

3GPP TSG RAN Meeting #95-e RP-220863

Electronic Meeting, March 17 - 23, 2022

Agenda Item: 9.1.4

Source: Moderator (Huawei, HiSilicon)

Title: Moderator's summary for discussion [95e-03-RAN4-R18-UEFR1RF]

Document for: Information & Decision

1 Introduction

In this document, a summary for the email discussion [95e-03-RAN4-R18-UEFR1RF] in RAN#95e is provided following the guidance in RP-220068.

The main target of the discussion is to achieve stable WI objectives during the email discussion for the recommended topics.

According to the recommendation in the RAN Rel-18 package summary [1], max three topics are considered under the WI for the March RAN scope discussion.

UE FR1 RF enhancements (**3 topics**)

- 4Tx for CPE/FWA/vehicle/industrial devices
- 8Rx for CPE/FWA/vehicle/industrial devices
- lower MSD

2 Initial round

2.1 Justification

The following justification are based on draft WID in [3] and recommendation in [1].

This work item includes the objectives of UE FR1 requirement focus on evolution for potential RAN4 enhancements for NR frequency range 1. The following working areas are based on the summary of email discussion in [RAN95e-RAN4-R18Prep-01] (RP-220019).

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

- Enable ~~[6Rx and]~~ 8Rx and for CPE/FWA/vehicle/industrial device
- Investigate the feasibility of lower MSD for inter-band CA/EN-DC/[DC] combinations

Please provide the comments below whether the justification part is agreeable or some revisions are needed.

Feedback Form 1:

<p>1 – Apple (UK) Limited</p> <p>The justification is agreeable.</p>
<p>2 – Nokia Japan</p> <p>We agree with the modification. Since now that RP-220068 was endorsed, we support to follow it and remove 6Rx from the objective.</p>

2.2 Scope and objectives for core part

2.2.1 4Tx for CPE/FWA/vehicle/industrial devices

According to guidance in RP-220068, the proposed objectives for 4Tx are:

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

- Investigate framework and architecture
- Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later from Rel-18)
 - ~~[FFS on FDD example band]~~
 - [Note 1: the total number of example band should be limited to 3.]
 - ~~[Note 2: if FDD example band is added, study the REFSNES degradation due to 4Tx FDD operation in the example band]~~
 - Note: FDD bands are not precluded to be introduced in the release independent way later from Rel-18.
- Specify the UE RF requirements to support 4Tx
 - First priority: 4x4 UL MIMO
 - Second priority: investigate and if necessary specify TXD requirement to support the same power class in UL MIMO and single antenna port
 - [PA configuration assumption: 23dBm x 4, 26dBm x4]
 - For UE power class (more clarification seems necessary particularly in combination with PA configuration, in terms of priority & the need to reduce the number of combinations)

- first priority: PC 1.5
 - second priority: PC2 and PC3
 - Note: PC1.5 is only applicable for TDD bands
- Specify the BS demodulation performance requirements to support UL 4-layerMIMO UE operation

Feedback Form 2:

1 – Skyworks Solutions Inc.

4Tx FDD: We do not see how FDD bands could be added later with release independence without a study establishing how 4Tx interference affects 4Rx (and 8Rx?), this should be clarified. In our view it would be better to add an FDD band since n77/n78 are tied together. one option would be band 7 which is in the same spectrum range than n41

Power class priority: unclear under which power class the 4x26dBm work would fall. also unclear why we should look into lower power classes than PC1.5 if 4x23dBm is the objective.

2 – MediaTek Inc.

We would also like to understand better what proponents have in mind in relation to power classes and corresponding PA configurations.

3 – Ericsson France S.A.S

We think it would be useful to add a bullet to clarify the relation with ULFPTX:

- The ULFPTx modes shall be used for UL MIMO and single-antenna port fallback.

For power classes we prefer to focus only on PC1.5; this will help in terms of workload and it is not obvious why the other mentioned PC are relevant for CPE.

4 – Qualcomm Technologies Int

Together with the PA configuration, maybe we could mention that "scope is limited to 4 antenna connectors" like we limited to 2 connectors in earlier WIs.

5 – New H3C Technologies Co.

We are fine with current work scope of 4Tx.

6 – Qualcomm Korea

For PA configurations, we suggest also including 2x23 + 2x26 as in important configuration. For n41, n77, and n78, we have already defined PC1.5 so the UE already has 2x26. If we were to upgrade this UE to 4Tx, we may only add 2x23 to it. Yet, we would not want to lose the ability to transmit full power with the 26 dBm PA's already available. We agree with other commenters that power class would need to be clarified, not necessarily limiting to PC1.5 but maybe also higher power classes (equivalent to PC1 maybe). We are also not sure of the value of PC3 and PC2 for 4Tx.

7 – ZTE Corporation

For power class of TDD band, we have similar concerns as other companies, please find the following proposals to make PA configurations and power class more clearly clarified.

- Specify the UE RF requirements to support 4Tx
 - First priority: 4x4 UL MIMO
 - Second priority: investigate and if necessary specify TXD requirement to support the same power class in UL MIMO and single antenna port
- ~~[PA configuration assumption: 23dBm x 4, 26dBm x 4]~~

- For UE power class for both UL MIMO and TXD if necessary

– **first priority: PC 1.5 [PA configuration assumption: 23dBm x 4]**

– **second priority: new PC2 and PC3 [PA configuration assumption: 26dBm x 4]**

Note: PC1.5 and new PC are only applicable for TDD bands

8 – Guangdong OPPO Mobile Telecom.

1. For clarification, does 4Tx and 8Rx are combined feature for CPE, and no for example 2T/8R, 4T/4R, or they are independent feature? Our understanding is they are independent like 2T and 4R, UE can choose to support either more Tx or more Rx.

2. About the bands, our understanding is that 4Tx is applied for high FR1 bands, e.g. >2.7GHz, and whether the mid bands around 2GHz is applicable needs study. So if the current scope only include n41/n77/n78 then later on when new bands are proposed it should not be independent automatically, at least study is needed to confirm the mid bands. Alternative is to add one middle band like n1 to study the impacts.

3. About the power class, with 4PAs activated, PA configurations 4x20, 4x23, 2x23+2x26 are preferred, i.e. PC2 and PC1.5 can be used as starting point, but FFS on the higher power capabilities considering the impacts to UE design like heating issues.

4. TxD is needed to achieve same power capability in PA configurations like 4x20, 4x23, 2x23+2x26 unless different power capability is allowed in 4 layer UL MIMO, 2 layer UL MIMO and single antenna port.

9 – Guangdong OPPO Mobile Telecom.

Proposed **changes**:

Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later from Rel-18)

Note 1: the total number of example band should be limited to 3.

Note: FDD bands are not precluded to be introduced in the release independent way later from Rel-18 **but feasibility study is needed.**

Specify the UE RF requirements to support 4Tx

First priority: 4x4 UL MIMO

Second priority: investigate and if necessary specify TXD requirement to support the same power class in UL MIMO and single antenna port

[PA configuration assumption: 20x4, 23x4, 23x2+26x2~~26dBm x 4~~]

For UE power class (more clarification seems necessary particularly in combination with PA configuration, in terms of priority & the need to reduce the number of combinations)

~~first priority:~~ PC 1.5

~~second priority:~~ PC2 and PC3

Note: PC1.5 is only applicable for TDD bands

Note: FFS on the higher power capabilities taken the impacts to UE design into consideration

10 – China Telecom Corporation Ltd.

For FDD band, we are ok with Skyworks's suggestion to add one FDD example band. Our preference is to add n1, since its carrier frequency is close to the TDD band n41.

For the power class, we agree PC 1.5 is the first priority.

11 – Apple (UK) Limited

Are CPE/FWA devices considered free from SAR issue? If not, how to handle UL duty cycle in FDD bands for PC2 and PC1.5 needs to be addressed. Also the REFSSENS impact for FDD bands need to be evaluated even for PC3 as more Tx interference would couple into diversity Rx paths.

12 – Verizon UK Ltd

The FDD band should not be excluded from this work. For FDD mid-band, RAN4 should consider band n66.

13 – vivo Communication Technology

We support to consider TDD bands in the WID, further discuss whether FDD band can be added after TDD requirements are concluded. We support focus on PC1.5 as 1st priority, not clear about the motivation of PC2 and even PC3, are they fallback modes from 4Tx to 1Tx?

We also prefer keeping 4x4 UL MIMO as first priority, and consider TxD as lower priority.

14 – China Mobile Group Device Co.

For the power class, we support PC1.5 as the first priority. About the second priority, if we only assume 23dbm*4 and 26dBm*4 PA configuration, do we really need PC2 and PC3? it seems the performance gain for PC3 4Tx is not obvious especially when we already increase the device cost due to 4Tx?

15 – SoftBank Corp.

Regarding the target power class, we would like to keep PC2 and PC3 as the second priority. If PC1.5 is not allowed in some region, it cannot get the benefits (e.g. UL throughput) of 4Tx.

16 – Intel Corporation (UK) Ltd

Objectives are quite stable, but UE PC details need further clarifications. We prefer to focus on UE power class 1.5 and 23dBm x 4 PA architecture as the first priority.

17 – Nokia Japan

Regarding FDD handling, we basically support the changes. But some modification on NOTE for FDD is necessary. Our alternative is as follows.

NOTE: FDD bands are not precluded to be studied once TDD requirements are completed and can be introduced in the release independent way from Re-18 once the corresponding requirements become ready.

Regarding PA configuration, we don't agree with inclusion of 26 dBm x 4.

Concerning PC, PC2 and PC3 should be removed from the below text. What is the point to discuss PC2 and PC3 with CPE device?

priority: PC 1.5 second priority: ~~PC2 and PC3~~

18 – AT&T GNS Belgium SPRL

We generally OK with the objectives but agree with Skyworks, China Telecom, and Verizon that in order to introduce FDD bands in a release independent manner that an FDD example band should be defined. If we are concerned about the total number of example bands going beyond 3, we should consider that n77 and n78 are similar and perhaps use the wider band of the two.

19 – Huawei Technologies France

In general, we are ok with the current objectives and the [] can be removed.

1. regarding FDD bands, we are ok to consider one example band as commented by Skyworks and CTC.
2. For PA configurations, we think it would be better to focus on the current assumptions in the objectives. But open to consider others later on.
3. For power class, we consider PC1.5 as first priority. PC2 in our view can also be considered.
4. regarding ULFPtx, that is part of MIMO requirements, no need to have additional objective.

20 – Spreadtrum Communications

We support 4Tx operating on TDD is the first priority due to work load concern , FDD band may not be precluded , yet additional work on FDD band is needed; Power class 1.5 is what we would like to persue.

21 – China Unicom

We share the same view that FDD bands should not be excluded from the work, NR band n1 can used as an example band.

22 – NTT DOCOMO INC.

Regarding PC, so far, we also would like to keep PC2 and PC3 as the second priority while we understand the comments from companies on the performance gain and the motivation of 4Tx for PC3.

Our current thought is:

Although Japanese government starts to study the introduction of HPUE feature, it is not yet concluded and HPUE is not allowed for n77/n78/n79 so far. Until the regulation is changed, we need to implement PC3 even for FWA/CPE devices.

We agree that we need to take care the cost effective when we try to use UE implementing 4Tx as PC3. But we wonder 23dBm x2 UL MIMO for PC3 is in the similar simulation. So, we think we don't need to exclude lower power classes.

Based on the above consideration, we agree that main target is HPUE(PC1.5), but our current preference is to keep PC2 and PC3 as the second priority.

2.2.2 8Rx for CPE/FWA/vehicle/industrial devices

According to guidance in RP-220068, the proposed objectives for 8Rx are:

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

- Example bands: n41, n77 and n78 (other bands to be introduced in the release independent way later from Rel-18)
- Specify the UE RF requirements to support ~~[6Rx and]~~ 8Rx
- ~~[Study the extension to 6/8 antenna SRS antenna switching]~~
- Specify RLM test cases with 8Rx
- Specify UE demodulation performance and CSI requirements to support ~~[6Rx and]~~ 8Rx
- Specify the requirements with 8 MIMO layers

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

Note: whether or not to further consider 6Rx in this objective is to be further checked in RAN#99

Feedback Form 3:

<p>1 – Skyworks Solutions Inc.</p> <p>if SRS antenna switching is not extended to 8 antennas, should there be some assessment on the performance loss? especially for 8 MIMO layer?</p>
<p>2 – Ericsson France S.A.S</p> <p>Most of the objectives are OK, but to do 8 layer MIMO then SRS antenna switching is needed:</p> <ul style="list-style-type: none">- Specify the extension to 8 antenna SRS antenna switching
<p>3 – New H3C Technologies Co.</p> <p>We are open to discuss about 8 antenna SRS antenna switching because it seems to get good 8x8 DL beamforming performance if 8 antenna SRS antenna switching is support</p>
<p>4 – ZTE Corporation</p> <p>We have similar concerns as Ericsson, it's better to add 8 antenna SRS antenna switching back.</p>
<p>5 – Guangdong OPPO Mobile Telecom.</p> <p>1. About the bands, we are ok with n41/n77/n78, i.e. bands higher than 2.7GHz, but for the middle bands, if introduced in the future should have further study the feasibility since it requires much more antennas and front ends which would be challenging for middle bands not to say the low bands. So if release independent is intended then study definitely is required. Propose to modify the Note below:</p> <p>Note: FDD bands are not precluded to be introduced in the release independent way later from Rel-18 <u>but feasibility study is needed.</u></p>

2. About the 8Rx SRS antenna switching, if introduced should be clear that UE can support with 1T8R, 2T8R, 4T8R, then corresponding SRS antenna switches and ILs.

6 – China Telecom Corporation Ltd.

1. We support to include the extension of SRS Tx port switching for 8 antennas. Perhaps 1T8Rx is not needed, and we can further discuss whether 2T8R is needed or not.
2. Similar to 4Tx, support to add FDD example band of n1

7 – Apple (UK) Limited

The following three bullets can be removed from the core requirements as they belong to the performance part which is covered in section 2.3.

- Specify RLM test cases with 8Rx
- Specify UE demodulation performance and CSI requirements to support [~~6Rx and~~ 8Rx
- Specify the requirements with 8 MIMO layers

8 – vivo Communication Technology

Similar views as 4Tx, we support to focus on TDD bands. FDD can be further discussed after TDD requirements concluded.

9 – China Mobile Group Device Co.

about the 8Rx SRS antenna switching, we also support to add it in the WID.

10 – Intel Corporation (UK) Ltd

Core part objectives:

- We are ok to add 8 SRS AP switching to the objectives, which is important to extract benefits from the network side.

Perf part objectives:

- RLM test cases and UE demodulation shall be moved to Perf part objectives
- 8 MIMO layers feasibility needs assessment and as shown in LTE it can work under zero correlation assumptions only, which is not practical. Therefore, additional study is needed and it can be feasible to define requirements for lower number of MIMO layers
- Suggest to adjust the performance objectives as follows
 - o *Specify RLM test cases with 8Rx*

- *Specify UE demodulation performance and CSI reporting requirements with 8Rx*
 - *Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers*

11 – Nokia Japan

The last NOTE for 6Rx shall be removed. This does not need in the WID. WID is the place to clarify what we target at specifying. It would be really great if the moderator could share the intention of this sudden addition with some highlights or explanations. Otherwise, some may miss it.

~~Note: whether or not to further consider 6Rx in this objective is to be further checked in RAN#99~~

Regarding FDD handling, we basically support the changes. But some modification on NOTE for FDD. Our alternative is as follows.

NOTE: FDD bands are not precluded to be studied once TDD requirements are completed and can be introduced in the release independent way from Re-18 once the corresponding requirements become ready.

12 – AT&T GNS Belgium SPRL

We generally OK with the objectives but have the same comment as in 4Tx concerning identifying an FDD example band. Feasibility studies of FDD in lieu of an FDD example band for introduction of a new feature would seem to be outside of RAN4 norms for developing generic requirements for cases where we expect bands to be introduced in a release independent manner. Hopefully, we can consider the alternative that we presented in 4Tx discussion about how to keep to 3 example bands.

13 – Huawei Technologies France

Ok with the current objectives for 8Rx. We are open for the objective of extension to 8 antenna SRS switching, but the wording should be clear, what mentioned by OPPO on the delta SRS is more specific.

14 – Spreadtrum Communications

It seems 8Rx SRS switching could improve 8 layers MIMO performance, we are also open to take 2T8Rx or 4T8Rx SRS switching extension into account during the performance assessment and relevant impacts on the RF requirements.

2.2.3 Lower MSD

According to guidance in RP-220068, the proposed objectives for lower MSD are:

Investigate the feasibility of and if necessary, specify lower MSD for inter-band CA/EN-DC/[DC] combinations (RAN4)

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

- During the study, based on the progress on the example band combinations, also check whether the generic approach can be applied based on UE indication of capability
- Aim to conclude the study phase by RAN#99

Feedback Form 4:

1 – Skyworks Solutions Inc.

In previous related RAN4 discussions, it has been difficult to have a common understanding about the type and granularity of the capability. It would be good to clarify especially since the study needs to assess if improvement can be achieved for all possible types of MSD.

the chosen BC do not have Harmonic mixing exceptions: another BC needs to be chosen to cover this type of MSD

should IMD to a third band be part of the discussion?

the chosen BC do not have cross band isolation exceptions: another BC needs to be chosen to cover this type of MSD

2 – Ericsson France S.A.S

The BS need to cover harmonic mixing, IMD, cross-band isolation. Since this is a technical discussion it may be better to allow RAN4 to decide on a set of band combinations. Objective something like:

- **Select a limited set of band combinations (2-4 combinations) that include harmonic mixing and IMD (and cross-band isolation for a band combination for which simultaneous Rx-Tx is optional).**

Also, as a sub-bullet of study the MSD combinations, add an objective:

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

- Study correlation of MSD improvement between different MSD resources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
- **Evaluate the MSD when the IMD just misses the wanted receive channel for a case in which the MSD would be large when the IMD overlaps with the wanted channel**

3 – Sony Group Corporation

The objectives are generally fine and we are okay to start item the with a study phase on how the MSD performance can be improved, with the understanding that no approach would be precluded to be studied. However, it is a bit unclear to us the meaning of the “generic approach”, a clarification would be helpful.

4 – Qualcomm Korea

This topic was discussed extensively during the Rel-17 timeframe. We suggest that the Rel-18 continue from where we left off rather than starting from scratch again as this would be very time consuming and inefficient. At the minimum, the discussion points from Rel-17 should be prioritized with respect to brand new discussion points.

5 – ZTE Corporation

Firstly, MSD requirement for NR-DC is reusing from that requirement of inter-band CA, therefore the low MSD should be also applicable for NR-DC, therefore we propose to remove the square bracket for DC.

Secondly, to cover different types of self-interfering signal of BC, we are also supportive to ensure all potential cases could be studied.

6 – Guangdong OPPO Mobile Telecom.

1. Study on the various MSD sources is ok but would be better to only focus on more promising MSD interference to save time. So there is no need to list many band combinations with each targeting one specific interference. Please proponent consider this, with more MSD sources on the table, more time consumes, and less likely there is successful outcome. In our view, we can focus on either harmonics or IMD2 or both, but no more than that.

2. The "generic approach" should only be considered after the successful outcome of lower MSD study. We cannot say no matter how the lower MSD study goes, just use the "generic approach" to let UE report how it can achieve then close the WI, because, if go with this way then there is no meaning of the painful lower MSD study anymore.

3. The meaning of "Aim to close the study phase by #99" should be clarified. If no conclusion by #99 then what should the group do? In our view, if that happens then this item should be dropped.

4. Proposed changes:

Investigate the feasibility of and if necessary, specify lower MSD for inter-band CA/EN-DC/[DC] combinations (RAN4)

[Example band combinations: *CAn1-n77*, *CAn3-n41*]

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

- Study correlation of MSD improvement between different MSD resources (harmonics, IMD2/~~3/4/5~~, **cross band isolation and harmonic mixing**)
- **If lower MSD definition is possible, During the study**, based on the ~~progress on the~~ example band combinations, **further discuss** ~~also check~~ whether the generic approach can be applied based on UE indication of capability
- Aim to conclude the study phase by RAN#99, **and if no lower MSD cannot be identified further discuss in RAN#99 whether this lower MSD objective can be dropped.**

7 – Guangdong OPPO Mobile Telecom.

Correct typo in our last comment:

- Aim to conclude the study phase by RAN#99, and if no lower MSD can be identified further discuss in RAN#99 whether this lower MSD objective can be dropped.

8 – Apple (UK) Limited

1. It is unclear what the “correlation of MSD improvement between different MSD resources” means. Some clarifications are needed.

2. We also suggest to study how the MSD varies with UL aggressor power reduction and potentially develop certain criteria to assist network to conditionally schedule the band combination with simultaneous Rx/Tx operation. For example, when UL aggressor is reduced by X dB from PCMAX, the MSD would become negligible. Under such condition, the band combination can be operated with simultaneous Rx/Tx without the concern of MSD.

9 – Verizon UK Ltd

RAN4 should continue this work from Rel-17 leftover to make this work more efficient. And, the various MSD sources should optimize to focus on the major impact sources, such as

- Study correlation of MSD improvement between different MSD resources (harmonics, IMD2/~~3/4/5~~, **cross band isolation and harmonic mixing**)

10 – KT Corp.

KT is fine with the objective proposed by the moderator

11 – Samsung Electronics Co.

For study phase, it is benefit to check different MSD sources and also different band combinations, otherwise, we did not see any value of keeping the generic approach aspects in the WID.

With that, we support the bullet suggested by Ericsson on selecting limited number of band combinations in Study phase. We also suggest to keep the current wording by keeping different MSD sources, i.e., IMD2/3/4/5, cross band isolation and harmonic mixing.

If the study is only limited to example band combination (CA~~n~~1-n77, CA~~n~~3-n41) and removing IMD3/4/5, cross band isolation and harmonic mixing as suggested by some companies, the generic aspect shall be removed correspondingly.

- ~~During the study, based on the progress on the example band combinations, also check whether the generic approach can be applied based on UE indication of capability~~

We are open to either above alternatives.

12 – vivo Communication Technology

if the target is just specifying requirements for example bands, then we are Ok to remove generic approach, however, if the intension is to redefine MSD for all the combinations in Rel-18 and/or future releases, then we prefer to develop a generic way to solve the problem, otherwise the casebycase discussion would be time consuming.

13 – China Mobile Group Device Co.

For example band combinations, we share the same view to choose 2-4 example bands that cover all MSD resources.

- for harmonic maxing, CA_n28-n40 is suggested as the example band which require larger than 30dB MSD from n40 to n28;
- for IMD, CA_n3-n41 is suggested as the example band which require 8.3dB MSD due to IMD4;

14 – Beijing Xiaomi Mobile Software

We support to focus on limited number of example combinations for the feasibility study of lower MSD. As the intention is to solve the problem due to high MSD, we are also open to have a study on the potential solutions for actual desense reduction to solve the same problem.

15 – Intel Corporation (UK) Ltd

We support the objectives and ok to focus on a set of example band combinations. Meantime, it is desirable that conclusions could be applicable in a generic manner to the existing and potential new band combinations.

16 – Nokia Japan

We definitely don't agree with the modification specifically removing the following bullet. We should just remove the [].

- {Study whether the generic approach can be applied based on UE indication of capability}

17 – AT&T GNS Belgium SPRL

We are fine with the objectives presented by the moderator and they reflect the outcome of significant discussion in Rel-17 and during the Rel-18 Prep. We are also OK with Nokia's suggestion above to alternately remove the brackets. We do not agree to limit the study to only harmonics and IMD2 and to keep the scope to consider different IMD sources as in the moderator proposal.

18 – Huawei Technologies France

As MSD could be resulted from differetn sources, for the SI, we don't think the study should be limited to some of them, but it also depends on whether only limited example band combinations are considered. We agree with Samsung that the bullet of general approach may not be needed. Also it is the sub-bullets of a removed bullet.

For the second proposed bullet by Ericsson on "Evaluate the MSD when the IMD just misses", it not very clear, some clarification is needed.

19 – Ericsson France S.A.S

To Huawei: To clarify our second proposal, what we mean is:

Evaluate the possibility to differentiate MSD between IMD inside wanted channel and when the IMD just misses the wanted receive channel, for a case in which the MSD would be large when the IMD overlaps with the wanted channel

20 – NTT DOCOMO INC.

We agree to keep different MSD sources, i.e., IMD2/3/4/5, cross band isolation and harmonic mixing, and to study the general approach.

We will check and propose the example band combination in intermediate round if any.

2.2.4 Others

Feedback Form 5:**1 – VODAFONE Group Plc**

As expressed during the GTW, a study on 6 Rx for smartphones (3.5 / 6 GHz) and 3 Tx on 2 bands are both of significant interest for Vodafone and of far higher priority than any FWA work. We would at the very least see these items included in the WI by the December checkpoint.

2 – China Unicom

We also support to include smartphones related enhancements in R18 UE FR1 work item. More specifically, UE 3Tx on two bands (1T+2T) is a high priority item for us.

3 – Huawei Technologies France

We support to have further discussion on enhancement of 3Tx on two bands and a study of 6Rx for smartphone at the checkpoint according to the GTW discussion and clarification by RAN chair.

2.3 Scope and objectives for perf part

The following perf objectives are based on draft WID in [3] and recommendation in [1].

The objectives of performance part for Rel-18 RF FR1 requirement focus evolution include:

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices
 - Specify the BS demodulation performance requirements to support UL 4-layer MIMO UE operation
- Enable ~~{6Rx and}~~8Rx for CPE/FWA/vehicle/industrial devices
 - Specify RLM test cases with 8Rx

- Specify UE demodulation performance and CSI requirements to support [~~6Rx and~~] 8Rx
 - Specify the requirements with 8 MIMO layers
- Investigate ~~6Rx on higher frequency bands targeting at support of smartphone~~
- ~~Specify the requirements to support 6Rx subject to the conclusion of feasibility study~~
 - ~~Specify RLM test cases with 6Rx~~
 - ~~Specify UE demodulation performance and CSI requirements to support 6Rx~~
 - [~~Investigate the feasibility and if necessary define the requirements with MIMO layer larger than 4~~]
- Specify release independence requirements in TS 38.307 if needed.

Feedback Form 6:

1 – Apple (UK) Limited

1. For RLM test cases with 8Rx, similar to LTE 8Rx, there is no need to introduce 8Rx RLM test cases but reuse 4Rx test cases instead.
2. Considering that 8 MIMO layers may not be practical in all scenarios, we propose the following modification for MIMO requirement.
 - Specify the requirements with up to 8 MIMO layers

2 – Intel Corporation (UK) Ltd

4TX

- Suggest to include lower number of MIMO layers in the scope and keep up to RAN4 discussion
Specify the BS demodulation performance requirements to support up to UL-4-layer UL MIMO UE operation

8RX (same as in section 2.2.2)

- 8 MIMO layers feasibility needs assessment and as shown in LTE it can work under zero correlation assumptions only, which is not practical. Therefore, additional study is needed and it can be feasible to define requirements for lower number of MIMO layers
- Suggest to adjust the performance objectives as follows
 - *Specify RLM test cases with 8Rx*
 - *Specify UE demodulation performance and CSI reporting requirements with 8Rx*

- Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers

3 – Huawei Technologies France

For 8Rx, some modification proposals are:

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

- Specify RLM test cases ~~with~~ to support 8Rx
 - Investigate if the existing 4Rx RLM test can be reused or the new test will be specified
- Specify UE demodulation performance and CSI requirements with up to 8 layers to support 8Rx
 - Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers
- Specify the SDR requirements with 8 MIMO layers

2.4 Affected specifications

The following impacted TS/TR are copied from the draft WID in [3] and the target completion RAN meeting are added based on [1].

Table 1:

Impacted existing TS/TR <i>{One line per specification. Create/delete lines as needed}</i>			
TS/TR No.	Description of change	Target completion plenary#	Remarks
<i>{E.g. "22.281"}</i>	<i>{Possible values: - either free text (e.g. "CS aspects to be removed") - or "Specification to be withdrawn"}</i>	<i>{E.g. "TSG#89"}</i>	<i>{Free text}</i>
38.101-1	Specify UE RF core requirements	#102	Core part
38.101-3	Specify UE RF core requirements related to EN-DC	#102	Core part
38.307	Specify release independence	#104	Perf. part

38.101-4	Specify UE demodulation performance and CSI requirements for >4Rx	#104	Perf. part
38.104	Specify BS demodulation performance requirements for >2Tx	#104	Perf. part
38.331	Specify the necessary signalling or capability to support the features	#102	Core part
38.214	Specify PHY to support UL 3-layer transmission with 3Tx	#102	Core part

Feedback Form 7:

<p>1 – T-Mobile USA Inc.</p> <p>Should TS 38.306 be added in case UE capabilities are impacted?</p>
<p>2 – MediaTek Inc.</p> <p>The affected 38.214 change seems not applicable?</p> <p>Can it also be clarified what the Release independence relates to here? Back to which Release?</p>
<p>3 – ZTE Corporation</p> <p>TS38.141-1 for conformance testing of BS demod is still missing, please add it.</p>
<p>4 – China Telecom Corporation Ltd.</p> <p>TS 38.141-1 is missing.</p>
<p>5 – China Telecom Corporation Ltd.</p> <p>Sorry for multiple comments. TS 38.141-2 is also impacted for demod requirements for BS type 1-O.</p>
<p>6 – Apple (UK) Limited</p> <p>Please clarify whether “Specify PHY to support UL 3-layer transmission with 3Tx” for TS 38.214 is needed as 3Tx is no longer included in the objective. Also the original intention for 3Tx was not meant for 3-layer transmission.</p>

7 – Huawei Technologies France

we think 38.306 should be added as commented by T-Mobile USA.

Ok to have TS 38.141-1 and 38.141-2.

For the RAN1 spec, 38.213 and 38.214 could be listed by using the general description, such as "Add impacts on 38.213 Physical layer procedures for control/Physical layer procedures for data, if needed"

2.5 Summary for initial round

2.5.1 Justification

Two companies provided feedback for the justification part and all agree with the proposed modification based on RP-220068. The justification part is stable.

Moderator suggests to capture the justification part in the final WID. No more discussion for the justification content in the intermediate round.

This work item includes the objectives of UE FR1 requirement focus on evolution for potential RAN4 enhancements for NR frequency range 1. The following working areas are based on the summary of email discussion in [RAN95e-RAN4-R18Prep-01] (RP-220019).

- **Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices**
- **Enable 8Rx and for CPE/FWA/vehicle/industrial device**
- **Investigate the feasibility of lower MSD for inter-band CA/EN-DC/[DC] combinations**

2.5.2 Scope and objectives for core part

2.5.2.1 4Tx

- **FDD bands:** 11 companies commented on FDD bands, one company thinks that feasibility study is needed, 2 companies commented that FDD bands can be studied once TDD requirements are completed. Four operators show strong interest in FDD bands. Bands n1, n7 and n66 have been proposed as example FDD bands.

- Moderator suggestion:

- include FDD example bands as second priority but no feasibility study is needed

- **Power classes and priority:** 15 companies commented on power classes and priority, 10 of them clearly support PC1.5 as first priority. One operator commented that there could be some regional regulation issue, thus want to keep PC2 and PC3 as second priority.

- Moderator suggestion:

- Still consider PC1.5 as first priority, keep PC2 and PC3 as second priority for the moment

- **PA configurations:** For PC1.5, 5 vendors expressed views that 4x26dBm may not be a viable configuration. Most vendors prefer to consider 4x23dBm for PC1.5. Besides this configuration, 2x23dBm+2x26dBm and 4x20dBm are also proposed.
 - Moderator suggestion for PA configurations
 - First priority: 4x23dBm
 - Second priority: 2x23dBm+2x26dBm, 4x20dBm
- **ULFPTx:** One company proposed to add a bullet to clarify the relation with ULFPTx, one company thought it is not necessary.
 - Moderator suggestion:
 - Further discuss in intermediate round whether clarification of ULFPTx is needed
- The last bullet is for BS demodulation performance requirement
 - moderator suggestion: remove the bullet and consider it in the perf part.

The following objectives are to be discussed in intermediate round:

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

- **Investigate framework and architecture**
- **Example bands:**
 - **TDD bands: n41, n77 and n78**
 - **FDD bands: [n1, n7, n66]**
 - [Note 1: the total number of example band should be limited to 3.]
 - Note 2: other bands to be introduced in the release independent way later from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority
- **Specify the UE RF requirements to support 4Tx**
 - **First priority: 4x4 UL MIMO**
 - **Second priority: investigate and if necessary specify TXD requirement to support the same power class in UL MIMO and single antenna port**
 - **PA configuration assumption:**
 - **First priority: 4x23dBm**
 - **Second priority: 2x23dBm + 2x26dBm, 4x20dBm**
 - **UE power class**
 - **first priority: PC 1.5**
 - **second priority: PC2 and PC3**
 - **Note: PC1.5 is only applicable for TDD bands**

2.5.2.2 8Rx

- **FDD bands:** Similar discussion as 4Tx. Two operators propose to consider FDD example bands, one company thinks feasibility study is needed for FDD band, and two companies consider FDD bands as second priority for specifying requirements.
- **SRS antenna switching:** 10 companies commented on SRS antenna switching, and most comments are positive to consider feature in Rel-18. 3 companies commented on specific antenna configurations, seems companies prefer to make it clear of the objective of SRS antenna switching if included.
- **Others:** One company commented that the last 3 bullets are perf relevant, which should be considered in the perf part. One company commented that the last note for 6Rx shall be removed, which is not needed in the WID.

Based on above discussion, the following modified objectives are to be discussed in intermediate round:

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

- **Example bands:**
 - **TDD bands**□n41, n77 and n78
 - **FDD bands**□[n1]
 - [Note 1: the total number of example band should be limited to 3.]
 - Note 2: other bands to be introduced in the release independent way later from Rel-18
 - Note 3: specifying requirements for TDD bands has first priori
- **Specify the UE RF requirements to support 8Rx**
- **Study and specify the requirements to support SRS antenna switching for [1T8R], 2T8R and 4T8R**

2.5.2.3 Lower MSD

- **inter-band CA/EN-DC/[DC]:** one company commented DC case is similar to CA, the [] can be removed
- **Example band combinations:** most companies agree to study limited example band combinations
- **MSD sources:**
 - Alt1: different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing), more companies favoured
 - Alt 2: limited MSD sources (harmonics, IMD2), two companies support
- **general approach:**
 - Option 1: depends on the study based on the example band combinations, more companies favoured

- Option 2: remove generic approach bullet if the purpose is to specify requirements for example band combinations
- One company proposed to consider a specific case while MSD when the IMD just misses the wanted receive channel for a case in which the MSD would be large when the IMD overlaps with the wanted channel. Moderator's suggestion is that cases can be discussed in RAN4 during the study phase, as the case is not very clear without a specific band combination.

Based on above discussion, the following modified objectives are to be discussed in intermediate round:

- **Investigate the feasibility of and if necessary, specify lower MSD for inter-band CA/EN-DC/DC combinations (RAN4)**
 - **Select a limited set of band combinations (2-4 combinations)**
 - **Example band combinations: CA_n1-n77, CA_n3-n41, CA_n28-n40**
 - **Study how the MSD performance can be improved for example band combinations**
 - **Study correlation of MSD improvement between different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)**
 - **During the study, based on the progress on the example band combinations, also check whether the generic approach can be applied based on UE indication of capability**
 - **Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.**

2.5.2.4 Others

Some companies commented that further enhancements on 6Rx for smartphone and 3Tx for two bands should be further checked in Dec RAN meeting according to the GTW discussion. Moderator suggestion is to follow the RAN chair guidance on the check point and no further discussion for the issues in the intermediate round.

2.5.3 Scope and objectives for perf part

There companies provide comments for the performance part.

The following modified objectives are to be discussed in intermediate round:

The objectives of performance part for Rel-18 RF FR1 requirement focus evolution include:

- **Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices**
 - **Specify the BS demodulation performance requirements to support UL 4-layer MIMO UE operation**
- **Enable 8Rx for CPE/FWA/vehicle/industrial devices**

- **Specify RLM test cases with to support 8Rx**
 - Investigate if the existing 4Rx RLM test can be reused or the new test will be specified
 - **Specify UE demodulation performance and CSI requirements with up to 8 layers to support 8Rx**
 - Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers
 - **Specify the SDR requirements with 8 MIMO layers**
- **Specify release independence requirements in TS 38.307 if needed.**

2.5.4 Affected specifications

7 companies commented for the affected specifications. Based on the comments, the following table with affected specs are to be discussed in intermediate round.

Table 2:

Impacted existing TS/TR <i>{One line per specification. Create/delete lines as needed}</i>			
TS/TR No.	Description of change	Target completion ple-nary#	Remarks
<i>{E.g. "22.281"}</i>	<i>{Possible values: - either free text (e.g. "CS aspects to be removed") - or "Specification to be withdrawn"}</i>	<i>{E.g. "TSG#89"}</i>	<i>{Free text}</i>
38.101-1	Specify UE RF core requirements	#102	Core part
38.101-3	Specify UE RF core requirements related to EN-DC	#102	Core part
38.307	Specify release independence	#104	Perf. part
38.101-4	Specify UE demodulation performance and CSI requirements for >4Rx	#104	Perf. part

38.104	Specify BS demodulation performance requirements for >2Tx	#104	Perf. part
38.141-1	conformance testing of BS demodulation requirements	#104	Perf. part
38.141-2	conformance testing of BS demodulation requirements	#104	Perf. part
38.133	Add RRM core requirements if needed	#102	Core part
38.133	Add RRM performance requirements if needed	#104	Perf. part
38.306	Add impacts on 38.306 User Equipment (UE) radio access capabilities, if needed	#102	Core part
38.331	Specify the necessary signalling or capability to support the features	#102	Core part
38.213	Add impacts on 38.213 Physical layer procedures for control, if needed	#102	Core part
38.214	Add impacts on 38.214 Physical layer procedures for data, if needed	#102	Core part

3 Intermediate round

3.1 Objective of core part

3.1.1 4Tx

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

- Investigate framework and architecture
- Example bands:

- TDD bands: n41, n77 and n78
 - FDD bands: [n1, n7, n66]
 - [Note 1: the total number of example band should be limited to 3.]
 - Note 2: other bands to be introduced in the release independent way later from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority
- Specify the UE RF requirements to support 4Tx
- First priority: 4x4 UL MIMO
 - Second priority: investigate and if necessary specify Tx D requirement to support the same power class in UL MIMO and single antenna port
 - PA configuration assumption:
 - First priority: 4x23dBm
 - Second priority: 2x23dBm + 2x26dBm, 4x20dBm
 - UE power class
 - First priority: PC 1.5
 - Second priority: PC2 and PC3
 - Note: PC1.5 is only applicable for TDD bands

Feedback Form 8:

1 – Qualcomm Korea

For PA configuration, we propose including 4x26 dBm as first priority along with 4x23. The moderator first round summary indicates that 5 vendors raised concern about viability of 4x26 but I wasn't able to identify the technical concerns from the first round comment. Our understanding is that this work item is for FWA (not smartphone) so we don't see the technical issue with 4x26.

For power class, since we are considering powers that may exceed 29 dBm then we should not limit the work item objective to PC1.5.

2 – Apple (UK) Limited

Is the intention to consider different PA configurations to define different sets of MPR/A-MPR requirements? One suggestion is to define only one set of requirements (minimum requirements) based on 4x23dBm for PC1.5. Other implementations chosen by UE, such as 2x23dBm + 2x26dBm or 4x26dBm which may help reduce MPR/A-MPR would be considered as UE's performance margin improvement and there is no need to further define tighter requirements for configurations with individual PA rating higher than 23 dBm.

3 – AT&T GNS Belgium SPRL

We support the moderator proposal.

4 – China Telecom Corporation Ltd.

Generally looks good. One minor comment on NOTE 1 for the example band. As several companies commented, n77 and n78 overlap and can be seen as one band from the RAN4 workload perspective, so some modifications on the NOTE 1 is needed.

We are fine to limit the number of FDD example bands if needed. n1 is our priority, and we can hear more operators' opinions.

5 – ZTE Corporation

We tend to agree with Qualcomm that 4x26dBm PA configuration should be added, for CPE device with 4x26dBm PA configuration, it should be feasible, for the vendors proposing the removal of 4x26dBm PA configuration, more clarity is needed.

In addition, for 4x26dBm PA configuration, then new power class should be defined, otherwise PA capability cannot be fully utilized in fact.

6 – vivo Communication Technology

Clarification is needed, what does 1st priority mean in the bullet note3; if we understand correctly it would mean only TDD requirements shall be finalized first then the 2nd priority work can be started. If 1st priority scope and 2nd priority can work in parallel, then we can not support adding example FDD bands in the WID currently.

We also think that we need to clarify ULFPTx mode for 4x4 MIMO requirements.

In addition, we are still not clear about the benefits of listing PC3 in the scope for 4Tx CPE, and want to know what is the PA configuration assumption for PC3?

7 – Guangdong OPPO Mobile Telecom.

1. For the example bands, the total is 3, so for TDD bands, it suggest to include only n41 and n78; for FDD bands, Either n1 or n7 probably is ok.

2. Suggest to limit the combination of PA configurations and Power classes, since if we consider 3 power classes (PC1.5/2/3) and 4 PA configurations (4x26/4x23/4x20/2x23+2x26) then the permutation will be 12 cases to be studied in RAN4, this will lead to huge work loads. Therefore, we tend to agree with Apple that only consider the basic PA configuration for each power class and then allow UE to implement better PAs can make the specification easier, if possible can make it clear in the WID. If no limitation on the permutation, then we suggest to remove following cases to keep RAN4 in a reasonable workload:

- PC3 (*too low power class and not clear why does UE transmit only 23dBm with 4PAs*)
- 4x26 (*this will exceed the highest power class that have ever considered in RAN4, FFS on the implementation impacts*)
- 4x20 (*not typical implementation and not see the benefits of this implementation, and what is the targeted scenario?*)

8 – Nokia Japan

Regarding PC3 and PC2, since it really would not make sense assuming 17 dBm x 4 and 20 dBm x 4 for CPE device. P-max would be utilized to address a country specific regulation as PC2 device is available in that country even now.

Too many permutations create the similar chaotic situation had been seen in Rel17 FR1 UE RF enhancement WI.

Hence, we suggest that we start with PC1.5 with PA configurations of 23 dBm x 4.

Maybe, PC1 with 26dBm x 4 can be the next one since a way of specifying requirements for 26dBm x 4 must be similar to that for 23dBm x 4, though values must be different.

Some other PA configurations together with PCs can be considered if time allows.

Finally, we should clarify that band specific issues like A-MPR can be discussed once generic requirements like MPR are completed.

9 – Huawei Technologies France

We are open to PA configurations of 4x26dBm, but new power class should be considered as 2nd priority.

For the example bands, there could be two alternatives:

Alt 1: remove brackets for FDD bands, and remove Note 1. According to Note 3, the work for FDD bands can be started after requirements for TDD bands are stable.

Alt 2: Insisted on the Note 1 with max 3 bands, and consider n77 and n78 as one band, then only consider 1 FDD band for the moment, n1 could be considered firstly

Slightly prefer Alt 1.

10 – Samsung Electronics Co.

In general, we are fine with current prioritization related to work scope. It is better to clarify the RAN4 workplan on handling different priority cases. Is RAN4 going to complete the requirements for 1st priority (4x23dBm, PC1.5, TDD) before starting any work in 2nd priority? If so, to adapt a phase-approach description in the WID is a better reflection of discussions, i.e., phase 1 for the 1st priority and phase 2 for the 2nd priority.

11 – SoftBank Corp.

For lower power classes, we understand the concerns from companies from the technical perspective. But as commented in the initial round, there is a problem that only PC3 (or PC2) can be used in certain regions even if it is a CPE device. Considering this situation, we still would like to keep PC2/PC3 as the second priority.

12 – TELECOM ITALIA S.p.A.

We are generally fine, but would like to add the 4x26 dBm case. This is of particular interest for outdoor CPE installations, where SAR and EMC issues are less relevant.

13 – NTT DOCOMO INC.

To Vivo, OPPO, Nokia

Regarding PC3, thank you for the comments.

Only concern from our side is that when RAN4 introduce 4x4 UL MIMO into only PC1.5, operators following a country specific regulation may not be able to use 4x4 UL MIMO.

One possible solution may be to use P-max, as Nokia commented. But we are not sure if it is possible for UE indicating PC1.5 to get a certification in such a country. Of course, we guess that operators in such a country must set P-max so that all UE (including roaming in UE from foreign countries) connecting with their NWs surely meet the maximum output power limitation in the regulation. Even if we consider the NW operation, we are still not sure if PC1.5 UE can get a certification. The issue can be solved if UE supporting 4x4 UL MIMO is allowed to indicate PC3.

About PA configuration for PC3, we are open, but we think 23dBm x 4 can be used for PC3. It means the UE implements 4PAs but total power should be equal to or lower than 23dBm. It is too high PA capability, so, as I commented in first round, we need to consider the cost effective when we try to use it.

==

Regarding example bands for FDD band, our preference is n1.

14 – China Mobile Group Device Co.

Generally, we support moderator's proposal.

For the example band, we are also OK if we update band n77/n78 with another FDD band.

15 – Intel Corporation (UK) Ltd

The moderator proposal is fine for us. With respect to prioritization - we suggest that the work on 2nd priority objectives can start after a reasonable progress is achieved for the 1st priority objectives (e.g. can start in Q2 2023).

16 – Skyworks Solutions Inc.

Since the goal for this is CPR for higher range/UL throughput. we do not see much benefit in PC3 and PC2. 4x23dBm PC1.5 should be the priority and then for 4x26dBm a new power class is needed (should this one be only valid for 4TX?)

17 – Skyworks Solutions Inc.

we agree that n77/n78 can be considered as one band.

18 – Huawei Technologies France

To further accommodate the comments by companies, we want to make some further revisions as below:

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

- Investigate framework and architecture
- Example bands:

- o TDD bands: n41, n77 and n78

- FDD bands: {n1,~~n7~~,n66}
 - {Note 1: the total number of example band should be limited to 3.}
 - Note 2: other bands to be introduced in the release independent way later from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority
- Specify the UE RF requirements to support 4Tx
 - First priority: 4x4 UL MIMO
 - Second priority: investigate and if necessary specify TxD requirement to support the same power class in UL MIMO and single antenna port
- PA configuration assumption:
 - First priority: 4x23dBm, **4x26dBm**
 - Second priority: 2x23dBm + 2x26dBm, 4x20dBm
- UE power class
 - First priority: PC 1.5
 - Second priority: PC2 ~~and~~, PC3, **and new power class if needed**
 - Note: PC1.5 is only applicable for TDD bands
 - **Note: Requirements are specified with phase approach. PC1.5 is considered in phase I, and other power classes are considered in phase II.**

19 – Ericsson France S.A.S

Generally the objectives are OK for us. For the TDD band, n78 could be taken as an example band for the n77/78 range. As mentioned by other companies, we should take care about the number of combinations, so starting with PC1.5 and 4x23dBm is prudent in our view. We would prefer not to include PC2/3, but if a need is identified on a regional basis PC2 could be considered after PC1.5 is completed. For the PA assumptions, the first focus should be 4x23dBm as suggested. For the second priority, we could replace 4x20dBm with 4x26dBm (and keep the 2x23dBm, 2x26dBm), but for 2nd priority PC we should either consider new PC *or* consider PC2/3, not both (otherwise the 2nd phase would become large in scope).

Hence in Huawei assumption above move "4x26dBm" to 2nd priority and "PC3, PC3 and new power class if needed" to "PC2/PC3 or new power class if needed". The scope may need further clarification once getting to the second phase.

We think it would be useful to clarify the use of ULFPTx modes, although if seen as implicit in the objectives we are also OK with the objectives the way they are.

20 – Deutsche Telekom AG

We see n78 for TDD and n1 for FDD as priority bands.

21 – Nokia Japan

We agree with Ericsson. I understand the challenges in moderating this topic, but the amount of work is becoming larger and larger....

To docomo, we understand the motivation. But if your assumption is 23 dBm x 4 but the total PC is 23 dBm, actually the device is in a similar or the same status that the UE's power is restricted up to 23 dBm by P-max...

We can keep PC3, assuming that it would be likely that a country cannot use PC1.5 also cannot use PC2. Then, PC3 would be prioritised compared to PC2. But the discussion on PC3 should start after the completion of PC1.5. And it would be great if the proponents of PC3 could check in offline, why roaming device of PC2 is OK to be used under P-max while why non-roaming devices are not allowed to be used under P-Max and monitor the latest situation on if still PC3 is needed before PC3 discussion starts since PC2 or higher may be able to be used by that time.

We still don't see the necessity of 20 dBm x 4.

3.1.2 8Rx

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

– Example bands:

- TDD bands: n41, n77 and n78
- FDD bands: [n1]
 - [Note 1: the total number of example band should be limited to 3.]
 - Note 2: other bands to be introduced in the release independent way later from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority

– Specify the UE RF requirements to support 8Rx

– Study and specify the requirements to support SRS antenna switching for [1T8R], 2T8R and 4T8R

Feedback Form 9:

1 – AT&T GNS Belgium SPRL

We are generally OK with the moderator proposal, but we think that the list of FDD bands in brackets should contain some other options than Band n1. When looking at the 4Tx case, it would be good to include n7 in the 8Rx list. Band n66 with its wide Tx-Rx separation may not be needed to be listed. Band n1 also has similar properties to n66 in this regard. Adding n7 and another mid-band FDD band with less Tx-Rx separation such as n2/n25 could be appropriate.

2 – China Telecom Corporation Ltd.

Thanks moderator for adding the FDD example band. Similar to the 4Tx objective, we think the NOTE 1 needs to be modified. We support to use n1 as one of the example FDD bands.

For SRS antenna switching, perhaps 1T8R can be removed, unless it is confirmed as one typical implementation.

3 – vivo Communication Technology

similar comments as 4Tx: Clarification is needed, what does 1st priority mean in the bullet note3; if we understand correctly it would mean only TDD requirements shall be finalized first then the 2nd priority work can be started. If 1st priority scope and 2nd priority can work in parallel, then we can not support adding example FDD bands in the WID currently.

4 – Guangdong OPPO Mobile Telecom.

1. For clarification, what is the necessity to list several example bands, is there many difference between them in supporting 8Rx? If not, then in total 3 or even 2 example bands are listed, and in this case n41/n78 and either n1 or n7 probably is enough.

2. For the SRS antenna switching, suggest to remove [] from 1T8R to cover the case of 1Tx + 8Rx case since 8Rx is optional feature can be supported with any Tx capability.

5 – Nokia Japan

Regarding SRS Tx port switching pattern, t18R, t2r8 and t4r8 should be included. However, the discussion on t4r8 shall start after at least one PC for 4Tx is completed.

6 – Huawei Technologies France

Regarding example bands, if we consider n77 and n78 as one band, then we can consider one FDD band, i.e. n1 for the moment. Other bands can be considered later, the first step is to specify general requirements for TDD and FDD bands firstly.

7 – Samsung Electronics Co.

In general, we are fine with moderator proposal. It is better to clarify the RAN4 workplan on handling 1st priority objective and 2nd priority objective (as we commented for 4Tx)

8 – SoftBank Corp.

We support moderator's proposed objective.

9 – TELECOM ITALIA S.p.A.

ok with moderator's proposal. 1T8R could be removed in our opinion, if it helps simplifying the objectives

10 – China Mobile Group Device Co.

Generally, we are OK with moderator's proposal.

For the example band, the same as 4Tx, we are also OK if we update band n77/n78 with another FDD band.

11 – NTT DOCOMO INC.

If we choose one example band for FDD, our preference is n1.

12 – Intel Corporation (UK) Ltd

We support defining SRS antenna switching requirements. We are overall ok with 1T8R, 2T8R and 4T8R. Also, the current UE capability framework does not support capabilities for SRS AP switching for 8RX (e.g., 1T8R is not formally defined in specs) and we recommend to rephrase the text to make it more generic:

- *Study and specify the requirements to support SRS antenna switching for ~~[1T8R]~~, 2T8R and 4T8R UEs capable of SRS transmission on up to 4 antenna ports over total of 8 antennas (e.g. 1T8R, 2T8R, 4T8R)*

13 – Skyworks Solutions Inc.

Adding n1 as the FDD example is useless since this band does not suffer from UL de-sense thus it does not provide anything better than a TDD case. band n7 at least has some de-sense for large CBW. we agree that n77/78 can be considered as one case.

14 – Ericsson France S.A.S

The proposals are generally OK; as for 4TX, in principle n78 could be used as an example for the n77/n78 range.

15 – Deutsche Telekom AG

We see n78 for TDD and n1 for FDD as priority bands.

16 – Spreadtrum Communications

We are fine with moderator's proposals. With one concern that 1T8R might lead to UL/DL coverage unbalance so that it won't be a practical case.

3.1.3 Lower MSD

Investigate the feasibility of and if necessary, specify lower MSD for inter-band CA/EN-DC/DC combinations

- Select a limited set of band combinations (2-4 combinations)
 - Example band combinations: CA_n1-n77, CA_n3-n41, CA_n28-n40
- Study how the MSD performance can be improved for the example band combinations
- Study correlation of MSD improvement between different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
 - During the study, based on the progress on the example band combinations, also check whether the generic approach can be applied based on UE indication of capability
 - Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

Feedback Form 10:

1 – T-Mobile USA Inc.

We support lower MSD both in the specs as well as in the devices. We support a generic approach, if possible. However, since the spec is a minimum requirement, we are not confident that much improvement will be agreeable to all. Since the real world MSD performance can often greatly exceed the spec, we would like to allow a UE to declare "low MSD" for a combination if it requires far less than the MSD allowed in the spec, so that the gNB can identify which UEs do and don't have MSD issues. It would be useful to know if a UE really needs the allowed 20+ dB of MSD in the spec, for example, or if it only needs 5 or even 0 dB. Therefore, we propose adding the following objective:

- Study the feasibility of and options for allowing a UE to signal actual lower MSD for combinations where MSD is allowed

2 – Qualcomm Korea

Our understanding of the motivation for this objective is to more closely align the MSD specification with actual performance of devices. Our view is that many of the existing MSD specifications do not reflect the performance of actual devices and are so large that they are not deployable if the devices only meet the specified performance. Thus, the objectives should include the opportunity to improve MSD by at least 10 dB, 20 dB or more. Incremental improvement of MSD will not address the problem.

3 – Apple (UK) Limited

1. RAN4 defines MSD as the minimum requirement which was based on the worst-case components performance and normally represents the tail of the statistical distribution. For example, certain filter isolation numbers taken from component vendor's data sheet could have 50dB as typical and 40dB as minimum. It would not be surprised if a few randomly selected devices could perform much better than specified MSD. However, the distribution of the device performance still cannot be ignored.

2. The limited antenna isolation may not be realized in conductive conformance tests. Therefore, some large MSD numbers may only be observed in OTA tests.

3. Combinations with large MSD are not necessarily not deployable, especially when the UE is not far away from the basestations where the UL aggressor power is reduced and DL victim carrier power is increased, and under such condition, the UL interference would no longer be an issue. The large MSD can also be mitigated by non-simultaneous Rx/Tx operation when necessary. Therefore, having a mechanism to allow UE switch between simultaneous Rx/Tx and non-simultaneous Rx/Tx based on field operating condition can benefit the performance of band combinations potentially with large MSD.

4. Propose to include the objective to study how the MSD varies with UL aggressor power reduction and potentially develop certain criteria to assist network to conditionally schedule the band combination with simultaneous Rx/Tx operation.

4 – AT&T GNS Belgium SPRL

In general, we are OK with the updated objectives. However, we note that an additional example band combination has been added without brackets but there was no consideration to previous requests concerning other example band combinations. In the Rel-18 Prep email discussions, AT&T proposed to add a low-low and a low-mid case to the example band combinations such as CAn5-n14 and CAn5-n66 to assess the different types of band combinations to maximize the opportunity for a generic solution. We note that many operators are keen to have their band combinations identified as example band combinations.

Given the situation, we would prefer to let RAN4 decide the example band combinations based on the overriding principles that are presented in the objectives as opposed to defining them in the objectives now. We think that the overriding bullet “Select a limited set of band combinations (2-4 combinations)” and the sub-bullet “Study correlation of MSD improvement between different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)” are sufficient to provide guidance for RAN4 to define example band combinations for the study.

5 – ZTE Corporation

Firstly, as mentioned by Qualcomm, if we have very bad MSD performance in spec. e.g. 30dB MSD, with incremental improvement in spec, it’s most likely that network would not remove the scheduling restriction to avoid the MSD issue. From that perspective, only MSD level improved to certain level to enable the removal of simultaneous Rx/Tx operation, then performance gain could be achieved in practice.

In addition, we also agree with Apple that, MSD is only defined based the UE transmitting with maximum output power, however that is only for cell edge UEs transmitting with maximum output power, there were lots of UE in the network transmitting with much lower power, then MSD reporting for these kind of UEs should be also considered.

6 – vivo Communication Technology

We share similar view with Apple, the real MSD performance is highly dependent on UE design, the distribution of the device performance is quite important, from low-end to high-end devices, the MSD improvement can not be applied to all. We support a generic solution for MSD issue, but the above situation should be considered and addressed.

7 – Verizon UK Ltd

This is a leftover work from Rel-17. For making this work more efficient, RAN4 should continually analyze further possible isolation enhancements and signaling impacts, and decide if the work should be for the new combinations being specified or should be optional applying to the existing combinations.

Same as Qualcomm, we also believe that incremental improvement of MSD may not address the problem.

8 – Guangdong OPPO Mobile Telecom.

For the following two bullets, it is still not clear on how this would go in RAN4. Based on the previous discussions in RAN4, it is clear that the ”generic approach (reporting a capability when UE is low MSD)” would be considered as possible if we use the approach of finding some good UEs to justify it. Then what is to be checked for the ”generic approach” is unclear and based on what kind of progress this generic approach can be applied is also unknown.

- During the study, **based on the progress** on the example band combinations, also **check whether the generic approach can be applied** based on UE indication of capability
- Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

Therefore, In order to avoid the dillamma that RAN4 stands on the starting point after many meetings we suggest to make some further clarification on the contents. Proposed changes are as below, considering if no conclusion on MSD improvement then there is no meaning of introduce the generic approach:

- During the study, **if improved MSD requirement is concluded achievable** based on ~~the progress~~ ~~on~~ the example band combinations, then further ~~also~~ check whether the generic approach can be applied based on UE indication of capability
- Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

9 – Nokia Japan

We agree with T-Mobile USA to include the following objective since that must be the original low MSD proposal. In order to address it, study of various type of root causes of MSD is needed since e.g., 10 dB improvement of IMD2 for a UE may not always apply to 2nd harmonic MSD, then, the UE must explicitly indicate that lower MSD only applies to IMD2. If the improvement applies to both IMD2 and 2nd harmonic, the signalling becomes even simpler. Or if it depends on an actual implementation solution, the signaling must be flexible enough.

- Study the feasibility of and options for allowing a UE to signal actual lower MSD for combinations where MSD is allowed

We don't agree with including the following objective proposed by Apple. That is not directly related to the original low MSD discussion. The purpose of the original low MSD is to allow NW to identify which UEs do and don't have MSD issues. Since without it, UE with far less MSD may be treated in the same manner as that of UE with large MSD. That is the fundamental and main stream to be addressed.

- study how the MSD varies with UL aggressor power reduction and potentially develop certain criteria to assist network to conditionally schedule the band combination with simultaneous Rx/Tx operation.

10 – Samsung Electronics Co.

In general, we are fine with Moderator proposal. On generic approach, we share the similar view as OPPO and suggest to revise the WID based on revised version from OPPO.

11 – China Mobile Group Device Co.

Generally, we support moderator's proposal.

About the signaling, it should be flexible enough. The objective proposed by T-mobile USA and Nokia is also OK for us.

About the example band, our preference is to explicitly list them into the objectives rather than discussing them during formal RAN4 phase. But if example band is still controversial after intermediate round, we are also OK to discuss example band in RAN4 WI phase.

12 – TELECOM ITALIA S.p.A.

We share the view expressed by T-Mobile USA and Nokia to include the following objective:

- Study the feasibility of and options for allowing a UE to signal actual lower MSD for combinations where MSD is allowed

We share the concern raised by Nokia on the new objective proposed by Apple

13 – Huawei Technologies France

We agree with AT&T that the example band combinations may not need to be decided in RAN, which can be further discussed in RAN4 with the principle of 2-4 band combinations for different MSD sources.

Regarding the objective by T-Mobile USA, we think that can be considered under existing bullet of the feasibility of generic approach, the approach is not limited to UE capability indicating, but the first thing is to study how much MSD can be improved. If we have too much discussion on the signaling aspects, we see it's a way to put the cart before the horse. In that sense, I think the proposed changes by OPPO makes sense.

For the comments by Qualcomm and ZTE on the incremental MSD improvement, I think it's too early to make judgement, as MSD is yet to be studied, without further study, no one knows exactly what's the improvement could be.

Some further revisions are proposed as below:

- Select a limited set of band combinations (2-4 combinations)
 - o ~~Example band combinations: CA_n1-n77, CA_n3-n41, CA_n28-n40~~
- Study how the MSD performance can be improved for the example band combinations
- Study correlation of MSD improvement between different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
 - o During the study, based on the ~~progress~~**study outcome of MSD improvement** on the example band combinations, ~~also~~ **check the feasibility** whether the generic approach can be applied, **e.g.** based on UE indication of capability
 - o Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

14 – Beijing Xiaomi Mobile Software

We are not sure what is difference between the new proposed objective by T-Mobile USA and the generic approach here. For our perspective, it seems they are the same. Anyway the new proposed objective by T-Mobile USA is acceptable for us. In addition, we also share the similar view with Apple and ZTE, as the actual MSD depends on actual Tx power, it is meaningful to have a study on how to treat UEs with high MSD dynamically by considering actual Tx power.

15 – NTT DOCOMO INC.

In general, we are OK with the moderator's proposal.

For example band combinations, we are open and the current example band combinations are also fine, but we think n1+n3+n77 may be one of good example band combinations because it has many types of MSD within one band combination according to TS 38.101-1 v17.4.0:

- MSD for UL harmonic(n1 to n77, n3 to n77)

- MSD for harmonic mixing(PC2 n78(n77) to n3)
- MSD for 2UL/2DL IMD(IM2 and IM4)
- MSD for 2UL/3DL IMD(IM2)
- MSD for cross band isolation(n1 and n3)

16 – Intel Corporation (UK) Ltd

Support T-Mobile proposal to add an objective on “Study the feasibility of and options for allowing a UE to signal actual lower MSD for combinations where MSD is allowed”

17 – Skyworks Solutions Inc.

We3 support the proposal that the band combinations example should cover all types of MSD issues. We may just have an agreement like: 2-4 band combinations are selected to cover all types of MSD (harmonic, harmonic mixing, IMD and cross band isolation)

18 – Ericsson France S.A.S

We share the view of AT&T that it may be better to let RAN4 decide on a small number of example combinations that give rise to the MSD issues that need to be studied. We proposed an objective along these lines in the 1st round:

- Select a limited set of band combinations (2-4 combinations) that include harmonic mixing and IMD (and cross-band isolation for a band combination for which simultaneous Rx-Tx is optional).

We agree with the proposed Nokia update bullet. We also share the view that the study should be focused on identifying improvements to MSD based on implementations and not network conditions, and so do not support to extend the study to UE position / network condition based reporting.

19 – Deutsche Telekom AG

We support T-Mobile USA view here

20 – VODAFONE Group Plc

We share the view expressed by T-Mobile USA, Telecom Italia and Nokia to include the following objective:

- Study the feasibility of and options for allowing a UE to signal actual lower MSD for combinations where MSD is allowed

21 – Sony Group Corporation

We support the objective proposed by T-mobile:

- Study the feasibility of and options for allowing a UE to signal actual lower MSD for combinations where MSD is allowed.

We also share a similar understanding as Apple that real life MSD can be affected by the UL power level and think this can actually be addressed if actual MSD can be dynamically indicated to the network.

22 – Huawei Technologies France

We don't think it would be helpful to explicitly say what kind of UE capability reporting mechanism is considered in the SI, all these are open to be discussed during the study, as usual, which is paper driven. The most important thing is to identify to what extent the MSD can be improved firstly. Skyworks suggestion is ok for us, which makes it clear how to select the example band combinations.

2-4 band combinations are selected to cover all types of MSD (harmonic, harmonic mixing, IMD and cross band isolation)

3.2 Objective of performance part

The objectives of performance part for Rel-18 RF FR1 requirement focus evolution include:

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices
 - Specify the BS demodulation performance requirements to support UL 4-layer MIMO UE operation
- Enable 8Rx for CPE/FWA/vehicle/industrial devices
 - Specify RLM test cases with to support 8Rx
 - Investigate if the existing 4Rx RLM test can be reused or the new test will be specified
 - Specify UE demodulation performance and CSI requirements with up to 8 layers to support 8Rx
 - Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers
 - Specify the SDR requirements with 8 MIMO layers
- Specify release independence requirements in TS 38.307 if needed.

Feedback Form 11:

1 – China Telecom Corporation Ltd.

For 8Rx, we don't support to investigate/FFS the necessity of specifying the requirements for 8 DL MIMO layers. According to the initial round discussion, the main concern on specifying 8Rx demod requirements is on the feasible correlation assumption for 8Rx, but we can find appropriate correlation assumption for testing purpose in the WI phase. Adding an investigation phase will increase the workload on arguing the necessity in RAN4.

We support the addition of SDR test for 8-layer.

2 – Guangdong OPPO Mobile Telecom.

For clarification, why only RLM test cases is mentioned in the 8Rx, how about other RRM requirements, is there no impact?

<p>3 – TELECOM ITALIA S.p.A.</p> <p>Similar to China Telecom, we have some concerns with the subobjective</p> <ul style="list-style-type: none"> - Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers
<p>4 – Intel Corporation (UK) Ltd</p> <p>For 4TX objectives we suggest adding an explicit objective for <u>”Specify the BS conformance requirements”</u></p>
<p>5 – Ericsson France S.A.S</p> <p>To Intel: Could you clarify what are the BS conformance requirements that need updating ? There are no new BS RF requirements. Of course, introducing performance requirements needs to be reflected in the BS conformance specification, although we think that is implicit.</p>
<p>6 – Huawei Technologies France</p> <p>To CTC and Telecom Italia, in the fading propagation condition, the required SNR for 8-layer demodulation would be very high, which could not be met considering the current available Rx EVM. So it would be better to study the required SNR and channel model to ensure the testability. Thus we prefer to keep the sub-bullet. Besides, there seems no 8-layer demodulation requirements under fading channel for LTE. So the 8-layer demodulation requirements under fading channel would be a new topic, which needs some study.</p> <p>To OPPO, for legacy 4RX, there are no core requirements and only RLM test cases for 4Rx are specified. we think the same principle can be reused for 8RX.</p> <p>To Intel’s comments, we share similar view with Ericsson. In our understanding the BS conformance testing is for demodulation rather than for RF.</p>

3.3 Affected specifications

Table 3:

Impacted existing TS/TR <i>{One line per specification. Create/delete lines as needed}</i>			
TS/TR No.	Description of change	Target completion primary#	Remarks
<i>{E.g. "22.281"}</i>	<i>{Possible values: - either free text (e.g. "CS aspects to be removed") - or "Specification to be withdrawn"}</i>	<i>{E.g. "TSG#89"}</i>	<i>{Free text}</i>

38.101-1	Specify UE RF core requirements	#102	Core part
38.101-3	Specify UE RF core requirements related to EN-DC	#102	Core part
38.307	Specify release independence	#104	Perf. part
38.101-4	Specify UE demodulation performance and CSI requirements for >4Rx	#104	Perf. part
38.104	Specify BS demodulation performance requirements for >2Tx	#104	Perf. part
38.141-1	conformance testing of BS demodulation requirements	#104	Perf. part
38.141-2	conformance testing of BS demodulation requirements	#104	Perf. part
38.133	Add RRM core requirements if needed	#102	Core part
38.133	Add RRM performance requirements if needed	#104	Perf. part
38.306	Add impacts on 38.306 User Equipment (UE) radio access capabilities, if needed	#102	Core part
38.331	Specify the necessary signalling or capability to support the features	#102	Core part
38.213	Add impacts on 38.213 Physical layer procedures for control, if needed	#102	Core part

38.214	Add impacts on 38.214 Physical layer procedures for data, if needed	#102	Core part
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Feedback Form 12:

1 – T-Mobile USA Inc.

The list looks good to us. Thanks for adding 38.306.

3.4 Summary for intermediate round

3.4.1 4Tx

Comments in intermediate round are focused on example bands, PA configuration and power classes.

- **Example bands:** Considering the work load in RAN4, companies are willing to have number limit of example bands to 3, and considering n77 and n78 as one band seems agreeable. And n1 as higher priority was confirmed by three operators.
- **PA configuration:** 4x26dBm was proposed by some companies to be considered, but different views on the priority for this PA configuration. Some companies commented that 4x20 may not be necessary.
- **Power class:** Most companies agree to consider PC1.5 as 1st priority. It is also proposed that phase approach should be considered for specifying the requirements according to the priorities. Also it is suggested by companies that RAN4 may not be able to handle all power class requirements in phase II.

Based on the comments for the above aspects for 4Tx, moderator’s suggestion is to check the modified objectives below in final round.

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

- Investigate framework and architecture
- Example bands:
 - TDD bands: n41, n78(n77)
 - FDD bands: n1
 - [Note 1: the total number of example band should be limited to 3.]
 - Note 2: other bands to be introduced in the release independent way later from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority
- Specify the UE RF requirements to support 4Tx

- First priority: 4x4 UL MIMO
- Second priority: investigate and if necessary specify TxD requirement to support the same power class in UL MIMO and single antenna port
- PA configuration assumption:
 - First priority: 4x23dBm
 - Second priority: 2x23dBm + 2x26dBm, **4x26dBm**,~~4x20dBm~~
- UE power class
 - First priority: PC 1.5
 - Second priority: PC2/PC3, **and/or new power class if needed**
 - Note: PC1.5 is only applicable for TDD bands
 - **Note: Requirements are specified with phase approach. PC1.5 is considered in phase I, and other power classes are considered in phase II.**

3.4.2 8Rx

Comments in intermediate round are mainly focused on:

- **Example bands:** Most companies agree to consider n77 and n78 as one TDD band. For FDD bands, two operators prefer to consider n1, and one operator and one vendor proposed to consider n7. Also there some comment on clarification on handling of priority.
 - Moderator suggestion: the FDD band n1 can also cover the case for n66 from the requirements perspective. Start from an easy band could be a good starting point.
- **SRS antenna switching:** different views on whether to include 1T8R. Also there are some proposal to antenna ports, but e.g. part seems not clear, as there are no other cases for antenna switching. One company commented that discussion on 1T8R shall start after at least one PC for 4Tx is completed.

Based on the comments, moderator's suggestion is to further check in final round whether the modified objectives are agreeable.

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

- Example bands:
 - TDD bands: n41, n78(n77)
 - FDD bands: n1
 - [Note 1: the total number of example band should be limited to 3.]
 - Note 2: other bands to be introduced in the release independent way later from Rel-18

- Note 3: specifying requirements for TDD bands has first priority. Phase approach is considered for the priorities, and requirements for TDD bands are specified in phase I.
- Specify the UE RF requirements to support 8Rx
- Study and specify the requirements to support SRS antenna switching for t1r8, t2r8, t4r8
 - Note: Discussion on t4r8 shall start after at least one PC for 4Tx is completed

3.4.3 Lower MSD

The comments in intermediate round are mainly focused on:

- **Example bands:** most companies agree the example bands should consider all types of MSD (harmonic, harmonic mixing, IMD and cross band isolation)
 - Moderator suggestion: specific band combinations can be decided in RAN4 with the principles that 2-4 combinations are considered with all types of MSD
- **MSD to be improved:** Some companies commented that incremental MSD improvement may not be enough to address the performance issue, some companies commented that how much the MSD can be improved should be based on the study
- **generic approach including the signaling aspects:** some companies proposed some specific signaling method to address the lower MSD issue, but also there are comments that the specific solutions are the second step, which should be discussed based on the MSD improvement study outcome.

Based on the comments, moderator suggests to check in the final round on the modified objectives as below:

- Select a limited set of band combinations (2-4 combinations) to cover all types of MSD (harmonic, harmonic mixing, IMD and cross band isolation)
- Study how the MSD performance can be improved for the example band combinations
- Study correlation of MSD improvement between different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
 - Based on the study outcome of MSD improvement on the example band combinations, check the feasibility whether generic approach can be applied, e.g. based on UE indication of capability
 - Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

3.4.4 Objective of perf part

There are some discussion on the objectives of:

- whether "Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers" is needed

- why only consider "Specify RLM test cases withto support 8Rx" for RRM requirements
- suggestion of adding an explicit objective for "Specify the BS conformance requirements"

For each comment, there are corresponding reply. In moderator's understanding, the comments can be clarified by the responses. Therefore, moderator's suggestion is to further check in final round whether the objectives below are agreeable according to the clarifications. i.e.

The objectives of performance part for Rel-18 RF FR1 requirement focus evolution include:

- **Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices**
 - **Specify the BS demodulation performance requirements to support UL 4-layer MIMO UE operation**
- **Enable 8Rx for CPE/FWA/vehicle/industrial devices**
 - **Specify RLM test cases withto support 8Rx**
 - **Investigate if the existing 4Rx RLM test can be reused or the new test will be specified**
 - **Specify UE demodulation performance and CSI requirements with up to 8 layers to support 8Rx**
 - **Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers**
 - **Specify the SDR requirements with 8 MIMO layers**
- **Specify release independence requirements in TS 38.307 if needed.**

3.4.5 Affected specifications

No objection for the moderator's proposal on the list of affected specs. The list will be captured in the final WID.

As there is a study phase for lower MSD, it would be better to have an internal TR to capture the the study outcome. Moderator suggestion is to have an internal TR to fulfill this purpose. Check in the final round whether such an internal TR is needed.

4 Final round

4.1 Objective of core part

4.1.1 4Tx

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

- Investigate framework and architecture Example bands:
 - TDD bands: n41, n78(n77)
 - FDD bands: n1
 - Note 1: the total number of example bands should be limited to 3.
 - Note 2: other bands to be introduced in the release independent way later from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority

- Specify the UE RF requirements to support 4Tx
 - First priority: 4x4 UL MIMO
 - Second priority: investigate and if necessary specify TxD requirement to support the same power class in UL MIMO and single antenna port
 - PA configuration assumption:
 - First priority: 4x23dBm
 - Second priority: 2x23dBm + 2x26dBm, **4x26dBm**, 4x20dBm
 - UE power class
 - First priority: PC 1.5
 - Second priority: PC2/PC3, **and/or new power class if needed**
 - Note 1: PC1.5 is only applicable for TDD bands
 - **Note 2: Requirements are specified with phase approach. PC1.5 is considered in phase I, and other power classes are considered in phase II.**

Feedback Form 13:

1 – Huawei Technologies France

For the TDD example bands, according to further comments, we are ok to list 3.5G bands as n77/n78, companies should be aware that they are considered as one example band.

2 – ZTE Corporation

Similar as 8Rx, phase based approach to handle for 4Tx could be also applied and please add the following sentence for NOTE 3.

Requirements are specified with phase approach, and TDD bands are considered in phase I.

3 – Qualcomm Korea

We are generally ok with the proposal from the moderator. We also support the idea of phasing the work between first priority and second priority.

4 – Guangdong OPPO Mobile Telecom.

ok with proposals.

5 – Huawei Technologies France

To ZTE’s comments, we are ok to consider phase approach for 4Tx as well. The note can be revised as:

Note 3: specifying requirements for TDD bands has first priority. Requirements are specified with phase approach, and TDD bands are considered in phase I.

6 – vivo Communication Technology

We share exactly the same view with ZTE on TDD bands, so we support the updated note3 from ZTE and Huawei.

7 – China Telecom Corporation Ltd.

OK with the updated objective and the phased approach for TDD and FDD.

8 – SoftBank Corp.

We are fine with moderator’s proposals.

9 – Apple (UK) Limited

For FDD example band, n7 might be a better choice as it has more pronounced REFSENS impact with 4Tx as compared to n1, similar to what was commented in 8Rx.

10 – Nokia Japan

More clarification is needed.

Concerning PA configuration, the listed PA configurations must be for PC1.5. PA configurations for other power classes must be FFS.

With respect to Phase I, Phase I must mean that requirements for all the listed PA configurations for PC1.5 are ready. That must be clarified. We really would like to avoid chaotic situation where multiple power classes with multiple PA configurations are discussed in parallel.

11 – Samsung Electronics Co.

In general, we are fine with objectives as well as priority.

For phase approach, maybe the note can be more generic for all the 1st priority objective instead of only limiting to PC 1.5, i.e., change the note as additional note for all the core part (instead of sub-bullet for PC)

- Note: Requirements are specified with phase approach. objectives with 1st priority is considered in phase I, and objectives with 2nd priority are considered in phase II.

The same note can be also applied for 8RX.

12 – Intel Corporation (UK) Ltd

We are fine with the proposed objectives. Also, agree with Samsung proposal to make Note on prioritization applicable for all aspects and not PC only.

13 – ZTE Corporation

we have one more question for further clarifications to avoid the further discussion in WG level, for 4Tx PC3, what's the PA configuration assumptions? by 4x23dBm only ?

Similar question for 4Tx PC2, 4x23dBm only or 2x23dBm+2x26dBm could be also considered?

14 – TELECOM ITALIA S.p.A.

A question for clarification to the moderator/Huawei statement in #1

We are ok with the statement, if it means the requirements are the same for the two bands

For the TDD example bands, according to further comments, we are ok to list 3.5G bands as n77/n78, companies should be aware that they are considered as one example band.

15 – China Mobile Group Device Co.

We support moderator's proposal and are also OK with phase approach.

16 – MediaTek Inc.

It seems best to leave the whole PA configuration and power class discussion up to RAN4 and give some high level guidance to narrow down the options. The current status is very confusing to us.

17 – Ericsson France S.A.S

The objectives look generally good and the phased approach is a good suggestion. Regarding the phasing, there seems to be a difference between the Nokia and Samsung proposals, but maybe it is not intentional. As I understand it, the Nokia proposal is Phase 1: PC1.5, TDD, all PA configurations. Phase 2: Other PC, FDD, all PA configurations. Then the Samsung proposal would become Phase 1: PC1.5, TDD, 4x23dBm. Phase 2: PC1.5, TDD, 2nd priority PA configurations, other power classes, FDD.

Possibly it may be better to take the Nokia approach to avoid a mixture of different activities in phase 2.

Regarding the PA configurations for phase 2, our understanding is that there is a need to check whether PC2/3 is useful and still needed for regulations. If it is, then we need to decide between PC2/3 or new PC or both depending on complexity and remaining time. The objectives capture that.

18 – Huawei Technologies France

To ZTE, in our understanding, if PC3 is considered, then 4x23 is one PA configuration can be considered. Regarding PC2, 4x23 could be one typical implementation, but we see PC2 is the second priority, how to consider it and which UE architecture is considered can be left to RAN4.

19 – China Unicom

We are fine with moderator's proposals.

20 – Nokia Japan

We agree with Ericsson. We appreciate an alternative from Samsung, but still it's not clear what the listed PA configurations mean. We know that PC1.5 is discussed in Phase I. But we don't know if the PA configurations listed as 2nd priority to be discussed in Phase I or not.

21 – Skyworks Solutions Inc.

Using n1 for FDD is not very useful since there is no desense due to the large duplex gap. In our view n7 is a better choice for both 4Tx and 8Rx as there is no anticipated issue with n1. n7 also nicely uses the same spectrum range than n41 so the only extra work is the one needed for FDD bands which is assessing the UL interference and related REFSENS impact.

22 – Huawei Technologies France

We are fine with the suggestion by Samsung to have a separate Note to clarify phase I and phase II requirements.

To Skyworks, for the example bands, we also need to consider the requests from operators. Now the selection of n1 for 4T and n7 for 8R is a compromised solution so far seems agreeable to most companies. If we keep discussing the example bands, little progress could be made for the objectives. Hope all companies can work together to consolidate the final objectives in the last moment for the WID.

23 – Nokia Japan

Clarification of phased approach is OK. But again, we can't agree with Samsung's suggestion as it is. We cannot know if phase I can be completed when PC1.5 with 23 dBm x 4 is completed, PC1.5 with 23dBm x 4 and some of the PA configurations are completed or PC1.5 with all the listed PA configurations are completed.

And we don't think the listed PA configurations are not for PC2 or PC3, though some of them can be considered.

Hence, it's not clear what is discussed in Phase 1 and 2, respectively.

At least we should make sure that in Phase 1, PC1.5 with the listed PA configuration will be discussed in the order of priority of PA configurations.

Then, in phase 2, other power classes are discussed while PA configurations are FFS.

24 – AT&T GNS Belgium SPRL

For the comments received during the intermediate round to treat n77 and n78 as the same case, we agree with other companies above that they should be listed as n77/n78 (perhaps with a note to make it clear that the set is considered as one band). We don't think that one of the bands needs to be listed in parentheses. We also support the comments made by Apple and Skyworks that n7 would be a more appropriate FDD example band especially if we are limited to only one.

25 – AT&T GNS Belgium SPRL

Although, we are OK with selecting n1 for 4Tx as previously proposed by the moderator and n7 for 8Rx.

26 – Spreadtrum Communications

We are fine with the proposed objectives and the phased approach, agreeing that the first priority tasks including TDD bands and PC 1.5 at 4*23dBm would be the targets in the phase I.

27 – NTT DOCOMO INC.

The moderator's proposal seems good to us. Phase approach is also OK to us.

Regarding handling of PC3, thank you for understanding and the comments from Nokia in intermediate round and from Ericsson in final round. We think the suggestion is reasonable, and thus we will further check whether PC3 is really needed from regulatory perspective before the Phase 2 starts.

28 – Huawei Technologies France

Thanks for the comments and discussion, the following are the tentative objectives, which can be further discussed in the GTW session.

Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices (RAN4)

- Investigate framework and architecture Example bands:
 - TDD bands: n41, n77/n78
 - FDD bands: n1
- Note 1: the total number of example bands should be limited to 3.
- Note 2: other bands to be introduced in the release independent way later on from Rel-18
- Note 3: specifying requirements for TDD bands has first priority
- Specify the UE RF requirements to support 4Tx
 - First priority: 4x4 UL MIMO
 - Second priority: investigate and if necessary specify TxD requirement to support the same power class in UL MIMO and single antenna port
 - PA configuration assumption:
 - First priority: 4x23dBm
 - Second priority: 2x23dBm + 2x26dBm, 4x26dBm
 - UE power class
 - First priority: PC 1.5
 - Second priority: PC2/PC3, and/or new power class if needed
 - Note 1: PC1.5 is only applicable for TDD bands

NOTE: Requirements are specified with phase approach. Objectives with 1st priority are considered in phase I, and objectives with 2nd priority are considered in phase II.

4.1.2 8Rx

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

– Example bands:

- TDD bands: n41, n78(n77)

- FDD bands: n1
 - Note 1: the total number of example bands should be limited to 3.
 - Note 2: other bands to be introduced in the release independent way later from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority. Requirements are specified with phase approach, and TDD bands are considered in phase I.
- Specify the UE RF requirements to support 8Rx
- Study and specify the requirements to support SRS antenna switching for t1r8, t2r8, t4r8
 - Note: Discussion on t4r8 shall start after at least one PC for 4Tx is completed

Feedback Form 14:

<p>1 – Huawei Technologies France</p> <p>Similar to 4Tx, the TDD bands can be listed as n41, n77/n78.</p> <p>Regarding the FDD example band, we think it's a fair argument by AT&T that n1 is selected for 4Tx while n7 is selected for 8Rx with narrower Tx-Rx separation. In our understanding, after finishing the requirements framework, case by case study for specific operation may not take more efforts. Since the requirements for operating bands are release independent, we are open for the selection of example FDD bands.</p>
<p>2 – Guangdong OPPO Mobile Telecom.</p> <p>ok with scope.</p>
<p>3 – China Telecom Corporation Ltd.</p> <p>OK with the updated objective, the phased approach for TDD and FDD, as well as using n7 (instead of n1) as FDD example band</p>
<p>4 – SoftBank Corp.</p> <p>We are fine with moderator's proposals.</p>
<p>5 – Apple (UK) Limited</p> <p>For FDD example band, we tend to agree with AT&T that n7 might be a better choice as its REFSENS impact from UL interference is more pronounced due to narrower duplex distance as compared to n1.</p>
<p>6 – CHTTL</p> <p>in general ok, just regarding Note 2, I guess probably there is no need to say other bands to be introduced later than Rel.18 at this stage? if the general requirements are completed earlier, the work for other bands can be started in Rel-18 based on the requests.</p>
<p>7 – Huawei Technologies France</p> <p>To Apple, we see n1 for 4Tx and n7 for 8Rx is a compromised selection to consider requests from different operators.</p> <p>To CHTTL, note 2 is not saying other bands will be introduced after Rel-18, probably "later on" would be more clear.</p>

8 – NTT DOCOMO INC.

We are OK with the current objective, and also can accept the moderator’s proposal that FDD example bands are n1 for 4Tx and n7 for 8Rx considering the feedbacks from companies.

9 – CHTTL

To Huawei, thanks, ”later on” seems good.

10 – ZTE Corporation

If we go with band 7 for 8Rx for CPE/FWA, then what’s the Rx number for n1 if supporting 4Tx, this should be clarified, 4Rx or 2Rx? Currently, 4Rx is optional support on band 1.

11 – China Mobile Group Device Co.

We support moderator’s proposal and are also OK with the example band: n1 for 4Tx and n7 for 8Rx.

12 – Ericsson France S.A.S

We are OK with the objectives and open for the FDD band either n1 or n7

13 – China Unicom

We are fine with moderator’s proposals.

14 – Skyworks Solutions Inc.

Using n1 for FDD is not very useful since there is no desense due to the large duplex gap. in our view n7 is a better choice for both 4Tx and 8Rx as there is no anticipated issue with n1. n7 also nicely uses the same spectrum range than n41 so the only extra work is the one needed for FDD bands which is assessing the UL interference and related REFSSENS impact.

15 – AT&T GNS Belgium SPRL

Adding comments from our earlier email when feedback form was locked to NWM:

Although band n1 can be acceptable for the 4Tx example band, we do not think that it is an appropriate example band for 8Rx if we are only considering one FDD band. As we noted in the intermediate round, we should identify an FDD example band that does not have as wide of a Tx-Rx separation as band n1 if we are to limit to one band. We suggested n7 or n2/n25 as an alternative. In addition, our proposal to consider n2/n25 was also missed in the moderator summary for the intermediate round.

Additional Final Round comments:

As commented in 4Tx, we think that listing n77/n78 with a possible note to clarify that the set is treated as one band would be preferable. We can support the compromise proposal of selecting n7 for 8Rx example FDD band and n1 for 4Tx example FDD band. However, we do agree with the Skyworks comment that using n7 for both could help to minimize any extra work.

16 – Spreadtrum Communications

We agree the proposed objectives. We prefer to the example FDD band n7.

17 – Huawei Technologies France

Thanks for the comments and discussion, the following are the tentative objectives, which can be further discussed in the GTW session. As suggested by AT&T, in note 1 make it clear that n77/n78 are considered as one TDD band during the study.

Enable 8Rx for CPE/FWA/vehicle/industrial devices (RAN4)

• Example bands:

- TDD bands: n41, n77/ n78

- FDD bands: n7

▪ Note 1: the total number of example band should be limited to 3. n77/n78 are considered as one band during the study.

▪ Note 2: other bands to be introduced in the release independent way later on from Rel-18

▪ Note 3: specifying requirements for TDD bands has first priority

• Specify the UE RF requirements to support 8Rx

• Study and specify the requirements to support SRS antenna switching for t1r8, t2r8, t4r8

- Discussion on t4r8 shall start after at least one PC for 4Tx is completed

NOTE: Requirements are specified with phase approach. Objectives with 1st priority are considered in phase I, and objectives with 2nd priority are considered in phase II.

4.1.3 Lower MSD

Investigate the feasibility of and if necessary, specify lower MSD for inter-band CA/EN-DC/DC combinations

- Select a limited set of band combinations (2-4 combinations) to cover all types of MSD (harmonic, harmonic mixing, IMD and cross band isolation)
- Study how the MSD performance can be improved for the example band combinations
- Study correlation of MSD improvement between different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
 - Based on the study outcome of MSD improvement on the example band combinations, check the feasibility whether generic approach can be applied, e.g. based on UE indication of capability
 - Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

Feedback Form 15:

1 – T-Mobile USA Inc.

In the intermediate round we proposed adding the following bullet, and we count 8 companies either said they support it or were OK with it.

- Study the feasibility of and options for allowing a UE to signal actual lower MSD for combinations

where MSD is allowed

We don't agree with the idea that signalling should only be considered after seeing how much MSD can be improved. RAN4 spends a lot of time working on MSD, but in order to allow for implementation flexibility the resulting MSD is fairly generous. After spending time working on this in RAN4 over the last year, we are not confident that we will be able to come up with significant improvements in specified MSD. We have worked with vendors to understand why some implementations have much lower MSD than allowed for in the specs, but we understand that it may not be agreeable to make such improvements mandatory. We think that rather than debating small incremental improvements in the minimum performance, the industry would be better served by allowing UEs to indicate MSD that is less than the required minimum performance. However, we don't think that such capability signalling should be just an afterthought of the MSD improvement work. We would prefer it to be done in parallel because the signalling could be quite complex - should the improvement be signalled per type of MSD? Should it be a function of victim bandwidth? Per victim band? Or should there be an alternative set of tables? Because of this potential complexity, we would prefer that the signalling aspects be worked in parallel with the MSD improvement work.

2 – Huawei Technologies France

To T-Mobile USA, the intention to put the MSD improvement as high priority is to avoid the situation that companies are rushing to the signaling discussion rather than focusing on the fundamental issue of MSD improvement, as we know that the RF aspects would require more efforts in RAN4. To proceed, we propose to make following revisions for the bullet below:

- Based on the study outcome of MSD improvement on the example band combinations, check the feasibility whether generic approach can be applied, e.g. based on UE indication of capability/**signaling reporting, etc.**
 - o **The discussion progress in Rel-17 can be taken into account as well**

3 – Qualcomm Korea

Similar views and concerns as expressed by T-Mobile USA. We see the value in low MSD objective as allowing for UE implementations which greatly exceed the minimum requirement to inform the network so that they can be scheduled accordingly. Not only does this improve the performance of this UE, but it should also improve the overall system capacity since the network knows which UE's are more tolerance of interference and which ones are more sensitive to interference and balance their scheduling. We do not propose that the significantly improved MSD is required of all UE's for all band combinations, but only for those that optionally signal the capability.

4 – Guangdong OPPO Mobile Telecom.

Ok with the scope, and in our understanding the signaling of lower MSD should also have corresponding requirements in RAN4, e.g. UE report MSD improvement 10dB, then this UE has to be tested with its REFSSENS to see whether it really can achieve that or not. This is the intention of MSD re-evaluation, i.e. tighten minimum requirements, in our understanding. From this perspective, it needs to be justified that whether and how minimum requirement can be improved.

(Unfortunately, it seems this discussion is coming back to the starting point again as we commented in previous rounds that this should be avoided if include this topic...)

5 – Verizon UK Ltd

We shared the same view as both T-Mobile and Qualcomm and agreed the bullet from T-Mobile to be reflected in the objective because it is part of discussions in Rel-17 after the related studies took place in RAN4.

As mentioned in the initial round, RAN4 should continue this work from Rel-17 leftover to make this work more efficient. Thus we also support the new sub-bullet ("**The discussion progress in Rel-17 can be taken into account as well**") from Huawei.

6 – Apple (UK) Limited

1. It is unclear the meaning of "correlation of MSD improvement between different MSD sources". Is the intention to find the correlation between let's say MSD improvement for UL harmonics and IMD2, dB by dB or what? Are they supposed to be within the same band combination or among all band combinations? Or can we simply change the wording to "Study MSD improvement for different MSD sources"?

2. We would like to have a clarification on how the network would handle the UEs differently if "low MSD" capability signaling would be introduced? Would the UE without such capability be deprioritized for scheduling or even refrained from scheduling the combination. We would be very concerned if this would be the intention since MSD has been defined as a minimum requirement under a certain worst-case test configuration. Network should not solely base on the specified MSD number to decide whether the combination is useful or not or refrain from scheduling the combination to the UE. There should be other mechanisms to assist the network to schedule the combination.

7 – Nokia Japan

We fully agree with comments from T-Mobile USA.

Although we appreciate an alternative from the moderator, it seems it does not address the comments from T-Mobile USA.

At least signalling mechanisms alone cannot go far ahead. As we commented already many times before, we need to know relation between the amount of improvement and MSD root causes if a band combination has multiple MSD root causes. If X dB improvement for a given MSD root cause "always" applies to all the other MSD root causes for a UE, the signaling becomes simple. That would not be true. But some MSD root causes may have correlation in terms of MSD improvement. In any case, we need to discuss potential issues and possible options for a UE to indicate MSD improvement for the respective MSD root causes in parallel.

8 – CHTTL

Agree with T-mobile USA

9 – Huawei Technologies France

To Apple comments, the correlation of MSD improvement with different sources, in my understanding is similar to your proposed wording, we are fine to use a concise description. To the signaling or capability, we think it's not a right time to discuss in RAN meeting, these are to be further discussed in RAN4 based on the MSD study, I don't think there could be meaningful clarification at this moment. The door is open for etc., the detailed discussion would be paper driven. Here we just consider upon the MSD improvement, generic approach/methods would be further discussed.

10 – vivo Communication Technology

We share similar concerns presented by Apple. But we are OK to further discuss the details in RAN4, with the understanding that whether signaling is needed or not is FFS.

11 – Intel Corporation (UK) Ltd

We share the proposal from T-Mobile USA and do not think that discussion on general capability framework shall take place subject to the conclusions of studies on MSD improvement. RAN4 is typically defining minimum performance requirements and based on current framework networks cannot exploit the benefits from better UE implementations. Therefore, such work can be considered in parallel.

12 – Beijing Xiaomi Mobile Software

Generally, we are ok with the new updated versions proposed by Huawei below. The detail signalling or capability and its feasibility can be left for the discussion in the study phase.

- Based on the study outcome of MSD improvement on the example band combinations, check the feasibility whether generic approach can be applied, e.g. based on UE indication of capability/signaling reporting, etc.
 - o The discussion progress in Rel-17 can be taken into account as well

13 – China Mobile Group Device Co.

we share the same view with T-Mobile USA. it maybe very challenging to come up with significant improvement of MSD as mandatory for all UE. but at the same time, it's sure that some UE could achieve much better MSD compared with the specified value. so it seems the study of signaling is necessary. maybe we should reflect T-Mobile's objective into the objectives.

14 – TELECOM ITALIA S.p.A.

share the concern from T-Mobile USA and support their proposal. Should we add RAN2 as lead for this objective?

15 – MediaTek Inc.

In our view we should gain a common understanding first of what type of MSD improvement we are talking about and in which conditions before we start trying to agree whether something is signalled or not, and whether such signalling is meaningful- in the first place. Apple's points are also void regarding handling. So we would prefer not to extend the scope to the study at this stage.

16 – ZTE Corporation

We also agree with T-mobile and other companies, that signalling to actual lower MSD to the network, this would help the network better understand of UE performance and to decide whether this full scheduling flexibility could be allowed for certain UEs.

In addition, Where MSD is allowed, this might need more clarifications.

17 – Huawei Technologies France

To companies share similar view with T-Mobile USA, as proposed above, the objective in our understanding already covers the signaling part preferred by T-Mobile. Without further study, we are not sure what the solution could be, so we don't think that the objective should be too specific for certain solution. Possible solutions can be discussed in RAN4.

To Telecom Italia, since this is RAN4 led WI, the TU budget at least in this RAN meeting is not supposed to have impact to other WGs. After the study phase, if necessary, we can update the TU budget to consider other WGs, or as usual, send the conclusion of RAN4 via LS for necessary signalling aspects.

18 – Orange

We share the same concern raised by T-Mobile USA

19 – Skyworks Solutions Inc.

We are not sure that it is useful to signal the actual lower MSD in high granularity since it is depending on UL configuration and/or type of MSD anyhow, in our view the benefit is anyhow limited to those UEs that signal better MSD in the cell so it can truly only make a difference if there enough of them or they have a significantly better MSD. So in the end the benefit should come from good enough improvement that a large number of UEs can achieve and not from a "beauty contest" between a limited number of UEs.

20 – Samsung Electronics Co.

We think there is some misunderstanding. In our understanding, the generic approach proposed is for generic MSD improvement instead only studying the generic approach for correlation of different MSD source, i.e., the generic approach shall be main bullet in the WID instead of sub-bullet in correlation of different MSD source. Therefore, we think what proposed by T-Mobile USA is better aligned with what has been discussed in the previous discussions. Even we think it is challenging to introduce UE actual value of MSD performance, to align with what we discussed, it is better to list T-Mobile USA proposal as a main bullet but remove the sub-bullet. Overall revision looks like:

- Select a limited set of band combinations (2-4 combinations) to cover all types of MSD (harmonic, harmonic mixing, IMD and cross band isolation)
- Study how the MSD performance can be improved for the example band combinations
- Study correlation of MSD improvement between different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
 - o ~~Based on the study outcome of MSD improvement on the example band combinations, check the feasibility whether generic approach can be applied, e.g. based on UE indication of capability~~
 - o ~~Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.~~
- Study the feasibility of and options for allowing a UE to signal improved lower MSD performance capability for combinations where MSD is allowed
- Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

21 – VODAFONE Group Plc

We agree with the concerns raised by T-Mobile USA.

22 – AT&T GNS Belgium SPRL

We support the comments made by T-Mobile USA and they are aligned with the original request in RAN4 during Rel-17. We support the proposed updates to the objectives as provided by Samsung to address this concern.

23 – MediaTek Inc.

Before any discussion about signalling anything, we should understand type of improvement is feasible to be done and how to characterise that in the specs. Agree with Skyworks comment in that respect (and MTK previous comments).

24 – Huawei Technologies France

Thanks Samsung for the further try of the objective revisions, which can also address the concerns from operators. We are ok with the changes. Any issues can be further discussed in the GTW session.

Investigate the feasibility of lower MSD for inter-band CA/EN-DC/DC combinations (RAN4)

- Select a limited set of band combinations (2-4 combinations) to cover all types of MSD (harmonic, harmonic mixing, IMD and cross band isolation)
- Study how the MSD performance can be improved for the example band combinations
- Study of MSD improvement with different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
- Study the feasibility of and options for allowing a UE to signal improved lower MSD performance capability for combinations where MSD is allowed
- Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

4.2 Objective of perf part

Further check whether the proposed objectives based on clarifications in intermediate round are agreeable.

The objectives of performance part for Rel-18 RF FR1 requirement focus evolution include:

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices
 - Specify the BS demodulation performance requirements to support UL 4-layer MIMO UE operation
- Enable 8Rx for CPE/FWA/vehicle/industrial devices
 - Specify RLM test cases withto support 8Rx
 - Investigate if the existing 4Rx RLM test can be reused or the new test will be specified

- Specify UE demodulation performance and CSI requirements with up to 8 layers to support 8Rx
 - Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers
 - Specify the SDR requirements with 8 MIMO layers
- Specify release independence requirements in TS 38.307 if needed.

Feedback Form 16:

<p>1 – China Telecom Corporation Ltd.</p> <p>We still prefer to remove the investigation phase for 8-layer MIMO demod requirements. The main point is to reduce the efforts on extra investigation and the debate on yes or no.</p> <p>But given this is already the final round, we can compromise and accept the proposal from moderator.</p>
<p>2 – Guangdong OPPO Mobile Telecom.</p> <p>ok with scope.</p>
<p>3 – SoftBank Corp.</p> <p>We are fine with moderator’s proposals.</p>
<p>4 – Intel Corporation (UK) Ltd</p> <p>We are fine with moderator proposal.</p> <p>With respect to our proposal for 4TX in the intermediate round ”Specify the BS conformance requirements” we would like to clarify that this is relevant to the BS demodulation requirements and think it could be better to this explicitly, since anyway 38.141-1 spec should be impacted. However, given companies comments we are ok not to add this objective and it will be anyway specified based on common RAN4 procedures.</p>
<p>5 – Huawei Technologies France</p> <p>We are fine with moderator’s proposals.</p> <p>just one typo: Specify RLM test cases with<u>with</u> support 8Rx</p>

4.3 Affected TS/TR

To check whether an internal TR is needed to capture the outcome of study phase for lower MSD.

Table 4:

<p>New specifications {One line per specification. Create/delete lines as needed}</p>					
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Type	TS/TR number	Title	For info at TSG#	For approval at TSG#	Remarks
Internal TR	38.xxx	Study of lower MSD for inter-band CA/EN-DC/DC combinations	#99	#100	

Feedback Form 17:

<p>1 – Huawei Technologies France</p> <p>The internal TR was not discussed for the previous rounds, but considering the study phase, we feel it would be better to have a TR to record the progress and agreements during the study.</p>
<p>2 – ZTE Corporation</p> <p>we support to have one internal TR to document the study and agreement for reference in future.</p>

5 Conclusion

5.1 Scope

The scope for Rel-18 UE RF FR1 are based on the RAN agreement in RP-220068, in which 3 topics are considered.

- 4Tx for CPE/FWA/vehicle/industrial devices
- 8Rx for CPE/FWA/vehicle/industrial devices
- lower MSD

There are some other remaining topics which are interested by more companies but not included in the scope, e.g. 3Tx for two bands, 6Rx for smartphone, as clarified in the RAN discussion, can be further considered later on in checking points of RAN meeting based on the study progress. However, those topics are based on future RAN discussion and decision.

5.2 Justification

Justification part was agreeable in the first round discussion.

This work item includes the objectives of UE FR1 requirement focus on evolution for potential RAN4 enhancements for NR frequency range 1. The following working areas are based on the summary of email discussion in [RAN95e-RAN4-R18Prep-01] (RP-220019).

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices
- Enable 8Rx and for CPE/FWA/vehicle/industrial device
- Investigate the feasibility of lower MSD for inter-band CA/EN-DC/DC combinations

5.3 Objective of core part

5.3.1 4Tx

In the last round discussion, the following issues have been discussed.

- **Selection of example bands:** it was clarified that n77/n78 are considered as one TDD band for the study. And most companies can accept that n1 is selected as FDD example band.
- **Clarification of PA configurations:** It was clarified that only 4x23dBm configuration is considered as first priority for PC1.5, which is accepted by most of companies.
- **Clarification of phase approach for the requirements:** It was further clarified that phase I requirements are for the first priority cases, which can be accepted by most of companies.

According to the discussion and clarifications, moderator propose the following modified objectives for 4Tx.

Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices (RAN4)

- Investigate framework and architecture Example bands:
 - TDD bands: n41, n77/n78
 - FDD bands: n1
 - Note 1: the total number of example bands should be limited to 3. n77/n78 are considered as one band during the study.
 - Note 2: other bands to be introduced in the release independent way later on from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority
- Specify the UE RF requirements to support 4Tx
 - First priority: 4x4 UL MIMO
 - Second priority: investigate and if necessary specify Tx/D requirement to support the same power class in UL MIMO and single antenna port
 - PA configuration assumption:
 - First priority: 4x23dBm
 - Second priority: 2x23dBm + 2x26dBm, 4x26dBm

- UE power class
 - First priority: PC 1.5
 - Second priority: PC2/PC3, and/or new power class if needed
 - Note 1: PC1.5 is only applicable for TDD bands

undefined NOTE: Requirements are specified with phase approach. Objectives with 1st priority are considered in phase I, and objectives with 2nd priority are considered in phase II.

5.3.2 8Rx

In the last round discussion, the discussion is mainly focused on the example FDD band. Considering together with 4Tx, selection of n1 for 4Tx and n7 for 8Rx as a compromised methods seems agreeable for most companies, which can balance the requests from different operators. There are also some discussion of clarification of phase approach for the requirements, which can be aligned with 4Tx.

According to the discussion and clarifications, moderator propose the following modified objectives for 8Rx.

Enable 8Rx for CPE/FWA/vehicle/industrial devices (RAN4)

- Example bands:
 - TDD bands: n41, n77/ n78
 - FDD bands: n7
 - Note 1: the total number of example band should be limited to 3. n77/n78 are considered as one band during the study.
 - Note 2: other bands to be introduced in the release independent way later on from Rel-18
 - Note 3: specifying requirements for TDD bands has first priority
- Specify the UE RF requirements to support 8Rx
- Study and specify the requirements to support SRS antenna switching for t1r8, t2r8, t4r8
 - Discussion on t4r8 shall start after at least one PC for 4Tx is completed

undefined NOTE: Requirements are specified with phase approach. Objectives with 1st priority are considered in phase I, and objectives with 2nd priority are considered in phase II.

5.3.3 Lower MSD

The lower MSD is the most controversial issue discussed in the last round. For the generic approach and signaling based solution, companies have different views. Some companies think that the signaling part shall be considered later once the MSD improvement is clear for the example band combinations, while some companies, especially operators have strong view that the work can be done in parallel and the progress in Rel-17 should be considered as well. As a compromise, the following objectives are proposed for the lower MSD topic.

Investigate the feasibility of lower MSD for inter-band CA/EN-DC/DC combinations (RAN4)

- Select a limited set of band combinations (2-4 combinations) to cover all types of MSD (harmonic, harmonic mixing, IMD and cross band isolation)
- Study how the MSD performance can be improved for the example band combinations
- Study of MSD improvement with different MSD sources (harmonics, IMD2/3/4/5, cross band isolation and harmonic mixing)
- Study the feasibility of and options for allowing a UE to signal improved lower MSD performance capability for combinations where MSD is allowed
- Aim to conclude the study phase by RAN#99, and further discuss in RAN#99 how to handle the objective based on the study progress.

5.4 Objective of perf part

The objectives of perf part are stable in the final round discussion.

The objectives of performance part for Rel-18 RF FR1 requirement focus evolution include:

- Enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices
 - Specify the BS demodulation performance requirements to support UL 4-layer MIMO UE operation
- Enable 8Rx for CPE/FWA/vehicle/industrial devices
 - Specify RLM test cases to support 8Rx
 - Investigate if the existing 4Rx RLM test can be reused or the new test will be specified
 - Specify UE demodulation performance and CSI requirements with up to 8 layers to support 8Rx
 - Investigate and, if necessary, specify the requirements with up to 8 DL MIMO layers
 - Specify the SDR requirements with 8 MIMO layers
- Specify release independence requirements in TS 38.307 if needed.

5.5 Affected TS/TR

Based on discussion, companies agree with having a TR to record the progress and agreements for the study phase of lower MSD.

Table 5:

New specifications <i>{One line per specification. Create/delete lines as needed}</i>					
Type	TS/TR number	Title	For info at TSG#	For approval at TSG#	Remarks
Internal TR	38.8xx	Study of lower MSD for inter-band CA/EN-DC/DC combinations	#99	#100	

Also the affected specs are agreeable as listed below:

Table 6:

Impacted existing TS/TR <i>{One line per specification. Create/delete lines as needed}</i>			
TS/TR No.	Description of change	Target completion plenary#	Remarks
<i>{E.g. "22.281"}</i>	<i>{Possible values: - either free text (e.g. "CS aspects to be removed") - or "Specification to be withdrawn"}</i>	<i>{E.g. "TSG#89"}</i>	<i>{Free text}</i>
38.101-1	Specify UE RF core requirements	#102	Core part
38.101-3	Specify UE RF core requirements related to EN-DC	#102	Core part
38.307	Specify release independence	#104	Perf. part
38.101-4	Specify UE demodulation performance and CSI requirements for >4Rx	#104	Perf. part

38.104	Specify BS demodulation performance requirements for >2Tx	#104	Perf. part
38.133	Add RRM core requirements if needed	#102	Core part
38.133	Add RRM performance requirements if needed	#104	Perf. part
38.306	Add impacts on 38.306 User Equipment (UE) radio access capabilities, if needed	#102	Core part
38.331	Specify the necessary signalling or capability to support the features	#102	Core part
38.213	Add impacts on 38.213 Physical layer procedures for control, if needed	#102	Core part
38.214	Add impacts on 38.214 Physical layer procedures for data, if needed	#102	Core part

6 References

[1] RP-220068, RAN R18 package summary, RAN chair, RAN4 chair

[2] RP-220019, Moderator's summary for discussion [RAN95e-RAN4-R18Prep-01] FR1 RF Enhancements, CMCC

[3] RP-220053, New WI: Further RF requirements enhancement for NR frequency range 1 (FR1), CMCC