam correspondence requirements for RRCINACTIVE in Rel-18.
- SI or WI (or WI with study phase) if approved:
    - ~~[~~WI with study phase~~]~~
    - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
    - No impact to RAN1 and RAN2. Additional test cases may be defined for the RAN5 test specifications.

4.4.8 Power-control tolerance

Summary

2 companies support this objective.

5 companies suggest to deprioritize this objective.

1 company suggests to add “this includes the consideration of replacing OL TPC by setting Tx power to Pcmax for PRACH transmissions.” while 1 company has a question on this solution.

The moderator suggests to add the sentence with [] as a reference for future discussion.

Based on the discussion in final round, the moderator suggests the modified proposals.

- Objective:
  - Power-control tolerance
    - Investigate and if feasible, improve both absolute and relative tolerances for power control in FR2 to enhance performance**: [this includes the consideration of replacing OL TPC by setting Tx power to Pcmax for PRACH transmissions.]**
- Justification:
  - There is potential to improve them to enhance performance. Several procedures reply on pathloss are impacted by the power control tolerance.
- SI or WI (or WI with study phase) if approved:
  - WI
  - Merged into UE RF FR2 enhancement WI including other objectives
- Potential impact to other WG(s):
  - No RAN1 and RAN2 impact. RAN5 may needs to take into account improved tolerances.

4.4.9 New proposals on achieving better FR2 coverage and/or performance

Summary

3 companies suggest to further discuss it in next RAN.

1 company comments that they are not convinced by the gain from the first two objectives 1) and 2) for now, and 3) is manly RAN1 issue.

1 company suggests to reprioritize the objective.

The moderator suggests to further discuss it in next RAN. The proposal is kept as it is.

- Objective(R4-2200287)
    - 1) maxUplinkDutyCycle-FR2 reporting, dynamic or semi-static, which would provide the network timely update to assist scheduling
    - 2) Better granularity of P-MPR reporting from UE
    - 3) Possible enhancements to R17 beam-specific P-MPR reporting
- Justification
    - 1)In R15/16, maxUplinkDutyCycle-FR2 is reported as part of UE RF capability. Once reported, there is no further update. While dynamic max. UL duty cycle reporting was discussed in R15/R16, there was no consideration of the possible use of body proximity sensor (BPS) to detect if a human tissue is close-by and then decide if P-MPR is needed. With BPS, the use of dynamic maxUplinkDutyCycle-FR2 reporting is more targeted and useful. For instance, instead of incurring a large P-MPR, a UE at the cell edge can rely on a smaller duty cycle to transmit with a high power and still meet MPE requirements.
    - 2)Optional P-MPR reporting was added in R16 so UE can inform gNB of the required P-MPR values for MPE compliance, but the granularity (3dB per notch) can be further improved.
    - 3)
        - A) based on RAN1 agreements, it is not guaranteed that the L1-RSRP of the associated SSBRI/CRI is always reported. In this case, the value of per-beam PMRP reporting is questionable.
        - B) In RAN1 discussion, body proximity sensing capability is assumed when per-beam PMPR reporting is introduced. From UL performance perspective, for the same SSBRI/CRI, UE can have different strategy to report P-MPR depending on human body approximation. If there is no human target around, UE should select the beam with the best EIRP in UL or L1-RSRP in DL and the corresponding P-MPR is reported. When there is human body approximate, the beam with maximum (L1-RSRP-P-MPR) should be selected and reported. Obviously, reporting a single P-MPR per SSBRI/CRI are not sufficient for MPE and UL performance enhancement.
- WI or SI
    - Merged into FR2 RF enhancement WI
- Impact to other WG(s)
    - TBD

4.4.10 multi-Rx chain DL reception

Summary

For RF objective:

For “Rx antenna model supporting 4 DL MIMO layers with dual TCI”, 5 companies have a question. 2 companies suggest to remove it. 1 company answers that the purpose is that there will be a condition that UE requirements are defined under the assumption that the UE is able to receive XPOL signals from two directions (TRPs) simultaneously.

The moderator suggests to move it from objective to NOTEs for future discussion.

For “Note that support of these enhanced requirements could be a separate optional UE capability”, 2 companies suggest to remove it.

The moderator suggests to remove it.

For “[Note that the current requirement of 50%-ile spherical coverage is kept intact]”, 2 companies suggest to remove []. 1 company suggests to remove the sentence itself.

The moderator thinks that there is no consensus, and thus suggest to keep it as it is with [].

For RRM objective:

There are several inputs and conflicts. 1 company prefer to have clear objective. 5 companies prefer to have high level objective. 1 company is OK with both.

The moderator suggests to use high-level objective at this moment considering the current situation. Companies can add objectives in RAN#95 if the consensus is reached.

For demodulation objective:

3 company suggest to remove HST related objective based on discussion in thread#6. 1 company comment that not sure HST part should be discussed here or othread#6. 1 company is OK to remove it.

2 companies suggest a high-level objective.

1 company suggest a modification and to remove the two bullets with [].

Considering the current situation, the moderator also suggests to use high-level objective at this moment. Companies can add objectives in RAN#95 if the consensus is reached.

Other:

2 companies suggest to merge the core part and test methods intro single WI.

The moderator adds this aspect as NOTE.

1 company has question on the value of note describing staged approach for 2 and 4 MIMO layers

The moderator adds “FFS staged approach for 2 and 4 MIMO layers should be needed.”

1 company prefer to keep it open whether a separate item is needed or whether it can be merged into FR2 RF WI.

The moderator adds [] into “dedicated WI”

Based on the discussion in final round, the moderator suggests the modified proposals.

- Objective:
  - Introduce necessary requirement(s) for enhanced FR2 UEs with DL reception simultaneously with different QCL TypeD RSs on single component carrier with up to 4DL MIMO
    - Enhanced RF requirements:
      - Specify RF requirements, mainly spherical coverage requirements, for devices with simultaneous reception with different QCL TypeD RSs
        - [Note that the current requirement of 50%-ile spherical coverage is kept intact]
        - ~~Note that support of these enhanced requirements could be a separate optional UE capability~~
      - ~~Rx antenna model supporting 4 DL MIMO layers with dual TCI~~
    - Enhanced RRM requirements
      - **Specify RRM requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier. At least following points can be candidates:**
        - **Delay/timing/interpretation/scheduling restriction**
      - ~~TCI switching delay requirements for simultaneous dual TCI with different QCL-D source RS~~
      - ~~Simultaneous reception impact on scheduling restrictions and TCI state switching delays,~~
      - ~~BFD/CBD/BFR/RLM requirements, if necessary, for mTRP with simultaneous dual-TCI reception.~~

- ~~L3- and L1-RSRP measurement requirements with reduced beam sweeping enabled by simultaneous dual reception of different QCL-D source RS~~
- ~~Reuse independent beam management (IBM) concept from inter-band CA to cover dual-TCI MIMO in the same CC.~~
- ~~Handover~~
- ~~Study timing difference from different directions, and if necessary, specify new Rx timing requirements (e.g. similar to MRTD) under certain conditions.~~
  - ~~For example, UE would be able to deal with larger timing difference based on more than 1 FFT windows~~
- ~~Enhancements to L3 and/or L1 measurements considering reduced beam sweeping factors. FFS impacted sections of RRM requirements.~~
- ~~SCell activiation/deactivation delay~~
-

- UE demodulation requirements:
  - Specify UE demodulation and CSI performance requirements for enhanced FR2 UEs with simultaneous DL reception with different QCL TypeD RSs on a single component carrier
    - ~~Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with dual TCI with different QCL typeD.~~
      - ~~Demod requirements on up to 4 DL MIMO layers~~
      - ~~CSI requirements to support up to 4-layer with 2 TCIs and Rel-17 mTRP Type I codebook~~
    - ~~Specify performance requirements for enhanced FR2 UEs supporting 4 DL MIMO layers with single TCI~~
      - ~~Demod requirements on 4 DL MIMO layers~~
      - ~~CSI requirement to support 4-layer with single TCI and Rel-15 Type I codebook~~
    - ~~Channel model for 4 DL MIMO layers with dual TCI~~
    - ~~[Requirements for simultaneous reception from different directions for Inter-cell multi-DCI based multi-TRP operation]~~
    - ~~[Requirements for FR2 HST multi-panel operation for train roof-mounted FR2 high power~~
      ~~devices]~~
    - ~~Note: requirements shall cover the scenarios with [single and] dual TCI~~

Notes:

- For the dual-TCI case, focus on handheld UEs supporting “simultaneousReceptionDiffTypeD-r16” UE capability, and for the 2- or 4-layer downlink MIMO reception, focus on UEs supporting the basic mTRP CSI reporting capability (FG 23-7-1 of NR FeMIMO).
    - stage 1: 2 layers downlink MIMO
    - stage 2: 4 layers downlink MIMO
    - **FFS staged approach for 2 and 4 MIMO layers should be needed.**
- ~~FFS “Study whether coherence between the simultaneous receptions with different QCL TypeD can be assumed. should be included in objective~~
- Justification:
    - The existing Rel-15 NR FR2 minimum UE requirements are defined with an assumption that UE is equipped with a single antenna panel and capable to perform DL reception using a single RX beam/chain reception. Furthermore, the UE performance requirements are limited for DL MIMO rank 1 and 2. In FR2, 4-layer MIMO reception requires beam reception from at least two directions. Although this is supported by the MIMO features since Rel-15, no performance requirements have yet been specified. This is important for high-rate MIMO in FR2, as well as for FR2 HST scenarios.
    - During Rel-16 and Rel-17, the support of NR FR2 CA with IBM (Independent Beam Management) and CBM (Common Beam Management) with simultaneous DL reception on different component carriers from the co-located and non-col-located TRPs was defined. The IBM concept implies a UE is capable of DL simultaneous reception on different UE panels/chains using separate beams on different component carriers and requires improved UE baseband and RF capabilities (multiple baseband chains and support of multiple antenna panels).
    - Several enhancements to enable efficient and robust DL multi-TRP/panel operation were introduced in the Rel-16 NR eMIMO WI. For instance, DL transmission schemes with simultaneous and non-simultaneous multi-beam reception from multiple TRPs/panels were introduced. The simultaneous reception may require support of simultaneous multi-panel operation with several independent RX beams/chains at the UE side. As part of this item, a new FR2 UE capability for simultaneous multi-beam reception was introduced (simultaneousReceptionDiffTypeD-r16). However, no RF, RRM or performance requirements were defined in Rel-16 and Rel-17 for FR2 UEs with simultaneousReceptionDiffTypeD-r16 capability.
    - Enhanced NR FR2 UEs with multi-beam simultaneous reception and multiple RX chains can provide a meaningful performance improvement in FR2 improving both demodulation performance (4-layer DL MIMO), RRM performance and improve RF spherical coverage. This work item aims to introduce the requirements for UEs capable of multi-beam/chain simultaneous DL reception on a single component carrier to achieve improved RF, RRM and UE demodulation performance.
    - Different implementation scenarios could be considered at the UE. Single-TCI reception on different beams has been supported since Rel-15 via the Type I codebook, requiring coherent reception at the UE from at least two directions, which could be achieved with either a single panel or multiple coherent panels. Alternatively, dual TCI operation can work with or without the

assumption of coherence at the UE, and can be combined with the Rel-17 mTRP framework even if the base station is actually deployed as a single TRP. Dual TCI operation is therefore the most flexible assumption allowing a variety of actual implementations.

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

- SI or WI (or WI with study phase) if approved:
  - [Dedicated WI]
- Potential impact to other WG(s):
  - No

NOTE:

Further discuss merging the core part and test methods into single WI.

FFS "Rx antenna model supporting 4 DL MIMO layers with dual TCI" should be included in Enhanced RF requirements in the objective.

5 Conclusion

The details of summary are captured in the summary for each topic in final round section.

Topic #4 UE FR2 requirements evolution

For the following topics, the moderator considers as working areas with more stabilized objectives:

- UL 256QAM
- RF enhancement in FR2-1 for 39GHz band
- Inter-band and intra-band DL/UL CA/DC RF enhancement in FR2-1

For the following topics, the moderator considers as working areas which need more discussions:

- Enhanced switching time (ON/ON transient time)
- Beam correspondence requirements for RRC_INACTIVE and initial access

- Power-control tolerance
- Achieving better FR2 coverage and/or performance

For the following topics, the moderator suggests to drop from Rel-18 work area:

- Inter/intra-band DL/UL CA enhancement for FR2-2 and between FR2-1 and FR2-2 based on CBM/IBM
- UE antenna scaling

Topic #14 requirements for FR2 multi-Rx chain DL reception

For the following topic, the moderator considers as working areas with more stabilized objectives:

- Requirement for FR2 multi-Rx chain DL reception

For working areas with stabilized objectives and working areas which need more discussions, the moderator plans to capture the outcome of final round in the form of WID for Topic#4 and Topic#14 respectively.

Note that:

- This is just the reference for future discussion, and can be further revised in RAN#95.
- Leaving blank for the rapporteur and supporting companies
- Objectives in Topic#4 are captured into WI for RF requirement enhancement for NR frequency range 2 (FR2), and objectives in Topic#14 are captured into WI for requirement for FR2 multi-Rx chain DL reception. But WI structure such as separating dedicated WI for some objectives can be further discussed in RAN#95.