

[94e-09-R18-FurtherCovEnh] - Version 0.0.5
RAN

3GPP TSG RAN meeting #94e

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Agenda Item: 8.6.1

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Title: Moderator's summary for discussion [94e-09-R18-FurtherCovEnh]

Document for: Discussion

1 Introduction

In RAN#93-e, UL enhancements (e.g. coverage enhancements; excluding MIMO) was identified as one of the potential areas for Rel-18 [1]. During the pre-RAN#94-e email discussion for Rel-18, justification and potential objectives of UL enhancements were discussed and summarized in [2]. After the discussion, a new WID on NR UL enhancements was drafted [3]. Based on the latest guidance in [4], the objectives of further UL coverage enhancements were revised as follows:

Table 1:

- Specify following PRACH coverage enhancements (RAN1, RAN2)
 - Multiple PRACH transmissions with same beams targeting 4-step RACH ~~{and 2-step RACH}~~ procedures
 - ~~{Study, and if justified, specify PRACH transmissions with different beams targeting 4-step RACH {and 2-step RACH}-procedures}~~ for FR2
 - Note: The enhancements of PRACH are targeting for FR2, which can also apply to FR1 when applicable.
 - Note: The enhancements of PRACH are ~~[format-agnostic and]~~ targeting ~~[for PRACH format B4, which can also apply to other]~~ short PUCCH formats when applicable.
- ~~{Study and if necessary specify following power domain enhancements}~~
 - ~~{Enhancements to realize dynamic power aggregation based on Rel-17 RAN4 work on “Increasing UE power high limit for CA and DC”, with checking relevant regulations ({RAN1,} RAN4)}~~
 - ~~{Note: The study can start after RAN4 work on “Increasing UE power high limit for CA and DC” is done depending on conclusions from RAN4.}~~
 - ~~{Enhancements to reduce MPR/PAR, including new transmission mechanism such as spectrum shaping, [reduced spectrum utilization with relaxed requirements on channel filtering,]}{and potential adjustments to MPR and test tolerance relations} (RAN4[, RAN1])}~~
- ~~Study and if necessary specify following enhancements for multi-carrier UL operation (moved to CA)~~
 - ~~UL Tx switching schemes across [more than 2] bands with restriction of 2 Tx simultaneous transmission for FR1 UEs, including mechanisms to enable more configured UL bands than its simultaneous transmission capability and to support dynamic Tx carrier switching across the configured bands (RAN1)~~
 - ~~Switching time and other RF aspects for above UL Tx switching schemes across [more than 2] bands (RAN4)~~
- ~~Alt.1: {Study and if necessary specify following enhancements for DFTS-OFDM (RAN1)}~~
 - ~~{Dynamic switching between DFTS-OFDM and CP-OFDM}~~
 - ~~{Multi-layer transmission with DFTS-OFDM, with considering LTE design}~~
 - ~~{Note: the study targets to select only one of above enhancements, unless necessity to specify both enhancements is justified in the study}~~
- ~~Alt.2: {Specify following enhancements for DFTS-OFDM (RAN1)}~~
 - ~~{Dynamic switching between DFTS-OFDM and CP-OFDM}~~

This contribution is a summary of email discussion on the new WID of further UL coverage enhancements including justification, objectives and time budget, following the guidance in [4].

2 Email discussion (initial round)

2.1 Justification

Justification is updated to keep alignment with the objectives based on the guidance in [4].

Table 2:

Coverage is one of the key factors that an operator considers when commercializing cellular communication networks due to its direct impact on service quality as well as CAPEX and OPEX. UL performance could be the bottleneck in most of scenarios in real deployment, while there are emerging vertical use cases that have UL heavy traffic, e.g., video uploading. In Rel-17 work item 900061 “NR Coverage Enhancements”, NR coverage has been extended for some of the bottleneck channels identified in the Rel-17 study item 860036 “Study on NR coverage enhancements”, in particular for PUSCH, PUCCH and Msg3. However, not all needs for coverage enhancement have been addressed by the Rel-17 WID, due to its limited scope.

In RAN Rel-18 Workshop in June 2021, UL enhancements have been identified as one of the key areas of interest by multiple players including operators, network and UE vendors and various industries, as reflected by the number of contributions proposing UL coverage and capacity enhancements based on the real and urgent demands for improving UL performance on top of Rel-17 enhancements. **After further discussion, the scope of UL enhancement is narrowed down to further UL coverage enhancement.**

~~Following justifications for specific UL enhancements have been identified during RAN Rel-18 email discussions:~~

- ~~– In Rel-17, PRACH coverage enhancement has not been addressed, despite being identified as one of the bottleneck channels in the corresponding studies. PRACH transmission is very important for many procedures, including initial access and contention-based beam failure recovery.~~
- ~~– {The UE transmission power is the most valuable resource in uplink and enhancements to unlock additional uplink power are highly valuable for both UL coverage and capacity. There are some studies and works in Rel-17 on the power domain, such as in “Study on NR coverage enhancements” and “Increasing UE power high limit for CA and DC”, and hence some further study is necessary to exploit the Rel-17 studies/works.}~~
- ~~– {For multi-carrier UL operation, there are some limitations of current specification, e.g. 2Tx UE can be configured with at most 2 UL bands, which only can be changed by RRC reconfiguration, and UL Tx switching can be only performed between 2 UL bands for 2Tx UE. Dynamically selecting carriers with UL Tx switching based on the data traffic, TDD DL/UL configuration, bandwidths and channel conditions of each band, instead of RRC-based cell(s) reconfiguration, will lead to higher UL data rate, spectrum utilization and UL capacity.}~~
- ~~– {DFT-S-OFDM waveform is beneficial for UL coverage limited scenario because of its lower PAPR compared with CP-OFDM waveform. Currently, UL waveform is configured via RRC and only single layer transmission is supported. These limitations impose a large barrier to switch over to DFTS-OFDM waveform for cell-edge UEs practically.}~~
- ~~– {In case of dense deployment where pathloss can be low, it would be possible to use wider bandwidth including UL CA for UL transmission with sufficient PSD so that UL performance can be largely improved. Considering that the dense deployment has some practical issues e.g., large cell planning effort for inter-cell interference coordination, one possible scenario to realize the dense deployment for UL is to deploy UL reception only points. In such scenario, since DL and UL are asymmetric, some enhancements are necessary for UL power control and beam management.}~~
- ~~– {In Rel-17, PUCCH coverage enhancements are introduced based on repetitions using multiple UL slots. However, those mechanisms may not be available in case of TDD bands with limited UL slot configuration, such as DDDSU and may not be practically useful due to existing collision handling rules. Therefore, there is a demand to enhance the coverage performance of PUCCH/UCI not relying on repetitions using multiple consecutive UL slots.}~~

Companies are encouraged to provide further comments on the justification.

Feedback Form 1: Comments on justification

1 – Nokia Corporation

Overall the justification is fine. We only propose to revise the paragraph on DFT-S-OFDM vs CP-OFDM because Objective 3 is now addressing the switching aspect only:

”(...) Currently, UL waveform is configured via RRC and ~~only single layer transmission is supported~~. These and this limitations imposes a large barrier (...)

2 – VODAFONE Group Plc

Same comment as Nokia if Alt 2 is chosen on Objective 3.

3 – Futurewei Technologies

Similar comment as Nokia, but ok with revisiting it after finalizing the objectives.

4 – vivo Communication Technology

Justification part to revised based on outcome of discussion on objectives

5 – Spark NZ Ltd

Spark has same comment as Nokia.

6 – ZTE Corporation

- For PRACH enhancements, we suggest the following changes. The current texts may imply we will only consider enhancements to the two included cases, while there are also many other important cases that could trigger 4-step PRACH transmission. In addition, both CBRA and CFRA procedure could be triggered by beam failure recovery, and we don't see the need to limit to CBRA only at this stage.

‘PRACH transmission is very important for many procedures, ~~including e.g., initial access and contention-based~~ beam failure recovery.’

- For power domain enhancements, one minor comment is we may no need to mention capacity as this WI intends for coverage only. In addition, we suggest to make clear that the Rel-17 CE study on power domain is referred to MPR/PAR reduction.

‘The UE transmission power is the most valuable resource in uplink and enhancements to unlock additional uplink power are highly valuable for ~~both-UL coverage and capacity~~. There are some studies and works in Rel-17 on the power domain, such as enhancements to reduce MPR/PAR in “Study on NR coverage enhancements” and “Increasing UE power high limit for CA and DC”, and hence some further study is necessary to exploit the Rel-17 studies/works.’

- For enhancements to DFT-S-OFDM waveform, we share similar view as Nokia.

7 – Intel Deutschland GmbH

We are generally fine with the description and update from Nokia.

<p>8 – Panasonic Corporation</p> <p>We are ok except the removal of PUCCH coverage enhancement.</p>
<p>9 – SHARP Corporation</p> <p>We are ok except the removal of PUCCH coverage enhancement.</p>
<p>10 – China Telecommunications</p> <p>We are generally fine with the justification. We share the similar view that the justification part can be revisited after all of the objectives are finalized.</p>
<p>11 – Spreadtrum Communications</p> <p>The part of “Currently, UL waveform is configured via RRC and only single layer transmission is supported.” can be delete due to only dynamic switching between DFT-s-OFDM and CP-OFDM is in the scope.</p>
<p>12 – Huawei Tech.(UK) Co.. Ltd</p> <p>The text in the justification will still need to be revised based on the outcome of the discussion of the following objectives in this meeting, but the discussion on objectives should come first.</p>
<p>13 – THALES</p> <p>Overall the justification is fine.</p>
<p>14 – Telia Company AB</p> <p>Justification is ok with Nokia proposal on Objective 3.</p>
<p>15 – Ericsson LM</p> <p>The justification may need some update based on the outcome of this round, and so we may comment in the next round.</p>
<p>16 – Facebook</p> <p>In general we are fine on the justification. However, probably some updates are needed based on the outcomes of the discussion.</p>

2.2 Objective 1

Table 3:

- Specify following PRACH coverage enhancements (RAN1, RAN2)
 - Multiple PRACH transmissions with same beams targeting 4-step RACH [~~and 2-step RACH~~] procedures
 - [~~Study, and if justified, specify PRACH transmissions with different beams targeting 4-step RACH [~~and 2-step RACH~~]-procedures]~~ for FR2
 - Note: The enhancements of PRACH are targeting for FR2, which can also apply to FR1 when applicable.
 - Note: The enhancements of PRACH are [format-agnostic and] targeting [for PRACH format B4, which can also apply to other] short PUCCH PRACH formats when applicable.

Companies are encouraged to provide further comments on the above objective, especially the content in the square brackets.

Feedback Form 2: Comments on objective 1

1 – Nokia Corporation

We support the revisions above. In addition we would be fine to remove text within the brackets in the last note as well, as they are not essential for the work to be done in RAN1 anyway.

2 – VODAFONE Group Plc

With the understanding that 2-step RACH is aimed more towards reducing latency and not usually in coverage limited scenarios, we're OK with removing it from the objectives. On the first note we think FR1 should have the same priority as FR2; in the second note we prefer the enhancements to be format agnostic

3 – Futurewei Technologies

We prefer to support format-agnostic enhancement. It is unclear how feasible it is to target B4 while applicable to other formats, and unclear how it may be done.

We support removing 2-step RACH.

4 – Lenovo (Beijing) Ltd

In principle, fine with the objective on PRACH enhancements. However, one aspect for clarification would be the intention of removing 2-step RACH from first two bullets. Is the intention to specify for 4-step RACH and it can also apply for 2-step RACH when applicable? If that is the intention, then it should be clarified with a note. However, if the intention is to not at all consider for 2-step RACH, then “targeting” in first and second bullet should be replaced with “for”. We prefer to enhance have the enhanced RACH format-agnostic, so the former is preferred to us.

5 – China Mobile Com. Corporation

Share a similar view that 2-step RACH is for reducing the latency. If the coverage is limited, 4 step RACH should be used. Then the coverage enhancement to 2-step RACH is not necessary. Fine with Lenovo's proposal replacing the “targeting” with “for”.

As discussed in the Oct's email discussion, the PRACH is clearly the least coverage limited channel in uplink no matter in FR1 and FR2. The only motivation to enhance PRACH is for FR2, in which all the uplink channel cannot satisfy the basic coverage, such as 200m in NLOS or with blockage. We see no motivation to enhance the FR1 PRACH. The 1st note is the outcome from last round email discussion as a compromise.

For the last note, we are fine with both statement in the bracket. As the enhancements to PRACH should be format agnostic. And the enhancements targeting format B4 and then applicable to other PRACH formats are obvious format agnostic. We are not targeting to introduce new formats for PRACH. Then either way seems fine.

6 – Spark NZ Ltd

In the context of coverage enhancements - we support 4-Step RACH as per Nokia comment.

7 – CATT

1) We agree that 2-step RACH should be excluded and support Lenovo's proposal to replace "targeting" by "for" for the first two sub-bullets.

2) The applicability of PRACH transmissions with different beams for FR2 is not clear since it is for FR2 only in the 2nd sub-bullet while can be applied to FR1 according to the 1st note. Clarification is needed.

3) We are fine with Nokia's proposal to remove text within the brackets in the last note.

8 – NTT DOCOMO INC.

- When we specify multiple PRACH transmissions, we think FR1 should have the same priority as FR2.
- We prefer to support format-agnostic enhancement.
- We should clarify whether the WID only considers enhancement of 4-step RACH or the enhancement can be also applied to at least PRACH preamble repetition in 2-step RACH. If we define PRACH beam assumption in Rel.18, we believe it can be also applied to 2-step RACH.

9 – ZTE Corporation

Support. We prefer format-agnostic enhancements, and therefore we suggest deleting the square brackets in the last note.

10 – SoftBank Corp.

We support the moderator's proposal. Our preference is format agnostic enhancement.

11 – Intel Deutschland GmbH

We are generally fine with the objectives for PRACH coverage enhancement. For the last note, we suggest to remove the text in []:

- o Note: The enhancements of PRACH are [~~format-agnostic and~~] targeting [~~for PRACH format B4, which can also apply to other~~] short PUCCH PRACH formats when applicable.

12 – Samsung Research America

- o ~~Study, and if justified, specify PRACH transmissions with different beams targeting 4-step RACH and 2-step RACH procedures for FR2~~

Change to

- o ~~Study, and if justified, sSpecify PRACH transmissions with different beams targeting 4-step RACH and 2-step RACH procedures for FR2~~

Reason:

The limitation for same beam seems to assume that a UE is always able to find the best tx beam and then repeats it. This implies the dependence on UE beam correspondence (BC) capability UE, which was previously discussed in RAN1 and RAN4. Only beam correspondence for connected mode is specified, which needs gNB assistance. RAN4 discussed the beam correspondence issue for initial access stage, however, it was not agreed how to be tested or verified. Thus, for Rel-18 enhancements on PRACH, different beams for multiple PRACH transmissions are meaningful, and should be included in the scope.

Related text from TS 38.101-2 follows.

6.6.4.1 General

The beam correspondence requirement for power class 3 UEs consists of three components: UE minimum peak EIRP (as defined in Clause 6.2.1.3), UE spherical coverage (as defined in Clause 6.2.1.3), and beam correspondence tolerance (as defined in Clause 6.6.4.2). The beam correspondence requirement is fulfilled if the UE satisfies one of the following conditions, depending on the UE's beam correspondence capability IE *beamCorrespondenceWithoutUL-BeamSweeping*, as defined in TS 38.306 [14]:

- If *beamCorrespondenceWithoutUL-BeamSweeping* is supported, the UE shall meet the minimum peak EIRP requirement according to Table 6.2.1.3-1 and spherical coverage requirement according to Table 6.2.1.3-3 with its **autonomously** chosen UL beams and without uplink beam sweeping. Such a UE is considered to have met the beam correspondence tolerance requirement.
- If *beamCorrespondenceWithoutUL-BeamSweeping* is **not** present, the UE shall meet the minimum peak EIRP requirement according to Table 6.2.1.3-1 and spherical coverage requirement according to Table 6.2.1.3-3 with uplink beam sweeping. Such a UE shall meet the beam correspondence tolerance requirement defined in Clause 6.6.4.2 and shall support uplink beam management, as defined in TS 38.306 [14].

13 – vivo Communication Technology

We are fine with current objective in general, for the second note where format agnostic is fine . The first note "Note: The enhancements of PRACH are targeting for FR2, which can also apply to FR1 when applicable" means not applicable for formats 0 3 for FR1

14 – Panasonic Corporation

We support the view from the moderator.

15 – Apple Computer Trading Co. Ltd

We support the PRACH enhancement for 4-step RACH.

For the second note, we are fine to remove the restriction of the enhancement focusing on PRACH format B4. To make it clear, the PRACH enhancements are targeting for short PRACH formats.

<p>16 – CAICT</p> <p>We are fine with moderator’s proposal.</p>
<p>17 – China Telecommunications</p> <p>We support current objectives for PRACH enhancement. For the last note, we prefer the following modifications:</p> <p>Note: The enhancements of PRACH are [format-agnostic and] targeting [for PRACH format B4, which can also apply to other] short PRACH formats when applicable.</p>
<p>18 – Qualcomm Incorporated</p> <p>We agree with the draft objective in general, except that applicability to 2-step RACH should be kept at least for the same beam preamble repetition case.</p>
<p>19 – Xiaomi Communications</p> <p>we support this objective. We prefer format-agnostic enhancements.</p>
<p>20 – Spreadtrum Communications</p> <p>We support the draft objective in general. And we prefer format-agnostic PRACH enhancement.</p>
<p>21 – Huawei Tech.(UK) Co.. Ltd</p> <p>We agree on most of the items in this objective for PRACH enhancement. However, for the second note, regarding to the PRACH format, format B4 is supposed to have the largest coverage capability for short sequence formats, however, in reality, due to limited uplink RX analogue beams in one symbol, to save more time domain resources for data channels, short PRACH formats are also used. Then short PRACH formats are also valid for coverage enhancement. Hence we also propose that the enhancement is PRACH format agnostic.</p>
<p>22 – THALES</p> <p>We Support objective 1 with format-agnostic enhancements,</p>
<p>23 – LG Electronics Inc.</p> <p>We support the revision above. Also, we are fine with removing 2-step RACH.</p>
<p>24 – China Unicom</p> <p>We support the proposed changes by moderator.</p>
<p>25 – Telia Company AB</p> <p>We agree that coverage enhancement to 2-step RACH is not necessary.</p>
<p>26 – TELECOM ITALIA S.p.A.</p> <p>ok with the moderator’s proposal</p>

<p>27 – InterDigital France R&D</p> <p>We support the draft objective in principle. And we also prefer format-agnostic PRACH enhancement and we support to remove 2-step RACH from the objective.</p>
<p>28 – Asia Pacific Telecom co. Ltd</p> <p>We support the current objective, and also prefer format agnostic.</p>
<p>29 – Orange</p> <p>We support the objective on 4-step RACH and don't think 2-step RACH is needed. In any case 2-step RACH is not designed for mobility and poor radio conditions, there we do not see the practical applicability of coverage enhancement for 2-step RACH.</p>
<p>30 – Verizon UK Ltd</p> <p>Support the objective. Removing 2-step RACH is reasonable. Also, we don't have much problem with FR1 RACH compared to FR2 indeed.</p>
<p>31 – Ericsson LM</p> <p>We also support the revisions on the objective. In our understanding, 2-step RACH use cases are not coverage limited.</p> <p>Regarding the square bracketed text in the note: the wording 'for PRACH format B4, which can also apply to other' is a bit strange, since it both targets a PRACH format but intends to specify something for all formats. Would it be simpler to say that we specify inter-slot repetition for PRACH, rather than 'for PRACH format B4, which can also apply to other'?</p>
<p>32 – Facebook</p> <p>We also think that the note on targeting FR2 should be removed. The rest looks fine.</p>
<p>33 – MediaTek Inc.</p> <p>We think the PRACH format should focus on B4... not sure what "other PRACH formats as applicable" really means. How do we decide applicability?</p>

2.3 Objective 2

Table 4:

- {Study and if necessary specify following power domain enhancements}
 - {Enhancements to realize dynamic power aggregation based on Rel-17 RAN4 work on “Increasing UE power high limit for CA and DC”, with checking relevant regulations ({RAN1,} RAN4)}
 - {Note: The study can start after RAN4 work on “Increasing UE power high limit for CA and DC” is done depending on conclusions from RAN4.}
 - {Enhancements to reduce MPR/PAR, including new transmission mechanism such as spectrum shaping, [reduced spectrum utilization with relaxed requirements on channel filtering,]{and potential adjustments to MPR and test tolerance relations] (RAN4[, RAN1])}

Companies are encouraged to provide further comments on the above objective, especially the content in the square brackets.

Feedback Form 3: Comments on objective 2

1 – Nokia Corporation

Support confirming the objectives above as they are an important aspect of coverage enhancements that have not been addressed in earlier releases.

2 – VODAFONE Group Plc

Support

3 – Futurewei Technologies

Generally fine with the objective. For the MPR/PAR enhancement, suggest to focus on cell-edge cases, i.e., “Enhancements to reduce MPR/PAR for cell-edge cases, ...”

4 – Lenovo (Beijing) Ltd

We support the current text.

5 – China Mobile Com. Corporation

We have no problem for the general enhancements in the power domain.

The power aggregation should begin after RAN4 finish their related work in Rel-17. Then we can have a clear view on the benefits and how it works. Based on current understanding, the motivation for dynamic power aggregation is not clear. Is the motivation that the UE could switch between modes with and without power aggregation dynamically? For the UE with power aggregation, it could get additional power?

As commented in the last round, the supportive companies and contributions for the 2nd bullet are very few during CE SI. But according to moderator’s summary in the appendix, the supportive companies increase. We could be more flexible if this is the majority view for study. And we have no problem for the normative work if enough performance gain with limited complexity is observed.

6 – CATT

For the dynamic power aggregation, although it is not clear yet to us what RAN1 impact would be, we could be fine to study. We propose to modify the note as follows.

Note: The study ~~can~~ starts after RAN4 work on “Increasing UE power high limit for CA and DC” is done depending on conclusions from RAN4.

For the enhancements to reduce MPR/PAR, we suggest to remove RAN1.

7 – NTT DOCOMO INC.

Support

8 – ZTE Corporation

Support the objective in principle. For MPR reduction, we propose to delete ‘~~new transmission mechanism such as~~’ to make the study more specific.

9 – AT&T

We support power domain enhancements. As Nokia pointed out, they have not been part of prior releases and should have priority.

10 – SoftBank Corp.

We support the proposal by moderator.

11 – Intel Deutschland GmbH

For dynamic power aggregation, it is not clear to us the exact scope for RAN1 and RAN4. It would be more appropriate to clearly list the objectives. In our view, given the slow progress for “Increasing UE power high limit for CA and DC” in RAN4, we can discuss the objectives after the RAN4 work is complete.

It is still not clear to us the need of enhancements to reduce MPR/PAR. In our view, pi/2 BPSK with DFT-s-OFDM waveform and new DMRS sequence design have been specified to reduce the PAPR for uplink transmission. Further reduction of MPR/PAR is not necessary. Note that the objective is very broad, and it is not clear to us whether this can be accommodated to the scope. As indicated by the Chair, “Should try to avoid “generic enhancements”-like scope”.

12 – Samsung Research America

The first bullet depends on the ongoing Rel-17 work in RAN4, hence we think this bullet should be kept in square brackets for now, and revisited when Rel-17 work in RAN4 is complete.

One aspect to consider in the scope of enhancements for MPR/PAR in addition to the transmission aspects is how an advanced receiver can handle the relaxation on the MPR, and further study potential signaling to leverage such advanced reception.

- ~~[~~Enhancements to reduce MPR/PAR, including new transmission mechanism such as spectrum shaping, [reduced spectrum utilization with relaxed requirements on channel filtering,]~~]~~and potential adjustments to MPR and test tolerance relations] (RAN4[, RAN1])~~]~~

Change to

- Enhancements to reduce MPR/PAR, including new transmission mechanism such as spectrum shaping, **and including exploiting advanced receiver**, [reduced spectrum utilization with relaxed requirements on channel filtering,] [and potential adjustments to MPR and test tolerance relations] (RAN4[, RAN1])

13 – Panasonic Corporation

We support the view from the moderator.

14 – Apple Computer Trading Co. Ltd

For the dynamic power aggregation, until now it's not clear RAN1 standard impacts without outcome from RAN4, it could be better that we leave this objective and revisit it after RAN4 close the related WI. As indicated by RAN chair, we should avoid "generic enhancements" without details. In addition, RAN4 is involved in this objective, so any further enhancement over existing RAN4 WI "Increasing UE power high limit for CA and DC" is expected for RAN4?

For enhancement to reduce MRP/PAR, according to previous discussion, no RAN1 standard impacts are expected for the spectrum shaping. For the rest targets in the brackets, there are no clarifications or justifications on these items, the clarities for these items are needed, it's not clear any impacts to RAN1 as well.

So based on the current discussions, the power domain enhancement seems not directly related to RAN1, it could be a potential RAN4 WI.

15 – vivo Communication Technology

For dynamic power aggregation, we prefer to wait for outcome of Rel-17 RAN4 WI, and it is not very clear what is related RAN1 work.

The second bullet on MPR/PAR reduction, spectrum shaping it seems purely RAN4 related work hence propose to remove "RAN1" from the second bullet.

16 – CAICT

Support

17 – China Telecommunications

We are generally fine with this objective.

For MPR reduction enhancement, MPR reduction solution was studied and discussed during Rel-17 SI. It is a straightforward method to improve the coverage.

For dynamic power aggregation, we think the objective is not clear at this stage. We suggest to revisit it after the related RAN4 work is finished.

18 – Telstra Corporation Limited

We support the moderators proposal

19 – Qualcomm Incorporated

Regarding dynamic power aggregation, it could be clarified, if needed, that an objective of the WI is to provide better information to the gNB about the state of the UE energy budget, for example by specifying power headroom reporting enhancements. This is not in the scope of the current RAN4 work.

It should be further clarified that specifying SAR or MPE management algorithms is not in the scope.

Regarding MPR/PAPR reduction, it would be useful to clarify whether spectrum expansion for DFT-S-OFDM is in scope. At the same time, adjustments to test tolerance-to-MPR relations should not be in the scope of this WI. That would be more suitable for a separate RAN4 TEI or SI/WI.

We would also like to note that the current MPR tables are already sensitive to spectrum/RB allocation and location of the allocation within the band. We would therefore like more clarity on what “reduced spectrum utilization with relaxed requirements on channel filtering” means.

20 – Xiaomi Communications

we are supportive of this objective, prefer the study starts after the ongoing RAN4 work is done.

21 – Spreadtrum Communications

For dynamic power aggregation, we think it is too early to have this objective in RAN1, since no impact to RAN1 has been identified until now. Thus, we want to confirm it after there is a clear identification in RAN4.

22 – Huawei Tech.(UK) Co.. Ltd

Firstly, in our understanding, the dynamic power aggregation, can be start after RAN4 work is done. And the relevant regulation should be complied with. So we suggest revising ”with checking relevant regulations” to ”in compliance with relevant regulations”.

Secondly, enhancements to reduce MPR/PAR, the motivation in our understanding is to reduce the MPR of the current transmission signal and increase the output power of the UE in order to increase the coverage. Besides the potential schemes proposed in R17 coverage enhancement, pi/2 BPSK could be also one possible direction to be enhanced since pi/2 BPSK already has higher maximum output power than QPSK. The potential enhancement for coverage is to increase the spectral efficiency of pi/BPSK to increase the throughput of the cell edge UE. Hence we propose the following.

Enhancements to increase cell-edge data rate, e.g. reduce MPR/PAR, including new transmission mechanism such as spectrum shaping with QPSK, multi-layer DFT-s-OFDM with pi/2 BPSK, reduced spectrum utilization with relaxed requirements on channel filtering, and potential adjustments to MPR and test tolerance relations (RAN4, RAN1)

23 – Deutsche Telekom AG

We think this objective 2 can be dropped in the light of workload management

24 – LG Electronics Inc.

We support the proposal from moderator.

25 – China Unicom

We support the current objective from moderator.

26 – Charter Communications

We support the moderators objectives

27 – CableLabs

We are supportive on the first sub-bullet of dynamic power sharing

<p>28 – Telia Company AB</p> <p>We support moderator’s proposal.</p>
<p>29 – InterDigital France R&D</p> <p>We support the draft objective from the moderator.</p>
<p>30 – TELECOM ITALIA S.p.A.</p> <p>Support the moderator’s proposal.</p> <p>Of course the overall capacity of RAN4 needs to be taken into account (this is a general comment, valid for all the proposed activities for Rel 18)</p>
<p>31 – TELENOR ASA</p> <p>Telenor supports moderator’s proposal.</p>
<p>32 – Orange</p> <p>We are supportive, there is potential to increase the UE power limit in DC and CA modes.</p>
<p>33 – CableLabs</p> <p>We are also okay with second sub-bullet objective</p>
<p>34 – Verizon UK Ltd</p> <p>Support - view this as the most promising aspect for Cov Enh.</p>
<p>35 – Ericsson LM</p> <p>We agree to removing all brackets.</p> <p>To elaborate on the potential adjustments to MPR and test tolerance relations, the MPR requirements, in particular for FR2, were developed to support conservative worst-case assumptions on implementations for the first release of NR in Rel-15. Furthermore, tolerances are applied on top of the MPR in the RAN4 specifications with additional test tolerances added for UE conformance testing by RAN5. These tolerances effectively increase the margins from MPR, leading to quite high total margins.</p> <p>To consider an example for FR2: for power class 3, 16QAM modulation with DFT-s-OFDM and allocations within a carrier of 100 MHz channel bandwidth, the maximum output power including MPR is 22.6 dBm (power class) – 3 dB (MPR) = 19.6 dBm. Added on top of the power class that already includes tolerance (contrary to FR1) and MPR are tolerances due to power accuracy at lower power levels (RAN4 specifications) of 2 dB and a test tolerance 3 dB test tolerance for conformance testing (RAN5 specifications) based on the worst performing lab resulting in a UE pass/fail limit of 14.6 dBm. The UE designed for a power back-off is therefore afforded 5 dB additional margin in testing. This margin increases further with MPR and MCS order. Specification of MPR (or A-MPR when applicable) should also account for the tolerance applicable at the nominal power level resulting from a power reduction of the power-class level by the MPR. While recognizing that the power accuracy is degraded at lower power levels, the impact of large tolerances is particularly notable for larger MPR (e.g. higher-order modulations) or for UL-MIMO for which the tolerances are larger. Therefore, the tolerance levels as a function of the output power levels could be reduced, while still accounting for the reduced power accuracy at lower output power. This would be consistent with the experience from commercial deployments of Rel-15.</p>

Reduced spectrum utilization with relaxed requirements on spectrum confinement techniques / channel filtering for both single-carrier and intra-band contiguous UL CA is another possible approach to reduce MPR for meeting EVM requirements and has been recently discussed in the context of the beyond 52.6 GHz work. This may also reduce filter complexity.

36 – Facebook

Fine with the proposal.

37 – Nokia Corporation

Just some further observations based on some of the comments above:

- RAN1 involvement: some companies seem to believe the topic is fully contained within RAN4, but that is not the case. RAN1 needs to be involved when discussing how to trigger PUSCH transmission involving spectrum extension, on how to control the excess band, and any potential updates to resource allocation due to those. These are relatively impacts, but it justifies keeping RAN1 as relevant WG for this objective.
- Re: Qualcomm: we would like to confirm that it is our understanding that spectrum expansion should be in scope, as mentioned above. And we tend to agree that aspects related to RAN4 test tolerances can be removed from the scope for simplification. Also the channel filtering aspects can be simplified as well from the objective as some of those can be left for implementation in the end.
- Regarding other modulation schemes, we think it is not beneficial to do parallel studies to the ones already ongoing for pi/2 BPSK, and hence we should focus on other modulations. Our proposal is to focus on QPSK to keep the workload reasonable. But we are open to consider 16QAM as well, if so desired by other companies.
- On waveforms: we think highest priority is for DFT-s-OFDM, and it is better to focus on it to avoid expanding scope.
- Regarding mentioning cell-edge explicitly: we have some concerns on such approach as it is difficult to define what cell-edge means in practice, especially for UL. It depends on allocated PRBs and data rate, for example. We believe focusing on QPSK is good enough delimitation of scope.
- On rank>1: we welcome the suggestion from Huawei but we wonder if such enhancement would create an overlap with the upcoming MIMO WID, as well as an overlap with ongoing pi/2 BPSK work, as mentioned before.

Based on the considerations above, we propose to revise the second sub-bullet of the objective as follows, so that its description is simplified and at the same time sharper in scope:

(...)

- *Enhancements to reduce MPR/PAR, including new transmission mechanism such as spectrum shaping with spectrum extension, [~~reduced spectrum utilization with relaxed requirements on channel filtering,~~] [~~and potential adjustments to MPR and test tolerance relations~~] (RAN4[, RAN1])*
 - o *Techniques to be considered for spectrum extension include, e.g. frequency domain spectrum shaping with spectrum extension and tone reservation.*
 - o *Evaluate resource allocation mechanisms taking into account the spectrum extension*

2.4 Objective 3

Table 5:

<ul style="list-style-type: none"> - Alt.1: [Study and if necessary specify following enhancements for DFTS-OFDM (RAN1)] <ul style="list-style-type: none"> o [Dynamic switching between DFTS-OFDM and CP-OFDM] o [Multi-layer transmission with DFTS-OFDM, with considering LTE design] o [Note: the study targets to select only one of above enhancements, unless necessity to specify both enhancements is justified in the study] - Alt.2: [Specify following enhancements for DFTS-OFDM (RAN1)] <ul style="list-style-type: none"> o [Dynamic switching between DFTS-OFDM and CP-OFDM]
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Companies are encouraged to provide further comments on the above objective.

Feedback Form 4: Comments on objective 3

<p>1 – Nokia Corporation</p> <p>Support.</p>
<p>2 – VODAFONE Group Plc</p> <p>Our first priority would be the enhancement for the dynamic switching between the two waveforms, although multilayer DFT-S-OFDM seems useful as well. As a way forward, we’re ok with the selecting Alt. 2</p>
<p>3 – Futurewei Technologies</p> <p>Ok</p>
<p>4 – Lenovo (Beijing) Ltd</p> <p>We support objective 3 in principle. However we suggest to make a minor change to the text: Specify following enhancements for DFTS-OFDM (RAN1)</p> <p><input type="checkbox"/> Specify enhancements to support dynamic switching between DFTS-OFDM and CP-OFDM</p>
<p>5 – vivo Communication Technology</p> <p>We are fine to limit to dynamic switching between DFT-s-OFDM and CP-OFDM waveforms, fine with the wording from Lenovo.</p>
<p>6 – China Mobile Com. Corporation</p> <p>Support to enhance the dynamic switching between DFT-S-OFDM and CP-OFDM only.</p>

7 – CATT

We are fine to support dynamic switching between DFT-s-OFDM and CP-OFDM only. Given that it is the only enhancement for DFT-s-OFDM, it seems that the sub-bullet from Lenovo's proposal is sufficient for objective 3, i.e..

- Specify enhancements to support dynamic switching between DFT-s-OFDM and CP-OFDM [RAN1]

8 – NTT DOCOMO INC.

Support. We are fine with CATT's update with the following modification (i.e. not [RAN1], but (RAN1)).

- Specify enhancements to support dynamic switching between DFT-s-OFDM and CP-OFDM (RAN1)

9 – ZTE Corporation

Support. We are ok with the updates from NTT DOCOMO.

10 – Intel Deutschland GmbH

Although we still prefer to also specify multi-layer transmission with DFTS-OFDM, which is important for UL capacity for cell edge UEs, we are fine to only focus on dynamic switching between DFT-s-OFDM waveform and CP-OFDM waveform as the WI is mainly for further coverage enhancement.

11 – SoftBank Corp.

We are OK with the proposal.

12 – Samsung Research America

We think that specifying the dynamic switching between DFT-s-OFDM and CP-OFDM is beneficial because it increases the opportunity of using UL MIMO (with CP-OFDM) and increases the UL peak data rate. It is suggested to further simplify the objective as follows:

- Specify dynamic switching between DFTS-OFDM and CP-OFDM

13 – Panasonic Corporation

We support the view from the moderator.

14 – Apple Computer Trading Co. Ltd

We support this proposal from moderator.

15 – SHARP Corporation

We are fine with the proposal

16 – CAICT

We support moderator's proposal.

17 – China Telecommunications

We support current version of Objective 3.

<p>18 – Qualcomm Incorporated</p> <p>We propose to include both multi-layer DFT-S-OFDM (copying the LTE scheme) and dynamic switching between CP-OFDM and DFT-S-OFDM. The two features are not expected to be used at the same time. But this doesn't mean they would be in any way contradictory or redundant.</p>
<p>19 – Xiaomi Communications</p> <p>we are fine with the proposal.</p>
<p>20 – CEWiT</p> <p>We support the objective and accept DOCOMO's update</p>
<p>21 – Spreadtrum Communications</p> <p>We support current version of Objective 3.</p>
<p>22 – Huawei Tech.(UK) Co., Ltd</p> <p>From our point of view, the multiple-layer DFT-S-OFDM should be prioritized over the dynamic switching between DFT-S-OFDM and CP-OFDM, because with higher transmission power of DFT-S-OFDM, rank 2 can be possible and this helps to improve the cell edge throughput. For dynamic switching between DFT-S-OFDM and CP-OFDM, our understanding is that a coverage-limited UE also has the chance to make rank 2 transmission, however the current specification limit the UE to be only rank 1 using DFT-S-OFDM, so enabling dynamic switching between the two waveforms can help the UE support rank 2 transmission at the cell edge. However, when making rank 2 transmission by CP-OFDM, the UE may sacrifice the maximum output power because the MPR of the CP-OFDM is higher than that of the DFT-S-OFDM. From the coverage point of view, rank 2 transmission using DFT-S-OFDM is more beneficial than dynamic switching between the two waveforms. Hence our preference is the alt1 without the note.</p>
<p>23 – Deutsche Telekom AG</p> <p>This is a good down-scope ! We support the remaining objective</p>
<p>24 – LG Electronics Inc.</p> <p>We support the proposal from moderator.</p>
<p>25 – InterDigital France R&D</p> <p>We support the draft objective from the moderator.</p>
<p>26 – TELECOM ITALIA S.p.A.</p> <p>ok with the proposal from the moderator</p>
<p>27 – Verizon UK Ltd</p> <p>We prefer to have both multi-layer DFT-S-OFDM and dynamic switching between CP-OFDM and DFT-S-OFDM. If we have to choose one, of course, we have to take the dynamic switching one but we hope to have both.</p>

28 – Ericsson LM

We prefer Alt 1, since multi-layer DFT-S-OFDM has potential to provide substantial system level throughput enhancement both at the cell edge and for mean throughput, as we show in RP-213154. We observe there that there is substantial cell edge gain (e.g. ~~30% or~~ 80% for 2 or 4 Tx) at the system level in a UMa scenario from fast switching between DFT-S-OFDM and CP-OFDM with both rank 1 and rank 2 UL MIMO, and that there are strong mean throughput gains (e.g. ~~15% or~~ 20% for 2 or 4 Tx) from rank 2 DFT-S-OFDM.

29 – Ericsson LM

(Re-post to remove strikethrough)

We prefer Alt 1, since multi-layer DFT-S-OFDM has potential to provide substantial system level throughput enhancement both at the cell edge and for mean throughput, as we show in RP-213154. We observe there that there is substantial cell edge gain (e.g. 30% or 80% for 2 or 4 Tx) at the system level in a UMa scenario from fast switching between DFT-S-OFDM and CP-OFDM with both rank 1 and rank 2 UL MIMO, and that there are strong mean throughput gains (e.g. 15% or 20% for 2 or 4 Tx) from rank 2 DFT-S-OFDM.

30 – Facebook

Support

31 – MediaTek Inc.

agree with moderator original proposal

2.5 Others

Any other comments?

Note: Based on the guidance in [4], the time budget for the core part of the new WID is reserved for RAN1/2/4, but not yet for the performance part.

Feedback Form 5: Any other comments?

1 – Intel Deutschland GmbH

We kindly request companies with concerns to reconsider their view on enhancements for UL dense deployment. We think it is natural approach to also address UL coverage problem using more efficient deployment. The amount of work for Rel-18 is very limited and gives opportunity for supporting operators to take advantage of the proposed enhancement in their NW.

2 – Panasonic Corporation

Our preference is to retain PUCCH coverage enhancement.

3 – SHARP Corporation

We propose to reconsider inclusion of enhancements of PUCCH/UCI not relying on repetitions using multiple consecutive UL slots, which not only improve PUCCH coverage, but also reduce the occurred number of

collisions. These enhancements are helpful for practically utilizing all coverage enhancements for PUCCH and PUSCH in Rel-17 (i.e., Enhancements on PUSCH repetition type A, TBoMS, Joint channel estimation for PUSCH and PUCCH, and Msg3 repetition) because these are based on repetition. From TU perspective, we can treat at least short PUCCH to utilize special slot and more improve PAPR than legacy short PUCCH formats.

4 – EURECOM

We propose to continue the discussion and work on DMRS-less PUCCH. Enhancing coverage through repetition is a straightforward relatively low effort solution and as such is rightly specified in Rel-17. However, as mentioned before, there are use cases where repetition is not an option. Moreover, there exist more spectrally efficient techniques to transmit small payloads at low SNR.

It is understood that the time budget is very limited, but as a group we should strive to improve spectral efficiency at the lowest level. In order to make progress on that topic, it is first necessary to achieve consensus on potential gains (SNR and PAPR) and the associated complexity of the proposed schemes.

Thus, we think it is beneficial to conduct a small evaluation/study to align results and decide on a way forward.

5 – Ericsson LM

Performance requirements will be needed

3 Email discussion (intermediate round)

3.1 Justification

Moderator's comments: Based on companies' views, justification is updated as follows. It can be revised later based on the objectives if necessary.

Table 6:

Coverage is one of the key factors that an operator considers when commercializing cellular communication networks due to its direct impact on service quality as well as CAPEX and OPEX. UL performance could be the bottleneck in most of scenarios in real deployment, while there are emerging vertical use cases that have UL heavy traffic, e.g., video uploading. In Rel-17 work item 900061 “NR Coverage Enhancements”, NR coverage has been extended for some of the bottleneck channels identified in the Rel-17 study item 860036 “Study on NR coverage enhancements”, in particular for PUSCH, PUCCH and Msg3. However, not all needs for coverage enhancement have been addressed by the Rel-17 WID, due to its limited scope.

In RAN Rel-18 Workshop in June 2021, UL enhancements have been identified as one of the key areas of interest by multiple players including operators, network and UE vendors and various industries, as reflected by the number of contributions proposing UL coverage and capacity enhancements based on the real and urgent demands for improving UL performance on top of Rel-17 enhancements. After further discussion, the scope of UL enhancement is narrowed down to further UL coverage enhancement.

~~Following justifications for specific UL enhancements have been identified during RAN Rel-18 email discussions:~~

- ~~– In Rel-17, PRACH coverage enhancement has not been addressed, despite being identified as one of the bottleneck channels in the corresponding studies. PRACH transmission is very important for many procedures, including e.g., initial access and contention-based beam failure recovery.~~
- ~~– {The UE transmission power is the most valuable resource in uplink and enhancements to unlock additional uplink power are highly valuable for both UL coverage and capacity. There are some studies and works in Rel-17 on the power domain, such as enhancements to reduce MPR/PAR in “Study on NR coverage enhancements” and “Increasing UE power high limit for CA and DC”, and hence some further study is necessary to exploit the Rel-17 studies/works.}~~
- ~~– {For multi-carrier UL operation, there are some limitations of current specification, e.g. 2Tx UE can be configured with at most 2 UL bands, which only can be changed by RRC reconfiguration, and UL Tx switching can be only performed between 2 UL bands for 2Tx UE. Dynamically selecting carriers with UL Tx switching based on the data traffic, TDD DL/UL configuration, bandwidths and channel conditions of each band, instead of RRC-based cell(s) reconfiguration, will lead to higher UL data rate, spectrum utilization and UL capacity.}~~
- ~~– {DFT-S-OFDM waveform is beneficial for UL coverage limited scenario because of its lower PAPR compared with CP-OFDM waveform. Currently, UL waveform is configured via RRC and only single layer transmission is supported. These and this limitations imposes a large barrier to switch over to DFT-S-OFDM waveform for cell-edge UEs practically.}~~
- ~~– {In case of dense deployment where pathloss can be low, it would be possible to use wider bandwidth including UL CA for UL transmission with sufficient PSD so that UL performance can be largely improved. Considering that the dense deployment has some practical issues e.g., large cell planning effort for inter-cell interference coordination, one possible scenario to realize the dense deployment for UL is to deploy UL reception only points. In such scenario, since DL and UL are asymmetric, some enhancements are necessary for UL power control and beam management.}~~
- ~~– {In Rel-17, PUCCH coverage enhancements are introduced based on repetitions using multiple UL slots. However, those mechanisms may not be available in case of TDD bands with limited UL slot configuration, such as DDDSU and may not be practically useful due to existing collision handling rules. Therefore, there is a demand to enhance the coverage performance of PUCCH/UCI not relying on repetitions using multiple consecutive UL slots.}~~

Companies are encouraged to provide further comments on the justification.

Feedback Form 6: Comments on justification

<p>1 – Panasonic Corporation</p> <p>We support the proposal.</p>
<p>2 – NTT DOCOMO INC.</p> <p>We support the revised justification.</p>
<p>3 – ZTE Corporation</p> <p>We support the updated justification.</p>
<p>4 – China Telecommunications</p> <p>We support the updated justification.</p>
<p>5 – Huawei Tech.(UK) Co.. Ltd</p> <p>This sentence should be deleted: <u>After further discussion, the scope of UL enhancement is narrowed down to further UL coverage enhancement.</u></p> <p>The Justification section is not meant for capturing the history of the WID drafting discussions. The moderator may consider revising the related paragraph.</p>
<p>6 – VODAFONE Group Plc</p> <p>We support the updated justification and agree with Huawei's comment</p>
<p>7 – Xiaomi Communications</p> <p>we support thte updated justification.</p>
<p>8 – Lenovo (Beijing) Ltd</p> <p>We support Huawei's proposal.</p>
<p>9 – Spreadtrum Communications</p> <p>We prefer HW's version.</p>
<p>10 – LG Electronics Inc.</p> <p>We are fine with the modified justification. Also, we are on the same page with HW's comment to delete a sentence.</p>
<p>11 – Intel Deutschland GmbH</p> <p>We are fine with the updated justification.</p>
<p>12 – Ericsson LM</p> <p>We are fine with updated justification.</p>

13 – AT&T

Agree with Vodafone and Huawei

14 – Futurewei Technologies

Support and agree with Huawei's comment.

3.2 Objective 1

Moderator's comments:

- It seems majority companies are fine to remove 2-step RACH while some companies would like to keep 2-step RACH. As pointed out by companies that 2-step RACH is mainly for the use case of low latency, let's focus on 4-step RACH in this objective.
- Regarding the FR, as commented by some companies that based on CovEnh SI the main motivation of PRACH enhancements is for FR2, while the enhancements may also apply to FR1 as well. Note 1 states clearly this intention and additional restriction of "FR2" for 1st and 2nd bullet is not needed.
- Regarding the targeted PRACH format, majority companies support format agnostic while some companies suggest to focus on short formats. Note 2 is revised accordingly.
- Regarding the study phase of different beams, from moderator understanding, it's a compromise based on Oct. email discussion, let's not debate it and keep as it is.
- @all: The revised objective for PRACH may not be preferable to everyone. However, as we have already discussed it extensively during the past half year, hope it can be acceptable.

Table 7:

- Specify following PRACH coverage enhancements (RAN1, RAN2)
 - Multiple PRACH transmissions with same beams targeting for 4-step RACH [~~and 2-step RACH~~] procedures
 - [~~Study, and if justified, specify PRACH transmissions with different beams targeting for 4-step RACH~~] [~~and 2-step RACH~~] procedures] for FR2
 - Note 1: The enhancements of PRACH are targeting for FR2, which can also apply to FR1 when applicable.
 - Note 2: The enhancements of PRACH are [~~format-agnostic and~~] targeting [~~for PRACH format B4, which can also apply to other~~] short PRACH formats, which can also apply to other formats when applicable.

Companies are encouraged to provide further comments on the above objective.

Feedback Form 7: Comments on objective 1

<p>1 – vivo Communication Technology</p> <p>We are fine with this revised objective.</p>
<p>2 – Panasonic Corporation</p> <p>We support the proposal.</p>
<p>3 – NTT DOCOMO INC.</p> <p>We support the revised objective with the two notes.</p> <p>Editorial comment: For the 2nd bullet, we assume ”for 4-step RACH procedures”</p>
<p>4 – Apple Computer Trading Co. Ltd</p> <p>We are fine with the updated Objective 1.</p>
<p>5 – ZTE Corporation</p> <p>Support the updated objective for PRACH enhancements.</p>
<p>6 – SHARP Corporation</p> <p>We are fine with the updated Objective 1.</p>
<p>7 – China Telecommunications</p> <p>We support the updated Objective 1.</p>
<p>8 – SoftBank Corp.</p> <p>We support the moderator proposal.</p>
<p>9 – Huawei Tech.(UK) Co.. Ltd</p> <p>Editorially, it would be better to rephrase “which can also apply to other formats when applicable” by simply replacing “which” by “and”.</p>
<p>10 – VODAFONE Group Plc</p> <p>We’re fine with the current proposal</p>
<p>11 – China Mobile Com. Corporation</p> <p>We are fine with the current proposal.</p>
<p>12 – Xiaomi Communications</p> <p>We support the updated Objective 1.</p>

<p>13 – Lenovo (Beijing) Ltd</p> <p>We are fine with concentrating the study on 4-step RACH since this objective is to enhance coverage, not to reduce delay. We support the current text.</p>
<p>14 – Guangdong OPPO Mobile Telecom.</p> <p>Only for 4-step RACH is fine for us.</p> <p>The enhancement is more beneficial for short format and can be applicable to other formats. In addition to Huawei’s editorial. We think the applicable is also not needed. If it can apply, then it applicable. So: <u>”and can also apply to other formats when applicable.”</u></p>
<p>15 – Spreadtrum Communications</p> <p>We support the updated Objective 1.</p>
<p>16 – Samsung Research America</p> <p>We are fine with the moderator’s proposal.</p>
<p>17 – LG Electronics Inc.</p> <p>We support the updated Objective 1.</p>
<p>18 – Intel Deutschland GmbH</p> <p>We are generally fine with the objectives for PRACH coverage enhancement. Our understanding is that based on the performance evaluation during Rel-17 CovEnh SI phase, PRACH coverage enhancement is mainly for short PRACH formats, but we can live with current proposal if majority support long PRACH formats.</p>
<p>19 – Ericsson LM</p> <p>Support the revised objective.</p>
<p>20 – Futurewei Technologies</p> <p>Support the updated objective.</p>
<p>21 – Telia Company AB</p> <p>We support this update.</p>
<p>22 – Qualcomm Incorporated</p> <p>We agree with the draft objective in general, although we still think that the applicability to 2-step RACH should be kept at least for the same beam preamble repetition case.</p>
<p>23 – Verizon UK Ltd</p> <p>Support the update</p>

3.3 Objective 2

Moderator's comments:

- It seems majority companies are generally fine with Objective 2, including dynamic power aggregation and MPR/PAR reduction. For the 1st bullet, some companies think the motivation of dynamic power aggregation is not clear and propose to revisit this objective after related Rel-17 work in RAN4 work is complete. Note 2 is added corresponding to companies' comments.
- The 2nd bullet is updated based on companies' comments to clarify the detailed scope. Regarding “[reduced spectrum utilization with relaxed requirements on channel filtering, and potential adjustments to MPR and test tolerance relations]”, it seems controversial. More comments are expected.
- Regarding whether there is RAN1 impact as commented by some companies, for dynamic aggregation, since the scope will be revisited, suggest to keep “RAN1” in square brackets. For MPR/PAR reduction, it seems some companies think there is no RAN1 impact, while some companies don't think so. From moderator's understanding, it depends on the detailed scope. Companies are encouraged to check the newly added details.
- @Samsung: It seems few companies are interested in advance receiver. Moreover, there was no discussion on advance receiver during the last email discussion. Thus, moderator suggests not to include “exploiting advanced receiver” in the 2nd bullet.
- @CMCC: From the moderator's understanding, the intention of dynamic power aggregation is to allow UE to fully use the transmission power across different bands and remove the artificial power limit imposed on certain band combinations.

Table 8:

- | |
|--|
| <ul style="list-style-type: none">– {Study and if necessary specify following power domain enhancements}<ul style="list-style-type: none">○ {Enhancements to realize dynamic power aggregation based on Rel-17 RAN4 work on “Increasing UE power high limit for CA and DC”, with checking in compliance with relevant regulations ([RAN1,] RAN4)}<ul style="list-style-type: none">▪ {Note 1: The study can starts after RAN4 work on “Increasing UE power high limit for CA and DC” is done depending on conclusions from RAN4.}▪ <u>Note 2: The detailed objective can be revisited after RAN4 work on “Increasing UE power high limit for CA and DC is done.</u>○ {Enhancements to reduce MPR/PAR, including new transmission mechanism such as spectrum shaping with spectrum extension for QPSK for DFT-S-OFDM, [reduced spectrum utilization with relaxed requirements on channel filtering,] and potential adjustments to MPR and test tolerance relations] (RAN4[, RAN1])}<ul style="list-style-type: none">▪ <u>Techniques to be considered for spectrum extension include, e.g. frequency domain spectrum shaping with spectrum extension and tone reservation.</u>▪ <u>Evaluate resource allocation mechanisms taking into account the spectrum extension</u> |
|--|

Companies are encouraged to provide further comments on the above objective. More comments are expected on “[reduced spectrum utilization with relaxed requirements on channel filtering, and potential adjustments to MPR and test tolerance relations]” and the detailed scope for spectrum extension.

Feedback Form 8: Comments on objective 2

<p>1 – vivo Communication Technology</p> <p>We still have some concern on this objective. It’s ok for the first bullet with the notes, however further clarification on number to Tx is needed, for example max number of Tx is 2. On the second bullet, we still propose to remove RAN1 hence do not agree with the newly added 2 sub-bullets.</p>
<p>2 – Panasonic Corporation</p> <p>We support the proposal.</p>
<p>3 – NTT DOCOMO INC.</p> <p>We support the revised objective.</p> <p>Regarding “[reduced spectrum utilization with relaxed requirements on channel filtering, and potential adjustments to MPR and test tolerance relations]”, we’re open to remove it.</p>
<p>4 – Apple Computer Trading Co. Ltd</p> <p>For the first bullet, it’s not clear what kind of works need to be done by RAN4 in Rel-18 on top of Rel-17 WI. Even the RAN1’s work is depending on the conclusion from RAN4 Rel-17 WI. It’s reasonable to put the first bullet and its sub-bullets in the brackets.</p> <p>For the second bullet, we suggest removing RAN1 from this target. After the RAN4’s study, if RAN1 is really needed to be involved, the WID can be updated correspondingly. In addition, the first sub-bullet seems covered by main bullet already.</p>
<p>5 – ZTE Corporation</p> <p>Regarding enhancements to reduce MPR/PAR, we suggest to follow what we have been studied in Rel-17 CE SI (copied below for reference). Basically, FDSS and tone reservation were studied as two separate enhancements, and both with and without spectrum extension can be considered for FDSS. With FDSS and tone reservation explicitly included, RAN1 could be added as a secondary working group while there is no need to specifically mention resource allocation. We are ok to remove the enhancements in brackets.</p> <p><i>‘UE transmit waveform design to reduce MPR was studied from several aspects, including tone reservation, FDSS (Frequency Domain Spectral Shaping) without spectral extension for pi/2 BPSK, and FDSS with and without spectral extension for QPSK. Potential specification impacts include: related signalling, design for spectral extension, RF requirements. Note: For tone reservation, a fraction of tones allocated to a UE are reserved for the UE to shape its waveform; no data is transmitted on these tones.’</i></p> <p>With said above, we suggest the following revisions.</p> <p>o Enhancements to reduce MPR/PAR, including frequency domain spectrum shaping with or without spectrum extension for QPSK for DFT-S-OFDM and tone reservation [reduced spectrum utilization with relaxed requirements on channel filtering, and potential adjustments to MPR and test tolerance relations] (RAN4[, RAN1])</p> <p>–Techniques to be considered for spectrum extension include, e.g. frequency domain spectrum shaping with spectrum extension and tone reservation.</p>

~~–Evaluate resource allocation mechanisms taking into account the spectrum extension~~

6 – China Telecommunications

For enhancement to realize dynamic power aggregation, we support current version of objective.

For enhancement to reduce MPR, we share the similar view as ZTE to follow what we have already studied in Rel-17 CovEnh SI. The modified objective from ZTE is fine with us.

7 – SoftBank Corp.

we support the proposal

8 – Huawei Tech.(UK) Co.. Ltd

The first objective is still unclear. Even though it is clarified that the objective will have to be revised based on the outcome of the RAN4 WI, what the current objective says is to study “dynamic power aggregation”. But this terminology is undefined, so it could mean anything. Could someone instead provide a precise description of what is intended to be the scope of the objective, instead of using the undefined terminology of “dynamic power aggregation”? Doing so would help in clarifying the difference from the objectives of the current RAN4 WI. Otherwise, this objective is not actionable and goes against the RAN Chair’s guidance, and it is impossible to determine which WGs should be involved.

9 – China Mobile Com. Corporation

Thanks for FL’s further clarification. We have no problem to remove the artificial power limits imposed over certain band combinations, which is obvious current Rel-17 RAN4’s scope. Our concern is whether we really need the “dynamic” power aggregation. Once the limit could be removed for the UEs in certain band combination, there is no further action or specification impact that needs the “dynamic”. Then we propose to remove the “dynamic” before the power aggregation.

For the reduction of MPR/PAR, the 2nd sub-bullet should be removed. The resource allocation could be based on implementation. And if there is a need to change the resource allocation and with the specification impact, we could directly do it during the phase afterwards. We do not need to list a target based on current limited understanding.

~~–Evaluate resource allocation mechanisms taking into account the spectrum extension~~

10 – Xiaomi Communications

We are supportive of FL’s updated version in general.

For the Enhancements to realize the dynamic power aggregation, we share the similar view with Vivo that further clarification on the max. # of Tx is needed.

For the Enhancements to reduce MPR/PAR, the second sub-bullet can be removed.

11 – Lenovo (Beijing) Ltd

Regarding the first bullet, before RAN4 completes its R17 work, it is not clear what is needed for R18. We agree with Apple’s proposal to put this bullet in square bracket.

Regarding the second bullet, it is clear the spec impact is in RAN4. We are OK to keep [RAN1] in the bracket in the second sub-bullet for now, although we do not believe it has RAN1 impact and prefer to remove it completely.

12 – Samsung Research America

1st bullet: RAN4 needs to conclude the study before considering an objective for RAN1, hence we suggest to remove RAN1 and merge the two notes in a single note as follows:

Note: This objective will be revisited after RAN4 work on “Increasing UE power high limit for CA and DC” is complete.

2nd bullet: The newly added two sub-bullets are too specific and we suggest to remove them. The text in the main bullet can be simplified by removing the text in square brackets.

13 – Nokia Corporation

On the second bullet, the main reason for proposing the addition of the two sub-bullets was to address concerns that the objective was not clear enough, but it seems some companies have concerns on it being too specific now. This seems to suggest that we are converging to the right level of details eventually, so we are OK with the revisions proposed by Samsung above. We have a preference on keeping RAN1 in brackets in this objective though.

14 – MediaTek Inc.

We have concerns about adding this type of detail in those 2 sub-bullets.

Also the text ”study and if necessary specify”.... it should be **”Study and, if clearly justified in terms of gain vs pain, then specify”**....

15 – InterDigital France R&D

We also share the same view from ZTE and China Telecom that Rel. 17 study outcome should be considered in this objective.

16 – Ericsson LM

Regarding dynamic power aggregation, improvements of total UE power capability for CA/DC in terms of dynamic power aggregation should be made in a manner predictable to the network and not only be left to UE implementation. If the actual UE output power is not consistent with power headroom reporting, there is no benefit, since the network will not be able to use the power reporting to improve its scheduling decisions.

Regarding “reduced spectrum utilization with relaxed requirements on channel filtering”, the aspect of “potential adjustments to MPR and test tolerance relations” is more crucial in our view. As we discussed in the prior round example, large tolerances (e.g. 5 dB or more) are added on top of MPR. These make it almost irrelevant to debate MPR enhancements of less than a dB, and if tolerances can be reduced as a function of power level, while still taking into account power inaccuracy, then the RAN4 requirements can be much more meaningful for real deployments and consistent with real UE designs.

Regarding spectrum shaping / extension, it is necessary to identify the requirements assumed for spectrum utilization, since the amount of PA backoff depends on this assumption, and the amount of net gain from enhancements may be better if different requirements are considered. Therefore, the spectrum shaping / extension study should be clear on this aspect.

Therefore, propose the following for the study (as compared to moderator's current proposal):

Study and if necessary specify following power domain enhancements

- Enhancements to realize dynamic power aggregation based on Rel-17 RAN4 work on “Increasing UE power high limit for CA and DC”, in compliance with relevant regulations ([RAN1,] RAN4)
 - o Note 1: The study starts after RAN4 work on “Increasing UE power high limit for CA and DC” is done depending on conclusions from RAN4.
 - o Note 2: The detailed objective can be revisited after RAN4 work on “Increasing UE power high limit for CA and DC” is done.
 - o **Note 3: Improvements of total UE power capability for CA/DC should be made in a manner predictable to the network and not only be left to UE implementation.**
- Enhancements to reduce MPR/PAR, including spectrum shaping with spectrum extension for QPSK for DFT-S-OFDM, ~~reduced spectrum utilization with relaxed requirements on channel filtering,~~ and potential adjustments to MPR and test tolerance relations (RAN4, RAN1)
 - o Techniques to be considered for spectrum extension include, e.g. frequency domain spectrum shaping with spectrum extension and tone reservation.
 - o Evaluate resource allocation mechanisms taking into account the spectrum extension
 - o **Different spectrum utilization requirements are considered**
 - o **Reduced tolerances as a function of output power level with a view toward reducing UE power backoff, in particular for FR2, and consider the MPR in conjunction with the tolerances.**

17 – Futurewei Technologies

For the first bullet, we agree with vivo, Apple, Huawei, China Mobile, Xiaomi, Lenovo, and Samsung that more clarifications are needed as of now (we still support the general direction, though). It is preferred to complete the current RAN4 R17 work, perform the necessary study in RAN4 on dynamic power aggregation or power aggregation, and then decide RAN1's study/work scope. We are fine with Samsung's version or Apple's version.

For the second bullet, we still suggest modifying to “Enhancements to reduce MPR/PAR for cell-edge cases”, as the item is to increase the power limit for cell-edge UEs, not for other cases such as cell-center UEs with wider frequency-domain resource allocation. We suggest removing the two sub-bullets and we are ok with combining tone reservation into the main bullet.

18 – Intel Deutschland GmbH

For the dynamic power aggregation, it is still not clear to us the exact scope for RAN1 and RAN4. It would be more appropriate to clearly list the objectives to be done in RAN1/4. We prefer to discuss the objective once RAN4 Rel-18 work is complete. Similar comments were provided by many companies in the initial round.

For enhancements to reduce MPR/PAR, given the majority support, we can be acceptable to further study it for the sake of progress. We have the following comments:

- For detailed objectives, we suggest not to limit the modulation to QPSK only and we can consider both FR1 and FR2 for the enhancement.
- Further, given that this is for study, we share similar view as other companies that other solutions can be considered in the study for enhancements to reduce MPR/PAR. For spectrum extension, we suggest to consider “spectrum shaping with and without spectrum extension for QPSK for DFT-S-OFDM and tone reservation”.

- It is not clear to us the candidate solution “reduced spectrum utilization with relaxed requirements on channel filtering”. It would be great that proponents can provide more details on the solution.
- In our view, the detailed solutions/resource allocation mechanisms should be part of study and we do not need to list in the objectives. We suggest to remove the last two sub-bullets.

We suggest to update the objective as follows (similar view as ZTE):

o ~~{Enhancements to reduce MPR/PAR, including new transmission mechanism such as e.g., spectrum shaping with and without spectrum extension for QPSK for DFT-S-OFDM and tone reservation, [reduced spectrum utilization with relaxed requirements on channel filtering,] and potential adjustments to MPR and test tolerance relations} (RAN4[, RAN1])}~~

~~—— Techniques to be considered for spectrum extension include, e.g. frequency domain spectrum shaping with spectrum extension and tone reservation.~~

~~—— Evaluate resource allocation mechanisms taking into account the spectrum extension~~

19 – Qualcomm Incorporated

The study on MPR/PAR needs to consider waveforms beyond QPSK for DFT-S-OFDM. QPSK for DFT-S-OFDM is a reference waveform that is transmitted with 0 MPR, i.e., it’s a waveform that is already transmitted at a power equivalent to the UE’s power class. The focus has to remain broad enough to target higher modulation orders where the issue of MPR is more relevant and severe. We suggest not mentioning QPSK explicitly.

Our remaining comment is on ‘adjustments to test tolerance-to-MPR relations’. We still think this should not be in the scope of this WI. That would be more suitable for a separate RAN4 TEI or SI/WI.

Correspondingly, we suggest the following edits to the main bullet:

”Enhancements to reduce MPR/PAR, including spectrum shaping with spectrum extension for QPSK for DFT-S-OFDM, [reduced spectrum utilization with relaxed requirements on channel filtering,] [and potential adjustments to MPR and test tolerance relations] (RAN4[, RAN1])”

20 – Verizon UK Ltd

Generally OK.

Very very sympathetic to Ericsson’s view: ”Regarding dynamic power aggregation, improvements of total UE power capability for CA/DC in terms of dynamic power aggregation should be made in a manner predictable to the network and not only be left to UE implementation.” Otherwise, a lot unforeseen problems down the road.

3.4 Objective 3

Moderator’s comments:

- It seems the majority are fine that only dynamic switching between DFT-S-OFDM and CP-OFDM is supported.
- @Huawei, Qualcomm, Verizon, Ericsson: Based on the previous several rounds of discussion and companies’ views summarized in the appendix, from moderator perspective, it seems rarely possible to reach consensus to support multiple-layer DFT-S-OFDM.
- Given that no company objecting to dynamic switching between DFT-S-OFDM and CP-OFDM and the clear majority views, let’s stick to only supporting dynamic switching between DFT-S-OFDM and CP-OFDM.

Table 9:

– Specify enhancements to support dynamic switching between DFT-S-OFDM and CP-OFDM (RAN1)

Please refrain any comments, unless you have strong concerns on the above objective.

Feedback Form 9: Comments on objective 3

1 – vivo Communication Technology We are fine with this objective.
2 – Panasonic Corporation We support the proposal.
3 – CEWiT We accept the proposal
4 – NTT DOCOMO INC. We support the revised objective. We believe this scope is beneficial for the commercial network.
5 – Apple Computer Trading Co. Ltd We support this objective.
6 – SHARP Corporation We support the objective.
7 – ZTE Corporation We support the objective.
8 – China Telecommunications We support the objective.
9 – SoftBank Corp. we support the moderator proposal
10 – VODAFONE Group Plc We're fine with the moderator proposal

<p>11 – China Mobile Com. Corporation</p> <p>Support the proposal.</p>
<p>12 – Xiaomi Communications</p> <p>we are fine with the proposal</p>
<p>13 – Lenovo (Beijing) Ltd</p> <p>We are fine with the proposal.</p>
<p>14 – Guangdong OPPO Mobile Telecom.</p> <p>We are OK with the proposal.</p>
<p>15 – Samsung Research America</p> <p>We are fine with the moderator’s proposal.</p>
<p>16 – LG Electronics Inc.</p> <p>We support the Objective 3.</p>
<p>17 – Spreadtrum Communications</p> <p>We support the objective.</p>
<p>18 – MediaTek Inc.</p> <p>We support this</p>
<p>19 – InterDigital France R&D</p> <p>We support the moderator’s Objective 3.</p>
<p>20 – Intel Deutschland GmbH</p> <p>We are fine with the proposal.</p>
<p>21 – Ericsson LM</p> <p>We agree that at least one of dynamic switching between DFT-S-OFDM and CP-OFDM or multi-layer DFT-S-OFDM should be specified, and so can support the moderator’s proposal.</p>
<p>22 – Futurewei Technologies</p> <p>Support</p>
<p>23 – Qualcomm Incorporated</p> <p>Can accept the proposal</p>

24 – Verizon UK Ltd

Can accept - of the 2, we preferred dynamic switching.

3.5 Others

Moderator’s comments:

- @Intel @Panasonic @Sharp, @EURECOM: Regarding UL dense deployment and PUCCH/UCI, based on the previous several rounds of discussion and companies’ views summarized in the appendix, it can be seen that there are many companies objecting to supporting them. In addition, considering the limited budget endorsed on Monday GTW session, moderator suggests no further discussion on enhancements for UL dense deployment and PUCCH/UCI.
- @Ericsson: Yes, performance part is needed. RAN4 Chair may consider overall time budget for all WIs.

Any other comments?

Feedback Form 10: Any other comments?

<p>1 – Panasonic Corporation</p> <p>We understand the situation and we are ok to follow moderator’s suggestion.</p>
<p>2 – Intel Deutschland GmbH</p> <p>We can live with the moderator’s suggestions</p>
<p>3 – Ericsson LM</p> <p>If additional time is available in the Rel-18 coverage enhancement work, then we would prioritize support for multi-layer DFT-S-OFDM given its clear benefit and limited standardization effort.</p>

4 Email discussion (final round)

4.1 Justification

Moderator’s comments: Regarding the comments by Huawei on the sentence “After further discussion, the scope of UL enhancement is narrowed down to further UL coverage enhancement”, we can simply delete the whole paragraph.

Table 10:

Coverage is one of the key factors that an operator considers when commercializing cellular communication networks due to its direct impact on service quality as well as CAPEX and OPEX. UL performance could be the bottleneck in most of scenarios in real deployment, while there are emerging vertical use cases that have UL heavy traffic, e.g., video uploading. In Rel-17 work item 900061 “NR Coverage Enhancements”, NR coverage has been extended for some of the bottleneck channels identified in the Rel-17 study item 860036 “Study on NR coverage enhancements”, in particular for PUSCH, PUCCH and Msg3. However, not all needs for coverage enhancement have been addressed by the Rel-17 WID, due to its limited scope.

In RAN Rel-18 Workshop in June 2021, UL enhancements have been identified as one of the key areas of interest by multiple players including operators, network and UE vendors and various industries, as reflected by the number of contributions proposing UL coverage and capacity enhancements based on the real and urgent demands for improving UL performance on top of Rel-17 enhancements. After further discussion, the scope of UL enhancement is narrowed down to further UL coverage enhancement.

Following justifications for specific UL enhancements have been identified during RAN Rel-18 email discussions:

- In Rel-17, PRACH coverage enhancement has not been addressed, despite being identified as one of the bottleneck channels in the corresponding studies. PRACH transmission is very important for many procedures, including e.g., initial access and contention-based beam failure recovery.
- {The UE transmission power is the most valuable resource in uplink and enhancements to unlock additional uplink power are highly valuable for both UL coverage and capacity. There are some studies and works in Rel-17 on the power domain, such as enhancements to reduce MPR/PAR in “Study on NR coverage enhancements” and “Increasing UE power high limit for CA and DC”, and hence some further study is necessary to exploit the Rel-17 studies/works.}
- {For multi-carrier UL operation, there are some limitations of current specification, e.g. 2Tx UE can be configured with at most 2 UL bands, which only can be changed by RRC reconfiguration, and UL Tx switching can be only performed between 2 UL bands for 2Tx UE. Dynamically selecting carriers with UL Tx switching based on the data traffic, TDD DL/UL configuration, bandwidths and channel conditions of each band, instead of RRC-based cell(s) reconfiguration, will lead to higher UL data rate, spectrum utilization and UL capacity.}
- {DFT-S-OFDM waveform is beneficial for UL coverage limited scenario because of its lower PAPR compared with CP-OFDM waveform. Currently, UL waveform is configured via RRC and only single layer transmission is supported. These and this limitations imposes a large barrier to switch over to DFT-S-OFDM waveform for cell-edge UEs practically.}
- {In case of dense deployment where pathloss can be low, it would be possible to use wider bandwidth including UL CA for UL transmission with sufficient PSD so that UL performance can be largely improved. Considering that the dense deployment has some practical issues e.g., large cell planning effort for inter-cell interference coordination, one possible scenario to realize the dense deployment for UL is to deploy UL reception only points. In such scenario, since DL and UL are asymmetric, some enhancements are necessary for UL power control and beam management.}
- {In Rel-17, PUCCH coverage enhancements are introduced based on repetitions using multiple UL slots. However, those mechanisms may not be available in case of TDD bands with limited UL slot configuration, such as DDDSU and may not be practically useful due to existing collision handling rules. Therefore, there is a demand to enhance the coverage performance of PUCCH/UCI not relying on repetitions using multiple consecutive UL slots.}

Companies are encouraged to provide further comments on the justification.

Feedback Form 11: Comments on justification

1 – NTT DOCOMO INC. We support the revised justification.
2 – Qualcomm Incorporated Agree with the justification
3 – SHARP Corporation Support the justification
4 – LG Electronics Inc. We support the text for justification section.
5 – Spreadtrum Communications We support the justification part.
6 – ZTE Corporation Support the revised justification.
7 – China Telecommunications We support the revised justification.
8 – Huawei Tech.(UK) Co.. Ltd The justification part looks fine. Since there is no form for objective 1 we provide our comment here: ”which” can also be changed to ”can” in note 1 of objective 1.
9 – VODAFONE Group Plc We support the updated justification
10 – Transsion Holdings We support the updated justification.
11 – Xiaomi Communications We support the updated justification
12 – Guangdong OPPO Mobile Telecom. Understand the change, but minor editorial: this should be kept ”Following justifications for specific UL enhancements have been identified.” before the listed bullets of -.

<p>13 – Futurewei Technologies</p> <p>Support</p>
<p>14 – Intel Deutschland GmbH</p> <p>Support</p>
<p>15 – Telia Company AB</p> <p>Looks fine for us.</p>

4.2 Objective 1

Moderator’s comments:

- Some editorial updates are made based on DOCOMO and Huawei’s comments.
- @OPPO: There is no harm to keep “when applicable”.
- @all: It seems the objective for PRACH enhancements is stable. No further discussion is needed.

Table 11:

<ul style="list-style-type: none"> – Specify following PRACH coverage enhancements (RAN1, RAN2) <ul style="list-style-type: none"> ○ Multiple PRACH transmissions with same beams targeting for 4-step RACH [and 2-step RACH] procedures ○ [Study, and if justified, specify PRACH transmissions with different beams targeting for 4-step RACH [and 2-step RACH] procedures] for FR2 ○ Note 1: The enhancements of PRACH are targeting for FR2, which can also apply to FR1 when applicable. ○ Note 2: The enhancements of PRACH are [format-agnostic and] targeting [for PRACH format B4, which can also apply to other] short PRACH formats, <u>which and can also apply to other formats</u> when applicable.
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4.3 Objective 2

Moderator’s comments:

- Based on the discussion so far, it seems the majority are fine with the direction of dynamic power aggregation. The concern is the wording “dynamic aggregation” and the detailed scope. If companies are not comfortable with “dynamic power aggregation”, we can use the wording from Rel-17 RAN4 WID, as anyway this is additional enhancement on top of Rel-17 RAN4 WID. Regarding the scope, if companies still have the concerns on note 2, we can revise note 2 and clearly states that the objective will be discussed after Rel-17 RAN4 WID is done. Regarding the suggestion of combining note 1 and

note 2, companies may have different understandings as these two notes serve different purposes. Let's keep them separately although it seems a bit redundant. Note 3 is added as per Ericsson and Verizon's comments.

- For MPR/PAR reduction, ZTE raised a good point that we can refer to TR38.830. The 2nd bullet is revised accordingly while also taking into account companies' views on the modulation order. It seems the majority suggest to delete "[reduced spectrum utilization with relaxed requirements on channel filtering, and potential adjustments to MPR and test tolerance relations]". In addition, the majority think the newly added two sub-bullets should be removed, as they are too specific. They can be part of work during the study phase.
- Regarding whether there is RAN1 impact, for the 1st bullet, since the scope will be revisited, suggest to keep "RAN1" in square brackets. For MPR/PAR reduction, it seems "RAN1" should be kept as a secondary working group, since we need to study whether there is RAN1 impact during the study phase.
- @vivo, xiaomi: From moderator's understanding, it's not necessary to mention the number of Tx chains, which is also not mentioned in Rel-17 RAN4 WID. If indeed necessary, we can revisit it as stated in the note.
- @Futurewei: From moderator's understanding, it's not necessarily to add "for cell-edge cases", as the whole WI is targetting coverage limited scenarios.

Table 12:

- {Study and if necessary specify following power domain enhancements}
 - o {Enhancements to realize ~~dynamic power aggregation~~ increasing UE power high limit for CA and DC based on Rel-17 RAN4 work on "Increasing UE power high limit for CA and DC", ~~with checking in compliance with~~ relevant regulations ([RAN1,] RAN4)}
 - {Note 1: The study ~~can~~ starts after RAN4 work on "Increasing UE power high limit for CA and DC" is done depending on conclusions from RAN4.}
 - Note 2: The detailed objective can will be revisited discussed after RAN4 work on "Increasing UE power high limit for CA and DC is done.
 - Note 3: Improvements of total UE power capability for CA/DC should be made in a manner predictable to the network and not only be left to UE implementation.
 - o {Enhancements to reduce MPR/PAR, including ~~new transmission mechanism such as frequency domain spectrum shaping with and without spectrum extension for QPSK for DFT-S-OFDM and tone reservation,~~ ~~[reduced spectrum utilization with relaxed requirements on channel filtering,] and potential adjustments to MPR and test tolerance relations} (RAN4[, RAN1])}

 - ~~Techniques to be considered for spectrum extension include, e.g. frequency domain spectrum shaping with spectrum extension and tone reservation.~~
 - ~~Evaluate resource allocation mechanisms taking into account the spectrum extension~~~~

Companies are encouraged to provide further comments on the above objective.

Feedback Form 12: Comments on objective 2

1 – Charter Communications

We are highly supportive of increasing UE power high limit for CA and DC. Notes 1 and 2 can be combined into a single note for simplicity.

2 – New H3C Technologies Co.

We support moderator's proposal.

3 – vivo Communication Technology

We prefer capturing supported number of Tx chains in the notes.

On the 2nd bullet, we still believe it is RAN4 objective only, if RAN1 is not removed at least keep in square bracket. RAN4 can always send LS to RAN1 if necessary.

~~{Enhancements to reduce MPR/PAR, including new transmission mechanism such as frequency domain spectrum shaping with and without spectrum extension for QPSK for DFT-S-OFDM and tone reservation, reduced spectrum utilization with relaxed requirements on channel filtering,} [and potential adjustments to MPR and test tolerance relations] (RAN4[, RAN1])}~~

4 – Lenovo (Beijing) Ltd

For the first bullet, it is not clear what enhancement is needed to “realize” “increasing UE power high limit for CA and DC” before RAN4's R17 work on “increasing UE power high limit for CA and DC” is complete. Since the objective will be discussed after RAN4 work on “Increasing UE power high limit for CA and DC” is done, we do not know what objective we are agreeing to at this time. We suggest to put the entire first bullet in square bracket or remove it for the time being. We can revisit this issue after RAN4 completes its R17 work.

For the second bullet, we think it is better to keep the square bracket around RAN1 because it is not clear what is required for RAN1 at this time.

5 – Samsung Research America

1st bullet: We suggest to

remove Note 3 - the objective will be revisited, no need to add restrictions as in Note 3 or else at this stage; remove '[RAN1]' or at least keep the square brackets (and it should be listed after RAN4).

2nd bullet: We suggest to

not add the content of the deleted sub-bullet in the main bullet, and add "etc." to indicate that the enhancements to reduce MPR/PAR discussed during the study might not be restricted to what is listed after "including";

remove '[RAN1]' - it is not clear the RAN1 impact at this stage.

○ Enhancements to reduce MPR/PAR, including spectrum shaping with and without spectrum extension for QPSK for DFT-S-OFDM, etc. (RAN4)

6 – NTT DOCOMO INC.

We support the revised objective 2.

7 – China Telecommunications

Moderator’s comments:

@vivo: As summary for the intermediate round, it’s not necessary to mention the number of Tx chains, which is also not mentioned in Rel-17 RAN4 WID. If indeed necessary, we can discuss it as stated in the note.

@Lenovo: The situation is that the majority are fine with the two directions of power domain enhancements. As stated clearly in the note for the 1st bullet, the scope of 1st bullet can be discussed after Rel-17 RAN4 WI is complete. I don’t think it would be helpful to repeat the discussion.

@Samsung: Fine to remove note 3, keep “RAN1” in square brackets and listed after RAN4 for the 1st bullet as the scope will be discussed anyway.

8 – Qualcomm Incorporated

It is unfortunate that our comments are not considered, while last minute comments by others are immediately included.

As we mentioned before, we are ok with mentioning in Objective 3 reporting enhancements in order to improve predictability by the network.

However, we will have to object to including Note 3 as currently written, unless the following is also added along with it. “Defining SAR/MPE/power management algorithms to be performed by the UE is not in the scope of this work.”

9 – China Telecommunications

Moderator’s comments:

@Qualcomm: Note 3 will be removed, the scope of 1st bullet will be discussed after Rel-17 RAN4 WI is complete, which means nothing details will be added to be time being.

10 – TELECOM ITALIA S.p.A.

We are fine with the moderator’s proposal (including latest comments)

11 – Nokia Corporation

Similarly to Telecom Italia, we are fine with the moderator’s proposal, including the latest comments above (#7 and #9).

12 – China Mobile Com. Corporation

Thanks moderator for the consideration of the wording updates. We are fine with the version with the moderator’s latest updates.

13 – CATT

We are fine with the latest proposal including comment #7 above.

14 – ZTE Corporation

We support the moderator’s proposal and also the latest comments.

15 – VODAFONE Group Plc

We're OK with the moderator's proposal

16 – Huawei Tech.(UK) Co.. Ltd

On power domain enhancements: we are fine with removing note 3. Regarding the change in note 2 from "revisited" to "discussed", our understanding of the previous version was that the objective should be revisited at RAN plenary when the RAN4 WI is done in order to clarify the scope of the enhancements (now it is too broad without differentiation from the current RAN4 WI objective). This implies that discussion will not start in the WGs before that clarification is done at RAN plenary. But the latest revision only implies the latter, while not asking for a revision of the objective before starting the work in WGs. In this case, what would be WGs be working on? Too broad objectives are not acceptable as emphasized by the RAN Chair. So we suggest revising note 2 as follows:

Note 2: The objective will be revisited in RAN plenary after RAN4 work on "Increasing UE power high limit for CA and DC is done, and the discussion in WGs will not start before the objective is revised with a clearer scope.

On Enhancements to reduce MPR/PAR, while it is unclear at this point what RAN1 would need to work on, we can live with the current proposal based on the understanding that the work in RAN1 will be triggered by RAN4.

17 – Transsion Holdings

We are fine with the latest proposal and the comment #7.

18 – Xiaomi Communications

We support the moderator's proposal for Objective 2.

19 – Guangdong OPPO Mobile Telecom.

We are fine with Huawei's added notes.

The other bullets also OK

20 – Apple Computer Trading Co. Ltd

For the first bullet, we still think the whole contents of the bullet should be in the brackets. First, What's RAN1's work is not clear until RAN4 finish its Rel-17 WI. Second, it seems not appropriate to assign RAN4 as the leading group or even RAN4 should be involved. It's not clear the possible leftovers of RAN4 Rel-17 WI. To move forward, we support Huawei proposed Note2.

For the second bullet, it's preferred to keep the RAN1 in the bracket. The spectrum shaping will impact the UE implementation, the feasibility study is needed for RAN4, after that it can be decided whether RAN1 will involve.

21 – Ericsson LM**Objective 2:**

As we commented in the last round, it is quite important that improvements of total UE power capability for CA/DC should be made in a manner predictable to the network and not only be left to UE implementation. It

is not our intention to define SAR/MPE/power management algorithms by the UE, and so we would like to keep Note 3 but amend as proposed by Qualcomm to include “Defining SAR/MPE/power management algorithms to be performed by the UE is not in the scope of this work.”. However, we can support Huawei’s proposed Note 2 to revisit the first bullet in RAN after the work on “Increasing UE power high limit for CA and DC” is done. **In that case, we understand that the aspect of total UE power capability being predictable by the network can be discussed when the first bullet is revisited in RAN. So, overall, we can support Huawei’s Note 2 with that understanding, and to omit Note 3 in the current draft of the WID if Qualcomm’s amendment to Note 3 is not acceptable to other companies.**

Objective 3:

Unfortunately, we have a comment for Objective 3 that was missed earlier. Since there is no feedback form, we comment here:

There may be a glitch when the UE switches between CP-OFDM and DFT-S-OFDM and/or a need for a switching delay. This should be addressed by RAN4. Therefore, we think that RAN4 should be listed as a secondary WG for Objective 3

22 – InterDigital France R&D

We support moderator’s version of Objective 2.

23 – MediaTek Inc.

We support the Huawei Note 2 (maybe “complete” instead of “done” though).

@Ericsson: Regarding Note 3, do you basically mean that “the network should be aware of how much UE transmission power is available at a given time, for UL scheduling purposes”?

24 – Intel Deutschland GmbH

For CA power limit enhancement, given that the detailed objectives are not clear at this moment and it will be further decided after the RAN4 work on “Increasing UE power high limit for CA and DC” is completed, we share similar view as Lenovo that the first main bullet needs to be put in [] and we can further discuss it later.

For enhancement on MRP/PAR reduction, we share similar view as Huawei/Apple that it is not clear to us why RAN1 is included as the WG. Our understanding is that RAN1 work is triggered by RAN4 LS so we think RAN1 is not listed in the objective.

25 – Futurewei Technologies

For the first bullet, we are fine with removing Note 3 and combining Notes 1 and 2. We support Huawei’s proposed Note 2 (which will be the only Note for this bullet).

We are generally fine with the second bullet, and support Apple’s suggestion to put RAN1 in brackets.

26 – Telia Company AB

We support moderator’s proposal on objective 2.

27 – Verizon UK Ltd

We are fine with the objective. We can agree with QC’s revision and Ericsson’s response. Predictability is needed by the NW to achieve efficient use of UE power. The intention is of course not to get into UE implementation... of course we want to leave room for UE innovation.

28 – Ericsson LM

Quick followup to Mediatek’s question: ‘@Ericsson: Regarding Note 3, do you basically mean that ”the network should be aware of how much UE transmission power is available at a given time, for UL scheduling purposes”?’:

Right, if the network does not know the available transmission power at a given time, it can’t schedule accordingly.

29 – Charter Communications

We support the moderator’s proposal and please add Charter Communications as a supporting company.

30 – MediaTek Inc.

@Ericsson: ok but then maybe the Note could be simplified to what I said - if it is to be kept? Predictability does seem like something very advanced.

4.4 Objective 3

Moderator’s comments: Objective 3 is stable. No further discussion is needed.

Table 13:

– Specify enhancements to support dynamic switching between DFT-S-OFDM and CP-OFDM (RAN1)

5 Reference

1. RP-262108, RAN Chair’s Summary for RAN Release 18, RAN#93e, 13th – 17th, September 2021.
2. RP-212662, Moderator’s summary of discussion [RAN94e-R18Prep-02] UL Enhancements (e.g. coverage enhancements; excluding MIMO), 3GPP RAN# 94e, Dec. 2021.
3. RP-212702, New WID on NR UL Enhancements, 3GPP RAN# 94e, Dec. 2021.
4. RP-213469, Summary for RAN Rel-18 Package, 3GPP RAN# 94e, Dec. 2021.
5. RP-212908 Views on NR UL enhancements for Rel-18 Intel Corporation
6. RP-212941 Discussion on DMRS-less PUCCH for UL Coverage Enhancements EURECOM
7. RP-213051 Views on Rel-18 UL coverage Qualcomm Incorporated
8. RP-213058 Discussion on draft WID of Rel-18 NR UL enhancements NTT DOCOMO, INC.
9. RP-213085 Discussion on NR UL enhancement for Rel-18 China Telecom
10. RP-213154 On Uplink coverage enhancements in Rel-18 Ericsson
11. RP-213159 Comments on Rel-18 Uplink draft WID Huawei, HiSilicon
12. RP-213207 Discussion on WID on NR uplink enhancements CMCC

- 13. RP-213269 Discussion on Rel-18 UL enhancement vivo
- 14. RP-213280 On Rel-18 UL Enhancements Nokia, Nokia Shanghai Bell
- 15. RP-213321 Views on NR UL Enhancements NEC
- 16. RP-213394 On Uplink Enhancements for 5G Advanced ZTE, Sanechips

6 Appendix

Based on the contributions and pre-RAN#94-e email discussion, companies' views on the objectives are summarized.

6.1 Companies' views on PRACH enhancement

- Enhancements also targets on 2-step RACH procedure.
Support: Qualcomm, NTT DOCOMO, NEC, Vodafone, Lenovo
Not Support: Intel, China Telecom, HW, HiSilicon, CMCC, vivo, ZTE, Ericsson
- Multiple PRACH transmission with different beams is also included
Support: Intel, China Telecom, HW, HiSilicon, ZTE, Lenovo, Apple, Spreadtrum
Not Support: NTT DOCOMO
- Whether the enhancements of PRACH are format-agnostic or targeting for PRACH format B4?
Companies support format-agnostic: NTT DOCOMO, HW, HiSilicon, NEC, Intel, Vodafone, Samsung
Companies support targeting for PRACH B4: China Telecom, CMCC, ZTE, Lenovo

To be more specific, 8 companies (Intel, China Telecom, HW, HiSilicon, CMCC, vivo, ZTE, Ericsson) prefer Alt.1-1 for the modifications on the **first bullet**, while 5 companies (Qualcomm, NTT DOCOMO, NEC, Vodafone, Lenovo) prefer Alt.1-2 as follows:

Table 14:

<p>Alt.1-1 Multiple PRACH transmissions with same beams targeting 4-step RACH [and 2-step RACH] procedures</p> <p>Alt.1-2 Multiple PRACH transmissions with same beams targeting 4-step RACH [and 2-step RACH] procedures</p>

10 companies (Intel, China Telecom, HW, HiSilicon, ZTE, apple, Lenovo, Spreadtrum, Nokia, NSB) prefer Alt.2-1 for the modifications on the **second bullet**, while 3 companies (vivo, Interdigital, NTT DOCOMO) prefer Alt.2-2 as follows:

Table 15:

Alt.2-1 ~~{Study, and if justified, specify PRACH transmissions with different beams targeting 4-step RACH and 2-step RACH} procedures}~~
Alt.2-2 ~~{Study, and if justified, specify PRACH transmissions with different beams targeting 4-step RACH and 2-step RACH} procedures}~~

Regarding the second note, companies' views are summarized as the following two alternatives:

Table 16:

Alt.3-1 Note: The enhancements of PRACH are ~~{format-agnostic and} targeting {for PRACH format B4, which can also apply to other} short PUCCH formats when applicable.~~
Alt.3-2 Note: The enhancements of PRACH are ~~{format-agnostic and} targeting {for PRACH format B4, which can also apply to other} short PUCCH formats when applicable.~~

6.2 Companies' views on power domain enhancement

8 companies (Intel, Qualcomm, NTT DOCOMO, HW, HiSilicon, CMCC, ZTE, AT&T) prefer the following modifications on the **first bullet** as in the following table, while some companies prefer to revisit dynamic power aggregation enhancement after the related RAN4 work is finished.

Table 17:

~~{Enhancements to realize dynamic power aggregation based on Rel-17 RAN4 work on "Increasing UE power high limit for CA and DC", with checking relevant regulations ([RAN1,] RAN4)}~~
~~{Note: The study can start after RAN4 work on "Increasing UE power high limit for CA and DC" is done depending on conclusions from RAN4.}~~

8 companies (NTT DOCOMO, China Telecom, HW, HiSilicon, Nokia, NSB, ZTE, AT&T) prefer the following modifications on the **second bullet** as in the following table, while 2 companies (Intel, CMCC) prefer not to include MPR/PAR reduction enhancement in Rel-18 UL enhancement, some companies prefer to revisit this topic when outcome of RAN4 WI is clear.

Table 18:

~~{Enhancements to reduce MPR/PAR, including new transmission mechanism such as spectrum shaping, {reduced spectrum utilization with relaxed requirements on channel filtering,} {and potential adjustments to MPR and test tolerance relations} (RAN4[, RAN1])}~~

Besides, **HW** proposes some additional refinement on the objectives as:

Table 19:

...“Increasing UE power high limit for CA and DC”, ~~with checking relevant~~ in compliance with regulations...
[Enhancements to increase cell-edge data rate, e.g. reduce MPR/PAPR, including new transmission mechanism such as spectrum shaping with QPSK, multi-layer DFT-s-OFDM with pi/2 BPSK...]

ZTE proposes to delete “new transmission mechanism such as” in the second bullet.

CMCC proposes to delete “dynamic” in the first bullet as “~~dynamic~~ power aggregation”.

Qualcomm has the following views for dynamic power aggregation:

- The dynamic power aggregation objective should take into account the output of the RAN4 WI fully
- The RAN1 dynamic power aggregation objective should focus on providing the necessary information to the gNB scheduler regarding the UE power management state, in order to enable efficient UL scheduling
- Avoid spending time on defining UE SAR management algorithms, this has multiple RAN4 precedents of being left up to UE implementation
- Focus on FR1, although any specified solution can be specified to FR2 as well, if applicable

Qualcomm has the following views for MPR/PAPR reduction:

1. Suggest exclusive focus on improving MPR values via spectrum/waveform shaping
 - Equal emphasis on lower and higher order modulations
 - Equal emphasis on FR1 and FR2
 - Consider both NS and non-NS value cases
 - No new waveforms besides CP-OFDM and DFT-S-OFDM to be considered
2. Aspects related to RAN4 test tolerances need not be included in the scope
3. Aspects related to channel filtering are vague and open-ended. No need to include it explicitly.
 - Also note that the current MPR tables are already sensitive to the size and location of RB allocation

Ericsson proposes additional considerations as:

- Jointly consider MPR and tolerances in deriving UE power backoff for meeting radio requirements (e.g. unwanted emission requirements), with a view toward reducing UE power backoff, in particular for FR2.
- For power domain enhancements, consider reduced spectrum utilization with relaxed requirements on spectrum confinement techniques for both single-carrier transmissions and intra-band contiguous UL CA to reduce MPR and/or reduce filter complexity.

6.3 Companies' views on enhancements for multi-carrier UL operation

Companies (NTT DOCOMO, China Telecom, HW, HiSilicon, CMCC, vivo, xiaomi, TELECOM ITALIA, Asia Pacific Telecom, CAICT, VODAFONE, LG, OPPO, SoftBank) support to include enhancements for multi-carrier UL operation in Rel-18 UL enhancement, while some companies (Nokia, Ericsson) don't support this enhancement. Some companies (vivo) propose to move this part to CA/DC enhancement.

6.4 Companies' views on enhancements for DFTS-OFDM

- **Companies support Alt.1:** CMCC, HW, HiSilicon
 - CMCC only support the first bullet in Alt.1.
- **Companies support Alt.2:** NTT DOCOMO, China Telecom, vivo, Nokia, NSB, ZTE
 - Majority companies only support the first bullet of Alt.2, while Nokia/NSB also supports the second bullet.

Moreover, based on the pre-RAN#94-e email discussion, majority companies (Samsung, CTC, vivo, CM, CATT, HW, ZTE, NTT DOCOMO, Apple, xiaomi, Nokia, Spreadtrum, Rakuten Mobile, OPPO, MediaTek) prefer to only support dynamic switching between DFTS-OFDM and CP-OFDM in Rel-18 UL enhancement.

6.5 Companies' views on enhancements for UL dense deployment

- **Companies support to include enhancements for UL dense deployment in UL enhancement WID:** Intel, NTT DOCOMO, Futurewei, Qualcomm, TELECOM ITALIA
- **Companies not support to include enhancements for UL dense deployment in UL enhancement WID:** China Telecom, HW, HiSilicon, CMCC, vivo, ZTE, Samsung, vivo, InterDigital, Lenovo, CATT, ZTE, xiaomi, Ericsson, LG, OPPO, MediaTek

6.6 Companies' views on enhancements for PUCCH/UCI

- **Companies support the first bullet:** Eurecom, China Telecom, NEC, ZTE, xiaomi, Qualcomm, OPPO
- **Companies support the second bullet:** Qualcomm
- **Companies support the third bullet:** Ericsson, Qualcomm
- **Companies not support the whole objective:** Intel, NTT DOCOMO, CMCC, vivo, CATT, Lenovo, HW, HiSilicon, Samsung, MediaTek, Ericsson