[94e-02-R18-MIMO] MIMO Evolution for Downlink and Uplink - Version 0.0.6
RAN

3GPP TSG RAN#94e RP-213530

Electronic Meeting, December 6 – 17, 2021

Agenda Item: 8A.1

Source: Samsung (moderator)

Title: Moderator's summary for discussion [94e-02-R18-MIMO] MIMO Evolution for Downlink and Uplink

Document for: Information & Decision

The discussion in this thread covers topic #2 "MIMO Evolution for Downlink and Uplink" and email discussion deadline and NWM organization are based on the guidelines provided by the RAN Chair.

The goal of the email discussion is to develop a WID for approval in RAN#94e.

1 Initial Round

1.1 General

An initial version of the revised WID is available in the draft folder of inbox for RAN#94e. Justification and objective sections of RP-212701 are revised according to the summary for RAN Rel-18 package from RAN chair and RAN WG chairs [RP-213469]. The text for the two sections is provided below for convenient discussion and company feedbacks are invited.

1.2 Justification Section

The text for justification section is revised to be very brief and is as follows.

=== start ===

MIMO is one of the key technologies in NR systems and is successful in commercial deployment. In Rel-15/16/17, some MIMO features are investigated and specified for both FDD and TDD systems, of which major parts were for downlink MIMO operation. In Rel-18, it is important to identify and specify necessary enhancements for uplink MIMO, while necessary enhancements on downlink MIMO would still need to be introduced to fulfil the request for evolution of NR deployments.

=== end ===

Moderator's recommendation is to further revise the text in justification section after stabilizing the text in objective section.

Feedback Form 1:

1.3 Objective section

Following the summary for RAN Rel-18 package, it is proposed to have the discussion on objectives #1, #2, #3, #4, #6, #7, and #8. Companies are encouraged to provide feedbacks to clearly define the scope.

Feedback Form 2:

1 – Samsung Research America

General comments:

- **Obj 1 and 4** (currently highlighted): It is our view that both objectives are important for Rel-18 MIMO - especially objective 4 from Samsung's perspective. It is also our view that coming up with narrow and clear scopes for the two objectives is feasible. Rel-18 can focus on enhancements based on *refinements* on the current features. This not only makes the scope small, but it also facilitates ease of use for addressing near-term needs for NW operators.
- **Obj 7 and 8**: The current wording of these two objectives leave much for guessing since the scope is not only unclear, but also (if interpreted as such) potentially excessive. Just as objectives 1 and 4, so these two objectives would benefit from rewording so that the scope may be narrow and clear.

2 – Nokia Corporation

We support the RAN chairman's proposal to limit the MIMO scope so it can fit to 3 TUs, as proposed in RP-213469. We see that the RAN chairman's proposal should be the starting point of the discussion, if something is added, then we should be able to agree what is dropped from the scope accordingly. In any case, it is important that the WID supports further UL evolution, as clearly indicated by many companies, including operators, in the Rel-18 Workshop and in subsequent email discussions. Naturally it is possible to accommodate reasonably-sized objectives on DL MIMO aspects as well, but those should not consume majority of the time allocated for MIMO enhancements in Rel-18.

Currently, only objectives 3, 6, 7, and 8 are UL-focused, while 1 and 4 are DL-focused, and objective 2 has a mix of UL and DL components. However, the objectives are not equally sized, and some objectives, e.g 4, require extensive system-level studies, further codebook developments, etc. It is very challenging to consider scopes for objectives 1 and 4 that could still fit into the existing 3TUs, but it seems feasible to find a suitable scope for considering objective 1 only.

Objective 2 can be quite large as well, considering the experience from R17. This extension is considered useful by many companies, but companies firmly believe development of more advanced DL MIMO features is critical for Rel-18, then we need to look at the possibilities of downscoping other DL-heavy objectives too, including this one.

On objectives 7 & 8 we support the statements from Samsung above, it is useful to clarify the scope of those as much as possible in RAN so that the discussion in the WGs is more focused.

3 – SoftBank Corp.

We share the proposal by the chair, i.e. the current scope is too big to fit into 3TUs. We believe UL enhancements are more important than DL in Rel-18 considering the current UL demand from the market. Also, quite many of pre-Rel-17 DL MIMO features have not been implemented in the real products. We should avoid the situation that 3GPP standard goes too far from the real products. If we do something for DL, we should focus on something everybody believes beneficial. Otherwise, DL related objectives (#1 and #4) can be dropped.

4 – LG Electronics Inc.

In general, we are supportive on the direction suggested by the chair that UL MIMO enhancement needs to be more emphasized than DL in Rel-18.

5 – TELECOM ITALIA S.p.A.

Fully support Softbank. The priority must be UL MIMO. DL improvements to be considered only if they fit in the available time units and there is large consensus.

We should stop over-engineering features.

6 – LG Uplus

We support Samsung's view in general. In Rel-18 MIMO, we should touch both DL and UL. Regarding DL, C-JT is essential feature with big gain and it is realistic one with evidence. Regarding UL, we think multi-TRP operation with efficient beam management is prioritized and multi-panel concept is positive but we are not sure that B2C device with multi-panel can be commercialized in time.

7 – KDDI Corporation

Basically we support the direction suggested by the chair that it is more important to identify and specify necessary enhancements for uplink MIMO. On the other hand, for downlink we are also interested in the objective #2, #3 and #4 and recognize that they can bring the benefits to enhance DL MIMO performance. In that sense, those DL parts can be included if TUs are available.

8 – Ericsson LM

The performance requirements for RAN4 are missing. Add something like:

- Specify as needed performance requirements associated with the items specified by RAN1 [RAN4]

9 – New H3C Technologies Co.

In principal, we agree that DL/UL MIMO enhancements are important in Rel-18. From our perspective, the WI scope should be limited with consideration of work load and limited 3 TUs.

10 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

In addition to the listed objectives, objective 5 on UE-initiated beam management/beam acquisition procedures should also be discussed. In the initial email discussions, there was concern on the scope being too broad with many proposals to consider. However, during the October email discussions, a good compromise was reached to list out a specific objective which was supported by many companies. Also, this topic

of UE-initiated beam management/acquisition was studied in Rel-17, but not specified due to lack of time. Hence, in our view objective 5 should be discussed and included in Rel-18 WI:

Objective 5: Study, and if justified, specify overhead and/or Latency reduction for UE-initiated beam management/beam acquisition procedures

11 – InterDigital France R&D

We believe that the scope of the work is still heavy, particularly due to Objectives #1 and #4. Because of their niche use-cases, we find Objectives #1 and #4 at a lower priority than others, suggest removing at least one of the two.

12 – Telia Company AB

We agree with Softbank and TIM that UL needs to be prioritised.

1.3.1 Objective #1

It is emphasized by RAN chair that for objectives #1 and #4, it is critical to have a clear and a *very* limited scope for them to be possibly considered; otherwise, both will be dropped. So, companies are encouraged to provide constructive feedbacks to define a clear and a very limited scope. The current status of text for objective #1 is as follows, which is highlighted by yellow color in the word document in inbox.

=== start ===

~~Study, and if justified, specify CSI enhancement, and possibly CSI-RS enhancement in high/medium velocities for exploiting time-domain correlation/Doppler-domain information to assist codebook based CSI acquisition mechanisms for DL precoding.~~

=== end ===

Feedback Form 3:

1 – HuaWei Technologies Co.

Both Objective-1 and 4 should be included in the scope, which are the most important parts for Rel-18 MIMO enhancements. To address the concerns for the scope of the two objectives, we propose the following restrictions to make the scope clear and narrow. For Objective-1, the enhancements are restricted only for CSI reporting. Specifically, the scope is restricted as Rel-16/17 Type-II codebook refinement without changes on spatial and frequency basis, and TRS based time domain channel information reporting which is used for Type-I or TDD scenarios in mobility scenarios.

For Objective-1,

Study, and if justified, specify CSI reporting enhancement~~, and possibly CSI-RS enhancement in~~ **for** high-/medium **UE** velocities ~~for~~ **by** exploiting time-domain correlation/Doppler-domain information to assist ~~codebook based CSI acquisition mechanisms for~~ DL precoding, **targeting FR1, as follows:**

· **Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis**

· **UE reporting of time-domain channel properties measured via TRS**

2 – Samsung Research America

Re obj 1 and 4, we share Huawei's assessment on the utility of both, especially (from Samsung's perspective) objective 4.

Re objective 1, since a limited and clear scope is the goal, we understand that while CSI enhancement for high-speed UEs can be vast, our view is as follows:

1) Rel-18 MIMO WI can include enhancements based on the existing CSI, measurements, and codebooks. This can be readily used for addressing immediate needs from NW deployments.

2) More advanced schemes (e.g. prediction, advanced codebooks) which may require more drastic spec enhancements can be investigated in Rel-18 ML/AI SI (which seems to have included this as well).

With the above mindset, **we support the above revision proposed by Huawei.**

3 – ZTE Corporation

Although we believe that a potential AI/ML based study item for air interface also discusses CSI compression feedback, we can compromise to have a limited scope for this time-domain correlation/Doppler-domain information based CSI enhancement. The updated proposal from Huawei looks good to us: the former sub-bullet targets for Rel-16/17 Type II CSI, and the latter one can apply to both Type-I and TDD cases. In a short, we can **support the updated revision of objective 1 from Huawei**.

4 – Fraunhofer IIS

From the previous e-mail discussions, there is a strong request from operators and verticals to improve CSI reporting for medium/high velocities UEs. It is also suggested by RAN chair to limit the scope of objective 1 and 4. In our view, Rel-16 Type-II CSI can be used as a basis for the considered mobility enhancements without modifying the spatial and frequency domain basis of the codebook. However, relying only on TRS for the Doppler estimation may not be sufficient as only a single port is supported. Therefore, we think that minor CSI-RS codebook configuration refinements (no change of CSI-RS design and maximum number of CSI-RS ports remains the same as in Rel-16) for Doppler CSI measurements should be considered. The following down scoped objective 1 is proposed.

Study, and if justified, specify CSI **reporting and measurement** enhancements~~, and possibly CSI-RS enhancement~~ in high/medium velocities for exploiting time-domain correlation/Doppler-domain information to assist codebook based CSI acquisition mechanisms for DL precoding **at FR1, as follows:**

- **Rel-16 Type-II codebook enhancements, without modification to the spatial and frequency domain basis**
- **UE reporting of time/Doppler-domain channel properties measured via CSI-RS**

5 – Nokia Corporation

We are OK with this objective given the revision above from Huawei. This helps in limiting the scope of discussions to a reasonable level. However we must observe that this reduction is just enough to allow this objective to be included, it is not enough reduction to consider introduction of objectives 1 and 4 simultaneously.

A detailed revision on last bullet though, to avoid forcing TRS to be always configured to support the feature: "UE reporting... measured via CSI-RS and/or TRS"

6 – VODAFONE Group Plc

As we expressed previously along with several other operators, objective 1 is of high priority for us in rel-18 MIMO. With the view of appropriately refining and limiting the scope, **we support the updated revision of objective 1 from Huawei.**

7 – vivo Communication Technology

CSI has been enhanced for few releases already, and it is common understanding that Rel-18 MIMO enhancement is to focused on UL enhancement, if Doppler domain information is deemed useful then the first priority should be based on SRS. Current spec supports flexible configuration of SRS including periodicity, and further minor enhancement could be to support SRS burst configuration.

8 – Intel Corporation (UK) Ltd

We support objective 1 to be part of Rel-18 NR. We note that the current formulation (from last round of discussion) is not good and requires refinements to have it more focused and concrete. We support Huawei intention/wording to clarify codebook types that should be considered for enhancement which is similar to the Intel's proposal in RP-212910.

9 – Apple GmbH

We are supportive of objective 1 and the potential clarification and narrowing down its scope

10 – Ericsson LM

We support the proposal from Huawei, and have the same view as ZTE that the 2nd subbullet is applicable to TDD, in particular reciprocity based MU-MIMO, where the Type-II spatial/frequency domain information is already obtained from SRS.

Note that TRS has the structure suitable for this task, whereas CSI-RS for CSI acquisition doesn't. So it makes more sense to use TRS here.

Regarding the relation to AI/ML, today's GTW session endorsed AI/ML for NR PHY as a SI only for Rel-18. This means that normative specifications resulting from this SI will at earliest come in Rel-19. The proposed enhancements address urgent deployment needs and should be included already in Rel-18.

11 – SHARP Corporation

We support the proposal from Huawei.

12 – MediaTek Inc.

We support working on this Objective for reasons provided in the past email discussion. So we can accept the compromise **proposal by Huawei** as a means to narrow the scope of the work.

13 – Futurewei

We believe it is essential to enhance MU-MIMO performance in high/medium mobility scenarios in Rel-18. We support the revision from Huawei to narrow the scope of this objective.

14 – Spark NZ Ltd

Spark also supports the revisions as suggested by Huawei for objectives #1 and #4.

15 – AT&T

Improving CSI reporting for medium/high velocity UEs is important for network deployment. While such an objective can be in general big in scope, the proposal by Huawei seems narrow enough to be considered for Rel. 18. We are ok with the direction of the objective as proposed by Huawei.

16 – NTT DOCOMO INC.

- We believe the original text of WID is already very limited. It already precludes "CSI-RS enhancement" and "reciprocity based". Since we believe feedback-based CSI acquisition is more useful than reciprocity based CSI acquisition in our network, we support the original text.
- If down scoping is needed, we prefer to remove Coherent Joint Transmission first. We don't prefer to limit the Rel.18 CSI for some specific CSI codebook. If we need to down select with some specific CSI codebook, we believe Type I single panel CSI codebook should be included because it is widely used in the current commercial network.
- Question to Huawei's proposal: Does it includes Type I single panel CSI codebook? Is it also applicable to FR2?

17 – Guangdong OPPO Mobile Telecom.

We are supportive of CSI enhancement (Objective#1), and agree that the scope of CSI enhancement should be down-scoped.

Regarding the revision from Huawei, we have a question for clarification. In our understanding, TRS based time domain channel information reporting seems also applicable to Type II codebook. If so, the second bullet is not only for Type-1 or TDD, but also for Type II. Any clarification on it would be appreciated.

18 – Sony Group Corporation

For both Objective 1 and 4, we believe the feedback-based CSI enhancement does matter. It's necessary to improve it for a) high/medium velocity UEs and b) NW with CJT capability at FR1. By checking the details (on Objective 1) from Huawei, we are fine with the refined version.

As for Objective 4, to make it even more compact, we tend to think it can be parallelly listed with Objective 1 as two sub-bullets under DL CSI enhancement. And if possible, they are going to share the same AI in upcoming Rel.18 WI phase.

19 – Spreadtrum Communications

For Objective #1, we also suggest to remove CSI-RS enhancement. Regarding Huawei's modification, we are supportive in principle. One clarification: For 'Rel-16/17 Type-II codebook refinement', does it mean Rel-16 Type-II CB, Rel-16 Type-II PS CB and Rel-17 Type-II PS CB will be refined together in Rel-18?

20 – China Mobile Com. Corporation

We support to limit the MIMO scope, especially for the DL part. We prefer to remove objective#1 and keep objective#4 since C-JT is promising for cell edge and cell average performance improvement. Even though the udpated version of objective#1 defines a more limited scope, we still think the workload is not manageable for the toally 3 TU work item.

21 – NTT DOCOMO INC.

Regarding to Huawei's modification, we'd like to include Type I single panel codebook (in addition to Type II), because we believe Type I single panel codebook is widely used in the current commercial network. We believe CSI enhancement for high/medium UE velocities is also useful/beneficial for Type I single panel codebook.

22 – TELECOM ITALIA S.p.A.

As stated in the general section, the scope of the project is too large and we should focus on UL.

However, the support of medium/high speed devices is an important aspect and if there is enough resources we could try to keep objective 1 with a very clear scope. Otherwise we should drop objective 1.

We further **propose to limit the scope to FR1.**

23 – Deutsche Telekom AG

We clearly support objective #1 as the benefits of CSI enhancements have been provided in medium/high velocity scenarios which become more and more relevant for NR (rails, automotive). We are supporting in limiting the scope if agreeable text can be found.

24 – Qualcomm Incorporated

Ok with removing this objective

25 – NEC Corporation

Firstly, we can live with this objective removed from Rel-18.

Secondly, two totally different methods are proposed in Huawei's revision: type II codebook refinement and UE report time-domain properties measured via TRS. It does not look like a *very* limited scope.

26 – LG Uplus

We support Huawei's revision for this objective.

27 – CEWiT

We support Huawei's proposal

28 – New H3C Technologies Co.

We support Huawei's modification for this objective

29 – CATT

Support Huawei's version except the second sub-bullet. For TDD system, time-domain channel properties can be estimated by SRS. Reporting of time-domain channel properties by UE is not necessary. For FDD system, time-domain channel properties can be acquired by refining codebooks. Reporting of time-domain channel properties by UE is not needed either. Therefore the second sub-bullet shall be removed.

30 – Beijing Xiaomi Mobile Software

We support objective 1. And as for the scope of this objective, we are fine to only consider limited codebook types. We want to clarify two points on Huawei's revision, Does Rel-16/17 Type-II codebook means Rel-16 Type II codebook, Rel-16 Type II port selection codebook and Rel-17 Type II port selection codebook? What is the motivation for precluding Rel-15 Type I codebook?

31 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

CSI enhancements for high/medium velocity has strong support by 23 companies in the October email discussions. Our preference is that the objective 1 as concluded in October email discussion should be agreed relative to objective 4 on CJT which in our view has should have lower priority.

If we need to limit the scope, then we can use Rel. 16/17 Type-II codebook as a baseline. We are also ok to consider Type-I codebook which are currently more widely implemented. We are supportive of UE reporting of time-domain channel properties measured via TRS based on the revision by Huawei.

Regarding the comments made that CSI and beam management discussion in AI may overlap with this objective, the AI-based CSI is a study for Rel. 18 and normative work would start in Rel. 19 at the earliest.

Thus, we suggest the following update to objective 1:

Study, and if justified, specify CSI enhancement in high/medium velocities for exploiting time-domain correlation/Doppler-domain information to assist codebook based~~, including potential enhancement to feedback-based~~ CSI acquisition mechanisms for DL precoding, based on Type-I single-panel codebook and/or Rel. 16 Type-II codebook; and UE reporting of time-domain channel properties measured via TRS

32 – InterDigital France R&D

In general, we don't see a strong urgency for this enhancement. Furthermore, the meaning of high/medium velocities is not clear to us. Is 60, 120, 250 or 500 Km/h considered a high velocity for this work? Also, if we are targeting a velocity of 250 Km/h and up, would CB-based transmission be the right transmission strategy?

The key to operation in high velocity is by using enhanced feedback reporting mechanisms that can leverage on prediction-based methods. In our view, such studies could be potentially conducted under the AI/ML CSI discussion. Hence, we would be OK with removing this objective.

33 – CableLabs

We are okay with the updated objective proposed by Huawei

34 – Continental Automotive GmbH

We are supportive of objective 1 and agree to limit the scope to handle the topic at a reasonable workload. Compared to objective 4 with minor priority we see objective 1 as a major enhancement to be included in Rel. 18 especially applying MIMO in moderate/high mobility scenarios. As several companies outlined it is reasonable to base the CSI mobility enhancements on the Rel-16 Type-II codebook without modification to the spatial and frequency domain basis to limit the scope of the objective 1. Our proposal is:

Study, and if justified, specify CSI enhancements~~, and possibly CSI-RS enhancement~~ in high/medium velocities for exploiting time-domain correlation/Doppler-domain information to assist codebook based CSI

acquisition mechanisms for DL precoding **at FR1, based on Rel-16 Type-II codebook without modification to the spatial and frequency domain basis enhanced by reporting of Doppler-domain channel properties measured via CSI-RS.**

35 – Volkswagen AG

Automotive applications benefit from MIMO enhancements at high velocity scenarios. Therefore it is encouraged to keep objective 1.

1.3.2 Objective #2

The current text for objective #2 is as follows.

=== start ===

Specify extension of Rel-17 Unified TCI framework, e.g.,

- For indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and inter-band) for multi-TRP and/or single-TRP schemes

=== end ===

Feedback Form 4:

1 – ZTE Corporation

Regarding extension of Rel-17 unified TCI framework (Objective-2), based on NWM discussion, there is a clear consensus on this further enhancement based on the previous NWM discussion, and so we can support to further specify the corresponding enhancement for mTRP.

One controversial issue is whether to further consider inter-cell/inter-band case together, and in our views, due to the typical deployment of FR1+FR2, we think that inter-cell/inter-band case can be considered herein. Alternatively, we can leave this issue open and further study the necessity of this related enhancement in RAN1.

2 – Samsung Research America

We are **supportive of objective 2**. To improve the clarity of this objective, the first 'e.g.' can be removed. That is:

Specify extension of Rel-17 Unified TCI framework~~**, e.g.,**~~

- For indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and inter-band) for multi-TRP and/or single-TRP schemes

3 – Nokia Corporation

We are generally OK with this objective conditioned on maintaining an overall reasonable amount of DL enhancements and a manageable workload. Otherwise this objective cannot be excluded from downscoping discussions, unfortunately.

4 – vivo Communication Technology

We are generally fine with this objective, also fine to remove e.g. as proposed by Samsung.

5 – Apple GmbH

We are supportive of this objective

6 – Intel Corporation (UK) Ltd

We support objective #2 in principle. However we prefer to avoid discussion on the new schemes for single-TRP and multi-TRP. In our view we should focus extensions only for the existing Rel-16/Rel-17 mTRP schemes. If other schemes are considered (beyond Rel-17), study phase may be needed to assess benefits of the proposed schemes. The potential proposed wording is as follows:

Specify extension of Rel-17 Unified TCI framework~~, e.g.,~~

- For indication of multiple DL and UL TCI states ~~(e.g., M>1 and/or N>1, and inter-band)~~ to support Rel-16/Rel-17 multi-TRP ~~and/or single-TRP~~ schemes using Rel-17 unified TCI framework

7 – Ericsson LM

We support Objective #2

8 – HuaWei Technologies Co.

For this Objective, we understand it is for extension work from Rel-17 to multiple TRPs case. But, it is unclear what is the ”single TRP schemes” in the Objective.

9 – SHARP Corporation

We are supportive of this objective

10 – Fraunhofer IIS

We support this objective for m-TRP schemes.

11 – Futurewei

We are supportive of Objective #2.

12 – Verizon UK Ltd

We support this objective - at least for mTRP. It is one of our priorities for Rel-18.

13 – KT Corp.

We are supportive of Objective #2. Also fine with removing e.g. proposed by Samsung.

14 – Beijing Xiaomi Mobile Software

We support Objective#2 for extension of Rel-17 Unified TCI framework.

15 – Spark NZ Ltd

As per Spark input - RP-212816 where we advocated for the need to consider distributed MIMO, this should be considered as part of objective #2 as it could be considered a spatially separated TRPs, resulting in an increase in channel rank.

16 – SK Telecom

We support Objective #2. And also, the first 'e.g.' can be removed.

17 – NTT DOCOMO INC.

Support.

In RAN1#107e meeting, working assumption was made that UE does not expect to be configured with Rel.15/16 TCI state/spatial relation and Rel.17 TCI state within the same band. It means if Rel.17 TCI state is configured, other Rel.16/17 features using Rel.15/16 TCI state/spatial relation (e.g. positioning, above 52GHz, etc.) cannot be configured within the same band. Hence, we should update all Rel.16/17 features using Rel.15/16 TCI state/spatial relation to Rel.17 TCI state, so that gNB can configure them within the same band. Thus, we support both multi-TRP and single TRP in the WID.

18 – AT&T

We are supportive of this objective

19 – Guangdong OPPO Mobile Telecom.

In general, we are supportive of Objective #2, i.e., the extension of R17 unified TCI framework. We are also fine with removing e.g., proposed by Samsung. Here are some further comments from our side:

1. Based on the previous discussions, one controversial part is whether intra-band or inter-band should be the target scenarios. From our understanding, there is no strong motivation/use case to use unified common TCI update for inter-band CA. Thus, we suggest to change "inter-band" to "intra-band".

2. R17 unified TCI framework design is focused on single TRP system. Thus, it is not clear what single-TRP schemes refer to. Are they referring to Rel-18 new single TRP scheme or anything else?

20 – LG Electronics Inc.

We support this objective and prefer to remove 'e.g,' to refine the scope.

21 – Spreadtrum Communications

We support this objective. We should focus on M-TRP scenarios, and S-TRP scenarios can be supported if the extension is straightforward.

22 – China Mobile Com. Corporation

We support this objective in principle. We also think we should focus on M-TRP, the motivation of indicating multiple DL and UL TCI states for S-TRP is not clear.

23 – Sony Group Corporation

We are supportive to extend Rel.17 unified TCI state framework for multiple TRP in Rel.18.

As for single TRP, RAN1 carried out the normative work on unified TCI for single TRP in Rel.17 and completed it in time. So we would like to call it as 'enhancement' for single TRP, rather than extension to it.

24 – Deutsche Telekom AG

We support this objective

25 – Asia Pacific Telecom co. Ltd

We are supportive of this objective

26 – NEC Corporation

We support Objective #2.

27 – Qualcomm Incorporated

Agree with the objective

28 – LG Uplus

We are positive on continuing Unified TCI state enhancement.

29 – CEWiT

We are supportive of this objective only for m-TRP schemes.

30 – New H3C Technologies Co.

We support this objective only for m-TRP schemes. For S-TRP, the proponent need clarify the motivation on indication of multiple DL and UL TCI states for S-TRP scheme.

31 – CATT

Support objective#2.

32 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

We are supportive of objective 2 and the revision proposed by Samsung (delete of e.g.,).

33 – InterDigital France R&D

We support the scope of this objective.

34 – CableLabs

We are fine with this objective

35 – MediaTek Inc.

We would like to focus Objective 2 on M-TRP.

1.3.3 Objective #3

The current text for objective #3 is as follows.

=== start ===

Study, and if justified, specify larger number of orthogonal DMRS ports for uplink MU-MIMO (without increasing the UL DM-RS overhead)

=== end ===

Feedback Form 5:

1 – HuaWei Technologies Co.

For Objective-3, since DL and UL DMRS are symmetrically designed from Rel-15, it does not make sense to enhance UL DMRS only. To limit the scope for DMRS enhancement, restrictions that strive for common design for DL and UL DMRS could be added to avoid increasing workload. Furthermore, the enhancements are restricted for CP-OFDM only and no more than 24 orthogonal ports to make the scope more clear and further narrow.

For Objective-3,

Study, and if justified, specify larger number of orthogonal DMRS ports for **downlink and** uplink MU-MIMO (without increasing the ~~UL~~ DM-RS overhead)**, only for CP-OFDM**,

- **striving for a common design between DL and UL DMRS**
- **Up to 24 orthogonal DM-RS ports**

2 – Samsung Research America

We **support the proposed revision of objective 3 from Huawei**.

Increasing the number of orthogonal DMRS ports is also beneficial for DL - especially for facilitating DL MU-MIMO. The additional work on including DL is limited as long as common design with UL is a design criterion. Limiting the scope to CP-OFDM is fine (since the need for doubling the number of orthogonal ports for UL is more relevant for CP-OFDM). Doubling the maximum number supported in Rel-15 seems to be a good goal.

3 – ZTE Corporation

Regarding support of more orthogonal DMRS ports (Objective-3), we think that this enhancement can includes both DL and UL MU-MIMO cases, and we can strive to have a common design for both DL and UL. Then, in our initial thoughts, the number of orthogonal DMRS ports can increase to 24 from 12, and some further justification can be left to RAN1 further study. Consequently, we can **support the updated objective-3 from Huawei**.

4 – Nokia Corporation

We have reservations about the revision from Huawei above as it increases the scope of the objective, and it incorporates aspects of objective 4. There has been no clear motivation for more DL DMRS ports except from coherent JT, which is in objective 4. Hence, those aspects need to be considered together with objective 4 when evaluating the amount of TUs required for objective 4. Hence, we do not support the revision from Huawei before there is clarify on objective 4.

We agree with the limitation of the work to CP-OFDM only.

5 – Intel Corporation (UK) Ltd

We agree with the wording proposed by Huawei. As noted in our tdoc RP-212910, it is beneficial to clarify the target number of additional orthogonal DM-RS antenna ports that should be specified and the applicable waveform for the corresponding enhancement. We are OK to also include DL DM-RS enhancements assuming the DM-RS design is the same /similar between DL and UL to reduce work load.

6 – Apple GmbH

For CP-OFDM, the DMRS design is symmetric between PDSCH and PUSCH. If this objective is in the WID, we do not see a need to limit the specification to only enhance DMRS for CP-OFDM PUSCH.

7 – Ericsson LM

We support the proposed revision from Huawei, increased number of DL and UL ports is beneficial for DL and UL MU-MIMO respectively. Having the cap of 24 is reasonable. Restricting to CP-OFDM is fine if scope needs to be limited. We'd like to point out that our understanding is that this is a doubling of the total number of ports without changing the DMRS footprint, and the increased number of ports is addressed as follows:

- Type 1, single symbol extend from 4 to 8 ports
- Type 1, double symbol extend from 8 to 16 ports
- Type 2: single symbol extend from 6 to 12 ports
- Type 2: double symbol, extend from 12 to 24 ports.

8 – SHARP Corporation

We are OK with the proposals from Huawei.

9 – Futurewei

We shared the same view as companies that the DMRS enhancement should include both UL and DL. We support the revision from Huawei to have a clearer scope of the objective.

10 – vivo Communication Technology

Need more discussion on justification for both UL and DL, if it is included then we don't see the reason for restricting to CP-OFDM only. Same view as Ericsson, further clarfication is needed such as up to 24 ports for type2 with 2 symbols. up to 16 ports for type1 with 2 symbols.

11 – KT Corp.

We are supportive with Objective #3 with the limitation of work to CP-OFDM only.

12 – China Telecommunications

We support the updated Objective #3 from Huawei.

It makes sense to enhance both DL and UL DMRS considering the symmetrically design. We think up to 24 orthogonal DMRS ports are reasonable. We agree to limit the work to CP-OFDM only.

13 – Lenovo (Beijing) Ltd

Given the similar structure for PDSCH and PUSCH with CP-OFDM, it is natural to enhance the DM-RS for both UL and DL. We support the revision by Huawei. Our understanding is this enhancement is only for CP-OFDM for the UL.

14 – CAICT

We support the revision from Huawei and to limit the enhancement for CP-OFDM only.

15 – SK Telecom

We support Objective #3. And also we are supportive to add 'downlink' in this objective scope.

16 – NTT DOCOMO INC.

We are fine with objective #3.

17 – Guangdong OPPO Mobile Telecom.

We support that UL transmission is the main scenarios for more orthogonal DMRS ports. Limiting the work to CP-OFDM only is beneficial for the down-scoping. If the DL part is also included, we suggest to enforce a common design between DL and UL DMRS, rather than "striving for a common design ….".

Regarding the maximum number of ports for type 1 and type 2 DMRS, we share the same understanding of Ericsson.

18 – Fraunhofer IIS

We support Objective #3 and to limit to work to CP-OFDM. Specific port numbers for Type-1 and Type-2 DMRS as mentioned by Ericsson need to be clarified.

19 – LG Electronics Inc.

We support the proposal. Further limiting to CP-OFDM seems reasonable.

20 – China Mobile Com. Corporation

We support the revision by Huawei. Limiting the scope to CP-OFDM is reasonable with symmetrically design for UL and DL.

21 – Spreadtrum Communications

We are open to support the objective.

22 – Deutsche Telekom AG

We are supportive of this objective with a balanced scope applicable for UL and DL

23 – China Unicom

We support to specify larger number of orthogonal DMRS ports for both downlink and uplink MU-MIMO, and it is reasonable to have up to 24 orthogonal ports to make the scope more clear. So we support the revision of objective 3 proposed by Huawei.

24 – Qualcomm Incorporated

We suggest that the target multiplexing orders to be spelled out, for example:

- For DM-RS Type 1 (both CP-OFDM and DFT-S-OFDM but excluding Pi/2-BPSK)
- Single symbol: 4 –> 8
- Double symbol: 8 –> 16
- For DM-RS Type 2:
- Single symbol: 6 –> 12
- Double symbol: 12 –> 24

Multiplexing capability of CP-OFDM with DFT-S-OFDM is to be retained.

The scope of enhancements is to be limited to extending the OCC and/or cyclic shift space, and it should exclude adding new root sequences or new tone mapping.

25 – Nokia Corporation

We tend to agree with Qualcomm above. Perhaps one way to address the target multiplexing orders is as follows (taking Huawei's version as baseline)

Study, and if justified, specify larger number of orthogonal DMRS ports for **downlink and** uplink MU-MIMO (without increasing the ~~UL~~ DM-RS overhead)**, only for CP-OFDM**,

· **striving for a common design between DL and UL DMRS**

· **Up to 24 orthogonal DM-RS ports, where for each applicable DMRS type, the maximum number of orthogonal ports is doubled for both single- and double-symbol DMRS**

26 – LG Uplus

We support Samsung's view.

27 – CEWiT

We are supportive of Huawei's proposal. And considering a common design for both DL and UL, the scope of the item will still in place to be accommodated within the TU budget.

28 – New H3C Technologies Co.

We support Huawei's modification on this objective for CP-OFDM.

29 – CATT

Clarification on the application scenario of this enhancement and the relationship of this objective and C-JT is needed. If objective 3 is included in Rel-18 MIMO enhancement, the maximum number of orthogonal DMRS ports shall be the outcome of the study.

30 – Beijing Xiaomi Mobile Software

We support to include both DL and UL, and prefer a common design between DL and UL DMRS with a clarification on the number of orthogonal DMRS ports.

31 – VODAFONE Group Plc

We support the proposals from Huawei.

32 – InterDigital France R&D

We support the scope of this objective. Also, we agree with suggested clarifications by Qualcomm.

1.3.4 Objective #4

It is emphasized by RAN chair that for objectives #1 and #4, it is critical to have a clear and a *very* limited scope for them to be possibly considered; otherwise, both will be dropped. So, companies are encouraged to provide constructive feedbacks to define a clear and a very limited scope. The current status of text for objective #4 is as follows, which is highlighted by yellow color in the word document in inbox.

=== start ===

~~Study, and if justified, specify enhancements of CSI acquisition (further clarification on the limited scope) for Coherent-JT for both FDD and TDD targeting FR1~~

=== end ===

Feedback Form 6:

1 – HuaWei Technologies Co.

As we mentioned, both Objective-1 and Objective-4 should be included in the scope, which is the most important parts in Rel-18. We have shown the potential benefits in Tdocs, where Coherent JT provides significant benefits for both cell average and cell edge. To address the concern for scope of the objectives, we propose the following restrictions. The scope of Objective-4 is restricted as Type-II codebook refinement for FDD, and SRS for interference reduction for TDD with multiple further restrictions (such as the same comb structure, same root sequence, and no additional resources, etc) to keep the scope narrow. Furthermore, the number of TRPs for the Coherent JT is limited as up to 4, and max number of CSI-RS ports per resource is also limited as the same as before, which are used to further limit the scope for Coherent-JT in Rel-18.

For Objective-4,

Study, and if justified, specify enhancements of CSI acquisition ~~(further clarification on the limited scope)~~ for Coherent-JT ~~for both FDD and TDD~~ targeting FR1 **and up to 4 TRPs**, as follows:

· **Rel-16/17 Type-II codebook refinement for CJT mTRP targeting FDD**

· **SRS enhancement to reduce inter-TRP interference targeting TDD CJT via SRS capacity enhancement and/or interference randomization, with the constraints that 1) without consuming additional resources for SRS; 2) reuse existing SRS comb structure; 3) without new SRS root sequences**

· **Note: the maximum number of CSI-RS ports per resource remains the same as in Rel-17, i.e. 32**

2 – Samsung Research America

Re obj 1 and 4, as already mentioned, we share Huawei's assessment on the utility of both, especially (from Samsung's perspective) objective 4. We have demonstrated in our previous Tdoc RP-211793 that even some simple refinement on Type-2 codebook targeting coherent JT can bring up to 20-40% user throughput gain.

Re the scope of objective 4, since a limited and clear scope is the goal,

- It is important to enhance features instrumental to both FDD and TDD CSI acquisition,
- The scope can be constrained to *refinements* of some existing features.

The proposed rewording by Huawei is quite clear and very narrow. Therefore we **support the rewording of objective 4 from Huawei**.

3 – ZTE Corporation

For preventing Objective #4 from becoming too large, we also need to sharp up the objective well. In our views, we need to consider enhancements on Rel-16/17 Type-II codebook refinement for facilitating Coherent-JT for both FDD and TDD targeting FR1. Then, it should be further noticed that there may be some further enhancements for SRS capability and interference randomization proposed by some proponent companies, especially for TDD case. From our perspective, we are open to further consider it if the related objective is clear and limited. The update from Huawei looks good, and for progress we can **support the updated revision of objective-4 from Huawei**.

4 – Nokia Corporation

Huawei's formulation helps clarifying the work required for this objective, and at the same time it makes it clear that the minimum workload required for such objective is quite high, and it could be considered as a separate SID on its own merit:

- Codebook refinements for FDD, which are in practice new codebook developments, even if taking existing ones as baseline. These need to be scalable to consider up to 4 TRPs with different deployment configurations. Extensive performance evaluations are needed to evaluate potential gains (which are not necessarily dramatic given the LTE experience).

- CSI feedback enhancements are missing, or are the proponents assuming the current CSI framework is enough to handle the extra overhead from reporting channels from up to 4 TRPs simultaneously?

- SRS enhancement objective tries to constrain the possible solution space, which sounds excessive in a study phase.

- Extension on number of DL DM-RS ports is currently missing from the list of objectives, unless one considers the revision from Huawei in objective 3 (see our comments there, as those revisions are actually targeting objective 4). It seems there are two distinctive enhancements proposed, one for FDD, based on Type II reporting and one for TDD based on full channel reciprocity and SRS-based DL channel estimation. If so, it's useful to clarify that in the SRS enhancement full channel reciprocity is assumed.

- In the SRS-based enhancement it is not clear what is intended by “SRS capacity enhancement” and “interference randomization”. Some clarification is needed here.

Hence, in our view the amount of work required here leads to excessive workload considering the number of TUs proposed by the Chair and the other objectives in this WID. If companies insist on keeping this objective than we need to consider either increasing number of TUs for MIMO or downscoping other objectives that have received even more support than this one originally.

5 – Intel Corporation (UK) Ltd

We agree with objective #4 for Rel-18 NR and share similar views with comments above that the scope of the objective should be clear and focused. From this perspective, we support intention from Huawei and proposed wording that explains in more details the required enhancements. On top of that we propose to reflect in justification part of WID the target deployment scenarios. We prefer to consider TRP deployments with small ISD, e.g. indoor or small cells.

6 – Ericsson LM

The update from Huawei further narrows the scope of Objective 4, and we think this is a reasonable compromise to move forward on ‘1+4’. Hence, **we support the revised version from Huawei**.

7 – Futurewei

We shared the same view as companies that Objective #4 is important for Rel-18 while a clear scope is necessary to reduce the related workload and we are supportive of the revised objective from Huawei. We have one question for clarification: Regarding the text “SRS enhancement to reduce inter-TRP interference targeting TDD CJT”, does “inter-TRP interference” refer to “UL SRS inter-TRP interference” or refer to both “UL SRS inter-TRP interference” and “DL inter-TRP interference”? We prefer to include both perspectives.

8 – Verizon UK Ltd

We prefer to keep the objective - and make the scope clear and reasonable. We support Huawei’s proposal and like the fact that it is even more tangable than #1 for certain scenarios - though we are in general supportive of #1 too.

9 – KT Corp.

We would like to keep the Objective as revised from Huawei.

10 – China Telecommunications

We support the updated Objective #4 from Huawei. We think the scope is now more narrowed and the objective is clearer.

11 – Spark NZ Ltd

We can support the proposed rewording from Huawei for Objective #4.

12 – CAICT

We support the revises Objective#4 from Huawei.

13 – NTT DOCOMO INC.

We are fine with removing objective#4.

14 – AT&T

CJT mTRP enhancements are important to improve user throughput especially for low FR1 FDD deployments, where massive MIMO deployments are limited by the form factor. We support specifying CSI acquisition enhancements for CJT mTRP targeting FR1 bands in Rel. 18.

As there are concerns on the scope of this objective, we are fine with the direction of the Huawei proposal to narrow the scope of enhancements to a limited number of TRPs and enhancements related to type II codebook refinements.

15 – Guangdong OPPO Mobile Telecom.

We are supportive of the enhancement for coherent-JT as there are a number of operators are in favor of this deployment. The objective should be clear and focused to keep a manageable scope.

There are quite divergence views on the detailed objective during previous discussions. The new proposal from Huawei is quite clear and limited. In our view, this proposal is a good balance between the workload and useful functionalities. Thus, we support it.

16 – SK Telecom

We think that Objective #4 which is reworded by Huawei seems quite clear and obvious. And we also agree that enhancements of CSI acquisition for Coherent-JT in both FDD and TDD is necessary. We support the modified Objective #4 from Huawei.

17 – LG Electronics Inc.

If the work scope is clearly defined, we are open for supporting CJT in Rel-18. It is important to us that the overall work scope for DL (obj#1+obj#2+obj#4) should be tightened in order to put more effort on UL in Rel-18.

18 – NTT DOCOMO INC.

(Please ignore our previous comment for Objective#4)

We realized the scope of modified Objective#4 from Huawei becomes small. Hence, we can support the modified Objective#4 from Huawei.

19 – Sony Group Corporation

As we mentioned for Objective 1, the CSI enhancement for CJT satisfies the requirement from real-life deployment. And we are in principle fine with direction in Huawei's rewording (thanks for drafting it). At current stage, we do have two minor comments in mind.

1. Regarding up to 4 TRPs, perhaps the maximum number of TRPs can be determined during WI phase in RAN1 and it seems too early to put the cap before Rel.18 starts

2. With respect to SRS enhancement, we understand that it applies to the case with channel reciprocity in TDD system. But by now we are not quite confident on how SRS (to be enhanced) could reduce the inter-TRP interference, e.g. interference randomization, and our guess would be SRS sequence re-design, etc. Perhaps in the WID, we don't need to catch this level of details. Moreover, there is also Objective 6 which seems handle the SRS enhancement as well. In line with narrowing things down, we slightly prefer to merge both SRS enhancements into single objective.

20 – China Mobile Com. Corporation

C-JT is a promising technique to improve cell edge and cell average preformance for both ourdoor and indoor scenario in FR1. To For Huawei's revision of objective #4, SRS enhancement tries to reuse the existing design as much as possible. We think the scope is reasonable and controllable. Hence, we support the revised version from Huawei.

21 – Spreadtrum Communications

We support to study cohenrent-JT and identify the perfoamnce gain and potential enhancements. Huawei's revision is acceptable to us.

22 – vivo Communication Technology

With revision proposed by Huawei, the scope of this objective is clearer, which is fine. The number of TRPs which is proposed as up to 4 seems reasonable however it should be further clarified whether the number of antennas (CSI-RS ports) are same for different TRPs,

SRS enhancement (interference randomization) should be further clarified if included in the objective.

23 – TELECOM ITALIA S.p.A.

See general comment. We should focus on UL in this project. Moreover, most of the already specified DL enhancements are not commercially deployed, and we must avoid over-engineering exercises.

If (big if) we can have objective 1 or objective 4 in scope, we prefer to keep objective 1 and discard objective 4

24 – China Unicom

We support to include objective 4 in the WID. Coherent JT provides significant benefits for both cell average and cell edge user data rates. We are fine with Huawei's proposed changes on the objective which is very clear and concise.

25 – Deutsche Telekom AG

We propose to remove the entire objective as coherent JT is complex and the claimed benefits are doubtful or can not be realised in commercial deployments. Also under consideration of the workload we need to remove objectives ...

26 – NEC Corporation

Firstly, we can live with this objective removed from Rel-18.

Secondly, even with Huawei's revision, we don't see any possibility to have a **very** limited scope if CJT is going to be supported.

27 – Qualcomm Incorporated

If this objective is to be kept, much clearer definition of the targeted enhancements needs to be included.

28 – Nokia Corporation

Just to elaborate further on our previous comment and facilitated further discussions, perhaps the aspects we raised on CSI reporting and the clarification on SRS interference handling could be captured as follows (using Huawei's version as baseline):

Study, and if justified, specify enhancements of CSI acquisition ~~(further clarification on the limited scope)~~ for Coherent-JT ~~for both FDD and TDD~~ targeting FR1 **and up to 4 TRPs**, as follows:

· **Rel-16/17 Type-II codebook refinement for CJT mTRP targeting FDD and its associated CSI reporting, taking into account throughput-overhead trade-off**

· **SRS enhancement to manage ~~reduce~~ inter-TRP cross-SRS interference targeting TDD CJT via SRS capacity enhancement and/or interference randomization, with the constraints that 1) without consuming additional resources for SRS; 2) reuse existing SRS comb structure; 3) without new SRS root sequences**

· **Note: the maximum number of CSI-RS ports per resource remains the same as in Rel-17, i.e. 32**

In any case we would like to repeat our previous statement that we see such objective as very large for addition in this WID given the current amount of TUs available.

29 – LG Uplus

We support Huawei's revision. Regarding DL MIMO enhancement, C-JT mTRP is essential and should be prioritized. It is most beneficial feature for cumstomers. Complexity and work load depends on the scope. Huawei's downscoping is reasonable.

30 – CEWiT

We are supportive of the objective and believe CJT based MTRP transmission will be beneficial for the network. We are fine with Huawei's proposal except for the 4TRPs part. As mentioned by Sony, we can conclude on the reasonable number of TRPs during the WI phase in RAN1.

31 – Samsung Research America

Re the comment from Qualcomm on "much clearer definition of the targeted enhancements", we assume you referred to the high-level description of this objective from the Chairman's version. Please check the text proposed by Huawei and further refined by Nokia - which should include a much clearer definition of the targeted enhancements.

32 – Orange

We support the need to specify enhancements for Coherant JT. Such feature will become more an more intersting with the deployment of centralised archictecture, allowing "ideal backhaul" between gNBs.

33 – New H3C Technologies Co.

We support this objective with Huawei's modification.

34 – CATT

We are supportive of objective 4. Regarding the version provided by Huawei, we have the following comments:

- The number of TRPs shall be studied in the study. We'd better not restrict the number to up to 4 TRPs at this stage

- The sub-bullet for SRS enhancement is not clear. Several solutions for SRS capacity enhancement have been specified in Rel-17. The motivation of further enhancement for SRS capacity in Rel-18 is not clear. What is the enhancement is not clear either. Rel-15/16/17 SRS design offers enough flexibility for interference randomization. The sub-bullet for SRS enhancement shall be removed to make the scope clearer and more focused.

35 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

Objective 4 is low priority. We agree with Nokia on the amount of work required is quite large. If TU permits, we can have a SI on Coherent-JT to investigate the gain over NCJT with realistic synchronization assumptions b/w non-collocated TRPs. The performance of Rel-16 NCJT and Rel-15 multi-panel codebook is the baseline, whether WI is needed can be dependent on the identified performance gain over Rel-15/16 schemes.

36 – HuaWei Technologies Co.

Some replies for the comments: We show the benefits in our Tdocs for RAN meeting multiple times, and we believe Coherent-JT is beneficial in practical scenarios in commercial deployment. It could be widely used for indoor distributed RRH deployment, inter/intra site macro deployment, etc. The proposed version from us or Nokia is very specific and very limited scope already to address the concern of scope.

Then, for TDD Coherent JT, the interference for SRS transmission is an issue, since the SRS transmitted by remote UE may be interfered by near by UE for a TRP reception. So, SRS enhancement to address the interference issue is very important for TDD Coherent JT. Through SRS capacity enhancement and/or interference randomization is the potential two directions for study. Rel-17 SRS capacity enhancement is discussed in single TRP scenario, and the solution of partial sounding may be with limited use cases (such as small bandwidth). To make it more clear, we are fine with Nokia's further revised wording on SRS part.

Then, for the discussion of number of TRPs, actually we are flexible for it in the scope. But, the restriction with max number is 4 TRPs is helpful to narrow down the scope.

37 – InterDigital France R&D

Further clarifications on the scope is needed. Companies seem to envision very different target deployment scenarios for this enhancement; Indoor (small ISD) vs. Inter-site (1700 m). This enhancement requires a very clear synchronization requirement that has not been discussed. There is no point for this work, if target scenarios cannot comply with the expected synchronicity and ideal back requirements. Such requirements need to be spelled out in the WID.

38 – MediaTek Inc.

Similarly to some others, we don't see a high priority for this work as we have not been convinced that it will be widely deployed in the near future. However, operators seem to be indicating that they think otherwise. So we acknowledge the work from Huawei to clarify the scope, and could accept that version or the Nokia update. We believe that we should "consider no more than 4 TRPs", so would not like to leave it up to the working groups to discuss if that means going beyond 4. Which number to select between 2 or 4 could be studied though.

39 – HuaWei Technologies Co.

To reply comment from IDC, applicable for some use cases does not means the feature itself will be much difference. The different ISD could be included the simulation assumptions in the study. Actually, in each feature discussion, we have many different simulation assumptions, such as different scenarios with UMa, UMi, Dense Urban, FR1, FR2, etc and also include different ISDs.

Look at HST in Rel-17, it is a simple feature, right? But we still discussed different ISDs for FR1 and FR2. Only for FR2, you can find at least 3 different ISDs from 200 to 700m and also with different min-distance between UE to BSs from 5 to 150m in the assumptions. But, as you see, we did not discuss and restrict use cases in the WID for HST.

40 – Continental Automotive GmbH

As mentioned under objective 1 we do not see the need for objective 4 in Rel. 18.

1.3.5 Void

1.3.6 Objective #6

The current text for objective #6 is as follows.

=== start ===

Study, and if justified, specify UL DMRS, SRS to enable 6 and 8 Tx UL operation to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

=== end ===

Feedback Form 7:

1 – ZTE Corporation

Firstly, we identify the clear motivation and benefits for enabling > 4 layer UL transmission (with >4 Tx), e.g., up to 8 layer for SU-MIMO and UE-aggregation. So we support the direction of this objective as proposed by the moderator. Then, with the increase of number of UL layers and UL TXs, >1 CWs using individual MCS, RV and NDI become much essential for uplink transmission, as what we have for NR DL transmission. The condition of enabling >1 CWs for UL transmission (e.g., while number of TX(s) and UL layers exceeds a threshold) can be further studied in RAN1. After that, straightforwardly, it applies to both codebook and non-codebook PUSCH transmission, and therefore, besides for DMRS and SRS related enhancement, TPMI and SRI refinement should be considered accordingly.

For Objective #6

Study, and if justified, specify UL DMRS, SRS**, codeword mapping, TPMI and SRI enhancements** to enable 6 and 8 Tx UL operation to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

2 – Samsung Research America

In general we are supportive of objective 6.

Regarding the revision proposed by ZTE:

- We agree that TPMI and SRI need to be added for CB-based and NCB-based transmissions, respectively. In particular, the TPMI enhancement includes codebooks for 6Tx and 8Tx (currently not supported)
- The current spec has included the UL codeword mapping for 1 to 4 layers per UE. Since codeword mapping doesn't depend on the number of (SRS) ports (number of 'Tx'), codeword mapping enhancement is needed only for the support of >4 layers per UE

Therefore the following revision of objective 6 can be considered:

Study, and if justified, specify ~~UL DMRS, SRS~~ **the following enhancements** to enable 6 and 8 Tx UL operation to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

- **UL DMRS and SRS**
- **TPMI (including codebooks) and SRI for 6Tx and 8Tx UL operation**
- **Codeword mapping for more than 4 layers per UE**

3 – Nokia Corporation

We support this objective as it is aligned with the overall direction of improving UL performance. We are OK with the revisions from ZTE in principle.

4 – Intel Corporation (UK) Ltd

We support objective #6 as part of Rel-18 NR. However considering high work load we suggest to focus the work on more essential aspects in this release. In particular we are OK to support SRS with 6Tx and 8Tx. However, we don't see strong motivation for more than 4 layers given that the performance requirements for DL 8 MIMO layers is not defined in RAN4. Moreover for CB precoding, we think that UE with non-coherent capability should be prioritized given that most of current UE implementation are non-coherent. The other codebook for UE with coherent capabilities can be defined in the future NR releases. Proposed modifications on top of Samsung's revision are provided below.

Study, and if justified, specify ~~UL DMRS, SRS~~ **the following enhancements** to enable 6 and 8 Tx UL operation to support up to ~~more than~~ 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

- **UL DMRS and SRS**
- **TPMI (including codebooks) and SRI for 6Tx and 8Tx UL operation**
  - **UE with non-coherent capability should be prioritized**
- ~~**Codeword mapping for more than 4 layers per UE**~~

5 – Ericsson LM

The scope seems very large for this item, we'd like to ask for some clarifications to focus the work. Since a UE with so many TX antennas can come in many different form factors, and since it is important to avoid fragmenting the market for this broad class of devices, we suggest to start with the non-codebook based approach as this is agnostic to such implementation aspects. Also, to reuse the CW2L mapping from DL will focus the work.

If a codebook based solution is considered, then the WID needs to be more specific on the assumed UE implementation, is this a fully, partial or non-coherent device? If a fully or partially coherent device is in scope, then RAN1 needs to know the antenna type, directionality, and placement to be able to design a codebook for such fully or partially coherent transmission over 6 and 8 TX.

So the proponents needs to provide some more guidance in the objective, for this work to be manageable.

6 – HuaWei Technologies Co.

Generally, we do not discuss much on UE antennas implementation in the scope, may be only a little in the simulation assumptions. We could be fine for Samsung's proposed version.

7 – SHARP Corporation

We are fine in principle. We support the proposal from Samsung.

8 – MediaTek Inc.

We would like to support the Intel proposed scope refinement. We also do not see the motivation to go higher than 4 layers for this work. Intel proposal copied below:

Study, and if justified, specify ~~**UL DMRS, SRS**~~ **the following enhancements** to enable 6 and 8 Tx UL operation to support up to ~~**more than**~~ 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

- **UL DMRS and SRS**
- **TPMI (including codebooks) and SRI for 6Tx and 8Tx UL operation**
  - **UE with non-coherent capability should be prioritized**
- ~~**Codeword mapping for more than 4 layers per UE**~~

9 – Futurewei

The scope of this objective is too big and need some downscoping. It is unclear to us the need of 6TX UL operation which requires a new codebook design that is time consuming. We suggest removing 6TX from the objective.

10 – Verizon UK Ltd

We are supportive of the objective. We are mostly interested in 4 layers, though we have no objection to having more layers.

11 – vivo Communication Technology

The amount of work could be very big with current wording, agree with further narrowing down the scope in line with Intel's revision. Since this type of device is very specific with flexibility in form factor, it is preferred to capture the antenna structure assumptions in order to avoid lenghty discussion in RAN1 on evaluation assumptions. For codebook based enhancement, non-coherent/partial-coherent antennas can be considered. It is fine to limit the number of layers to 4.

12 – Lenovo (Beijing) Ltd

To support 6Tx and 8Tx UL transmission, it is necessary to enhance UL DMRS, SRS, TPMI and SRI. It is also necessary to consider 2 CW when the number of layers is more than four. Therefore we support Samsung's revision. On top that. it is necessary to clarify whether layers 1-4 is allowed for 6Tx and 8Tx UE. In our opinion such low rank transmission can be supported either with UE implementation/antenna virtualization, or explicit support can be specified. It is better to clarify it here.

13 – NTT DOCOMO INC.

- We support objective #6.
- We agree with ZTE that codeword mapping, TPMI and SRI enhancements should be considered in this scope.
- Regarding to the gain of more than 4 layers, we observed the performance gain in Indoor/dense urban in our system level simulation result (p.4 of RWS-210268).

- Regarding to Intel's suggestion to limit to 4 layers, if we limit the scope to 4 layers, we think the benefit to support 6/8 Tx is too small.
- Regarding to Intel's comment of "non-coherent", we think the reason why "non-coherent" is typical assumption is that only 2Tx UEs exist in the current commercial network. In future, when 4/6/8 Tx UE will be available, we assume partial coherent or full coherent UE will appear.

14 – SoftBank Corp.

Even though the proposal by Samsung is our first priority, we also understand the scope is too big. The proposal by Intel is reasonable in Rel-17 and also acceptable.

15 – AT&T

We support objective #6 on UL enhancements targeting CPE/FWA/vehicular/industrial devices. We are fine with the proposed refinement of scope by ZTE

16 – Guangdong OPPO Mobile Telecom.

We are supportive of Objective#6. Either ZTE's version and Samsung's version is fine with us.

Regarding 6Tx/8Tx, we think 8 ports is more common in UEs, should have higher priority than 6 ports. Thus, we are also ok to remove 6Tx

17 – Fraunhofer IIS

We are fine with Objective #6 and support Intel's revision.

18 – LG Electronics Inc.

We support this objective in general, and we are open for further refining the scope suggested by ZTE, Samsung, and Intel(limiting to up to rank 4).

19 – Spreadtrum Communications

We are fine with ZTE's revision. The objective should focus on more than 4 layers, and enhancement on codeword mapping as well as precoding information is necessary when the number of layers >4.

20 – China Mobile Com. Corporation

For 6 and 8 UL TX operation, we support to enable >4 layer transmission. Otherwise, we do not think much gain can be achieved. The enhancement should be applied to both codebook and non-codebook PUSCH transmission. And enhancement for UL CW mapping is preferred. Hence, we support the updated version from ZTE.

21 – Sony Group Corporation

We support the UL enhancement. The revision from Samsung looks good us.

Particularly, when >4 UL layers per UE, there is a chance to re-design the CW-to-layer mapping rule.

22 – TELECOM ITALIA S.p.A.

We support this objective.

Moreover we share the following point raised by DOCOMO:

- *Regarding to Intel's suggestion to limit to 4 layers, if we limit the scope to 4 layers, we think the benefit to support 6/8 Tx is too small.*

We also share the point raised by Ericsson (**we cannot assume the antenna design**):

Since a UE with so many TX antennas can come in many different form factors, and since it is important to avoid fragmenting the market for this broad class of devices, we suggest to start with the non-codebook based approach as this is agnostic to such implementation aspects.

23 – Xiaomi Communications

We support this objective#6 in general. Either the proposal from Samsung or ZTE is fine to us.

24 – China Unicom

We support to have 2 CW for more than 4-layer UL transmissions. And we support the proposed changes by ZTE to include codeword mapping, TPMI and SRI enhancements in the objective. For next round discussion, we propose to take ZTE's revision as baseline for refining the wording.

25 – Deutsche Telekom AG

We support the objective but down-scoping / focus is needed.

26 – Qualcomm Incorporated

As commented previously, support of 6 and 8 Tx does not necessarily mean Rank=6 or Rank=8 support. As a matter of fact, we propose limiting the work to Rank 4 only and remove any changes to CW-to-layer mapping. Even if Rank>4 is to be added, the capability of 6 and 8 Tx with max Rank=4 needs to be included.

27 – Asia Pacific Telecom co. Ltd

We support this objective in general. Samsung's revision is clearer to us.

28 – LG Uplus

This is deprioritized.

29 – CEWiT

We are supportive of Samsung's proposal. We also believe restricting to 4 layers for a 6Tx or 8Tx UE is unreasonable and loses a lot of gain. Also for CW mapping we support 2CW only for >4 layers.

30 – KDDI Corporation

We are fine in this objective #6 and support the proposal from Samsung.
Also, we think that if the maximum number of UL layers is limit to 4 layers, the performance gain of UL will not be sufficient in >4 Tx operation.

31 – Samsung Research America

Re Nokia's latest revision, we agree that the clarification on unified TCI extension seems valid and helpful. Meanwhile the content is identical to ZTE's proposed revision.

Re proposals to expand the scope of objective 7, we would like to remind companies that it took two releases and tremendous amount of resource and effort in RAN1 to agree on small amount of spec support for panel

selection. Therefore, we are concerned with such proposals. STxMP is more complex than panel selection. Even with the scope implied in ZTE revision, we expect it would be very challenging to converge on this objective in RAN1. Hence further expanding the scope is simply infeasible.

32 – Samsung Research America

Please ignore the above comment (intended for objective 7)

33 – CATT

We think more than 4 UL layers is important to reap the benefit of 6Tx/8Tx. In order to support 6Tx/8Tx, codebook designs for no more than 4 layers and more than 4 layers are needed for codebook based PUSCH transmission. Since the target UEs including various types of UEs in various scenarios, it is not reasonable to exclude partial-coherent/fully-coherent UEs at this stage.

In summary, we support the updated version provided by ZTE with codebook included in the scope. Our proposed modifications on top of ZTE's revision are provided below:

Study, and if justified, specify UL DMRS, SRS**, codeword mapping, TPMI(including codebooks) and SRI enhancements** to enable 6 and 8 Tx UL operation to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

34 – VODAFONE Group Plc

As mentioned by others, we support this objective as it is aligned with the overall direction of improving UL performance. The proposed modification from Samsung seems reasonable, also encompassing ZTE's and CATT's views.

35 – InterDigital France R&D

We generally support the scope of this objective, however some additional clarifications may be needed.

We suggest to limit the scope to CP-OFDM, also agree with Ericsson's comment to reuse DL CW2L mapping.

We have a question for companies (@Qualcomm, @Intel, …) who do not support >4 layers operation. We would like to know whether their intention is to use UE-based antenna selection, or to employ an implementation-based 4 to 6/8 antenna mapping.

36 – CableLabs

We are okay in principle.

1.3.7 Objective #7

The current text for objective #7 is as follows.

=== start ===

Study, and if needed, specify features to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability

=== end ===

Feedback Form 8:

1 – ZTE Corporation

Generally speaking, we think that some restriction may be needed for limiting the scope of simultaneous multi-panel UL transmission (Objective-7).

- In our views, we think that the total number of layers is up to four and total number of codewords is up to two, for a given PUSCH transmission across different panels. Regarding UL precoding indication for PUSCH, no new codebook is introduced for multi-panel simultaneous transmission.
- Then, in general, there are two candidate move-forward mTRP transmission schemes, i.e., single-DCI based and multi-DCI based, both of which should be considered herein. Furthermore, unified TCI state structure can be considered for UL beam indication, and meanwhile, for multi-DCI based approach, only one physical channel/signal type is transmitted across different panels (for instance, in such case, we can consider PUSCH+PUSCH, rather than PUSCH+SRS).

For Objective #7

Study, and if needed, specify ~~features~~ **the following items** to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability**, targeting FR2 and multi-TRP**

- **UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission**

o **The total number of layers is up to four and total number of codewords is up to two, considering single DCI and multi-DCI based multi-TRP operation.**

- **UL beam indication for PUCCH/PUSCH, where unified TCI state structure is reused, considering single DCI and multi-DCI based multi-TRP operation**

o **For the case of multi-DCI based multi-TRP operation, only one physical channel/signal type is transmitted across different panels.**

2 – Samsung Research America

As commented before, the initial version from the moderator is ambiguous in terms of scope and can lead to much confusion.

The revised version from ZTE is more definite and much clearer in terms of scope. especially by spelling out the two main components: UL precoding and beam indication - and each of the components is also clearly explained.

In particular, focusing on unified TCI and one channel/signal type across different panels is important in our view - the case with different channel/signal types across different panels can be worked out in later releases.

Therefore we **support the revised wording of objective 7 from ZTE**.

3 – HuaWei Technologies Co.

Similar view with ZTE and Samsung, we concerned the original scope of Objective-7 is unclear and too broad, which is required to be clarified. For ZTE's revision, list the main parts of the enhancements for simultaneous UL multi-panel transmissions with UL precoding indication and UL beam indication, where restrictions for each item are included, e.g., no new codebook design, restrictions on number of layers/CW, and restriction with same type of channels/signals for simultaneous panels transmission. This version is acceptable for us.

So, we are supportive on ZTE's version of Objective-7.

4 – Nokia Corporation

We support this objective in general. The revisions from ZTE are good in the sense that they further clarify the work ahead. However some revisions are needed, as unified TCI done in Rel-17 is not available for mTRP scenarios. Hence, it should be clarified if the work for mTRP is supposed to be based on the outcome of Objective 2, or if it is supposed to be based on the existing mTRP TCI framework. If the latter, then a small revision is needed to decouple single- and multi-TRP cases. From our point of view it would be cleaner to separate single- and multi-TRP in the objective in any case, e.g.:

Study, and if needed, specify the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, targeting FR2 and multi-TRP

· *Multiple-panel simultaneous transmission modes for transmitting same physical channel (PUCCH & PUSCH) with the same content, for reliability and robustness, considering for single-DCI based multi-TRP operation,*

· *UL precoding indication for PUSCH where no new codebook is introduced for multiple-panel simultaneous transmission*

· *The total number of layers is up to four and total number of codewords is up to two.*

· *UL beam indication for PUCCH/PUSCH ~~where the unified TCI state structure is reused,~~ , ~~considering single UL-related DCI or two UL-related DCIs~~*

· ~~*For the case of two UL-related DCIs, only one physical channel/signal type is transmitted across different panels;*~~

· *Support multi-panel simultaneous transmission for transmitting same or different physical channel/signal for multi-DCI based multi-TRP operation.*

5 – Apple GmbH

We are not supportive of simultaneous multi-panel UL transmission. Again, the main goal of this objective is for FR2 in which case we do not think simultaneous multi-panel UL transmission is a commercially useful feature due to UE power consumption and thermal concern.

6 – Intel Corporation (UK) Ltd

We support objective #7 for Rel-18 NR. We also support revision proposed by ZTE to make the scope clear wrt to beam indication framework that should be considered for enhancements as also noted in our tdoc RP-212910. We think it is also beneficial to list the required enhancements as proposed by ZTE. Some editorial modification, however, may be needed to clarify some terminology, e.g. "...two UL-related DCIs..."

7 – Ericsson LM

The scope of the initial moderator version is very large, and may lead to a completely new scheduling paradigm, where the NW performs individual scheduling of the transmissions over the UE panels.

The modification proposed by ZTE provides some narrowing of the scope for important aspects: we maintain the UL precoding paradigm, we use the unified TCI framework, and we do not allow that different channels are transmitted on different panels.

Hence, we support the revision proposed by ZTE.

8 – SHARP Corporation

We support this objective.

9 – Fraunhofer IIS

We support to study simultaneous multi-panel UL transmission for single- and multi-DCI m-TRP operation at FR2. As mentioned by Nokia, it should be clarified if UL beam indication is based on the unified TCI-framework of Objective 2.

10 – Futurewei

We share the same view as companies that the original version of the objective is too broad and ambiguous and the scope needs to be narrowed. We are in general ok with the direction of ZTE's revision. Regarding UL beam indication, our view is that it should be based on a single framework, which is the Rel-17 unified TCI framework with extension from Objective 2.

11 – Verizon UK Ltd

Supportive and agree with ZTE's proposal.

12 – KT Corp.

Supportive and agree with ZTE's proposal.

13 – Lenovo (Beijing) Ltd

We share the same view with ZTE and Samsung. ZTE's revision provides a clear scenario and scope for this enhancement. It is important to build this on top of the unified TCI framework. The only question we have on ZTE's revision is the last bullet: "**For the case of multi-DCI based multi-TRP operation, only one physical channel/signal type is transmitted across different panels.**" We think it is too broad and shall be narrowed down. We see no problem if different channel or signal types are scheduled by multi-DCIs to be transmitted in different panels in different CCs. So the last bullet shall be changed to: "**For the case of multi-DCI based multi-TRP operation, only one physical channel/signal type is transmitted across different panels in the same CC".**

14 – NTT DOCOMO INC.

Support.

15 – AT&T

We are supportive of specifying features to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability. To make the objective clearer and to better define the scope of this objective, we are fine with the direction of the proposal by ZTE.

16 – Guangdong OPPO Mobile Telecom.

We support this objective. For the UL beam management, we prefer to only use one signaling framework (e.g., either R15/16 signaling or R17 unified TCI signaling, but not both).

We are generally fine with ZTE's proposal that has a focused and clear scope.

17 – LG Electronics Inc.

We support this objective. Re ZTE's version, we have several comments/concerns.

- **'Targeting FR2'**: STxMP is indeed a useful feature for vehicle UEs for improving reliability/throughput. Currently, vehicle communication is mainly on FR1 so we prefer to delete this part.
- **'no new codebook'**: For reliability improvement with STxMP, multiple panels can transmit same layer(s), e.g. rank 1 transmission with multiple panels. We are not sure current UL codebook can support this mode of operation well, e.g. considering unequal number of ports across panels. Thus, we prefer to remove this restriction which can better be decided during the study.
- **'unified TCI structure'**: We sympathize the issue raised by Nokia that adding this condition will create inter-dependency between obj#2 and obj#7. For safety, we suggest to remove this condition so that whether to use Rel-17 unified TCI or Rel-15/16 signaling can be decided during the study.
- Other restrictions are fine to us.

Thus, we can be ok with the following version:

For Objective #7

Study, and if needed, specify ~~features~~ **the following items** to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability**, targeting** ~~**FR2 and**~~ **multi-TRP**

- UL precoding indication for PUSCH~~**, where no new codebook is introduced for multi-panel simultaneous transmission**~~

o **The total number of layers is up to four and total number of codewords is up to two, considering single DCI and multi-DCI based multi-TRP operation.**

- UL beam indication for PUCCH/PUSCH~~**, where unified TCI state structure is reused**~~**, considering single DCI and multi-DCI based multi-TRP operation**

o **For the case of multi-DCI based multi-TRP operation, only one physical channel/signal type is transmitted across different panels.**

18 – Sony Group Corporation

We are supportive to simultanesou multi-panel UL transmission.

With ZTE's rewording, we think it gets more clear on what we are going to do in Rel.18. One minor comment on new UL codebook is that it seems too early to put such constraint. For instance, if inter-panel coherent transmission can be applied, there could be need for UE to precode with newly design UL codebook. Note that current UL codebook assumes single panel UL transmission.

19 – TELECOM ITALIA S.p.A.

We are supportive of the objective and we think the proposals from ZTE and others are going in the correct direction.

However **we do not agree to focus the work on FR2 only**.

For non-smartphone type of devices (expecially industrial devices) the some limitations (power, size) do not apply. Therefore we should remove the limitation to FR2 in the final text for the objective.

20 – Deutsche Telekom AG

We think this objective can be removed. If not, a focus on FR2 only is not acceptable for us.

21 – NEC Corporation

We support Objective #7 and ZTE's revision.

22 – Asia Pacific Telecom co. Ltd

We generally support ZTE's revision, which provides a clearer direction.

23 – Qualcomm Incorporated

Both multi-DCI and single-DCI based frameworks should be considered. Simultaneous transmission of different channel types, e.g. PUSCH and PUCCH on different panels should be supported both on different CCs and on the same CC.

24 – Xiaomi Communications

We support Objective#7. Same view with LGE to remove "this unified TCI structure" that whether to use Rel-17 unified TCI or Rel-15/16 signaling can be decided during the study, so we are fine with ZTE's revision with the following modification,

- **UL beam indication for PUCCH/PUSCH~~, where unified TCI state structure is reused~~, considering single DCI and multi-DCI based multi-TRP operation**

25 – Nokia Corporation

While we would agree with some of the comments above regarding larger applicability of the objective, for the sake of keeping the scope under control perhaps the following revision could be considered further (on top of ZTE's version):

Study, and if needed, specify ~~features~~ **the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, targeting FR2 and multi-TRP**

· **UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission**

o **The total number of layers is up to four and total number of codewords is up to two, considering single DCI and multi-DCI based multi-TRP operation.**

· **UL beam indication for PUCCH/PUSCH, where unified TCI ~~state structure~~framework extension in objective 2 is assumed ~~reused~~, considering single DCI and multi-DCI based multi-TRP operation**

o **For the case of multi-DCI based multi-TRP operation, only one physical channel/signal type is transmitted across different panels *in a same CC*.**

Another point here is that to make the linkage between objective 2 and this objective more clear, as we commented earlier. This is something that needs to be considered in the work plan to ensure objective 2 is completed in time so that completion of this objective is not compromised.

26 – LG Uplus

mTRP is more prioritized.

27 – CEWiT

We support ZTE's version . We also believe having a new UL codebook designed for CJT across panels may go beyond the allowed scope. So we do not support transmission of same layer across panels.

28 – Samsung Research America

Re Nokia's latest revision, we agree that the clarification on unified TCI extension seems valid and helpful. Meanwhile the content is identical to ZTE's proposed revision.

Re proposals to expand the scope of objective 7, we would like to remind companies that it took two releases and tremendous amount of resource and effort in RAN1 to agree on small amount of spec support for panel selection. Therefore, we are concerned with such proposals. STxMP is more complex than panel selection. Even with the scope implied in ZTE revision, we expect it would be very challenging to converge on this objective in RAN1. Hence further expanding the scope is simply infeasible.

29 – New H3C Technologies Co.

we support ZTE's revision for this objective

30 – vivo Communication Technology

Scope of original proposal from moderator is too big. On the revision from ZTE (further revised by Nokia), we would like to clarify few points below

1) the first bullet where it is mentioned that "no new codebook is introduced", it should be further clarified that max Tx across 2 panels is 2 (1+1) or 4 (2+2).

2) the second bullet, where it is mentioned "total number of codewords up to 2", it is not clear whether is for sDCI or mDCI based operation. For mDCI based operation, similar to DL we assume 2 independent PUSCHs are scheduled.

3) we agree with Nokia that there is some relevance with objective#2, it should be clarified which TCI framework is assumed.

4) only one type of physical channel/signal is supported

31 – CATT

Supportive and agree with ZTE's proposal.

32 – InterDigital France R&D

We generally support the scope of this objective. Also, we are OK with ZTE's proposed revision, with minor change of removing the last bullet (*... only one physical channel/signal type is transmitted across different panels.*). We prefer this aspect to be studied and decided during the WI.

33 – CableLabs

We are supportive of this objective. We are fine, as a principle, with revisions from ZTE.

However, we do not prefer to limit the scope to FR2 only.

34 – MediaTek Inc.

We support the Nokia proposed version with one more addition: We would like to add:

- **Target "device type vs Tx configuration" feasibility shall be identified as part of the study.**

We believe this is important especially considering that handheld devices are power limited, and reasonable operational complexity is important, to make sure this feature can be practically used in the field.

1.3.8 Objective #8

The current text for objective #8 is as follows.

=== start ===

Study, and if justified, specify panel-specific timing/power control for UL multi-TRP/panel scenario

=== end ===

Feedback Form 9:

1 – ZTE Corporation

In our views, some further clarification on panel-specific timing/power control may be also needed. Technically speaking, the enhancement on panel-specific timing is much relevant to multi-DCI (e.g., multi-TA case), and then that on power control is much relevant to single-DCI (e.g., more than two PL-RSs for facilitating a single PUSCH transmission across multiple panels). It should be noticed that the above two aspects may apply to both FR1 and FR2, and for FR2 case, multi-UE-panel should be considered by default. After that, in Objective #8, for the use case of simultaneous transmission, we only need to consider the clarification for the Objective #7 accordingly. Finally, for this enhancement, unified TCI state structure should be reused.

For Objective #8

Study, and if justified, specify ~~**panel-specific timing/power control**~~ **multiple TAs** for UL **multi-DCI and power control for UL single DCI** multi-TRP~~/**panel**~~ scenario **where unified TCI state structure is reused.**

- **Simultaneous UL operation will only be considered limited to the Objective 7 scenarios.**

2 – Samsung Research America

We **support the revised wording of objective 8 from ZTE.**

As commented before, the initial version (above) from the moderator is ambiguous in terms of scope and can lead to much confusion.

The revised version from ZTE clearly delineates the two features (multi-TA and PC for mTRP). THe reuse of unified TCI also ensures that the scope is limited.

3 – HuaWei Technologies Co.

As commented before, we concerned the original proposal for this objective unclear and uncontrollable scope, especially including so many potential combinations of different assumptions on number of scenarios, TRPs, Panels, DCIs and different TCI frameworks. ZTE's revision is with more reasonable scope, which is acceptable for us.

So, we are supportive for ZTE's version of Objective-8.

4 – Nokia Corporation

We would like to thank ZTE for the revision proposal. There are some aspects that still require clarification though. Multiple TAs can arise with both s*DCI and m*DCI modes, and it is mainly related to propagation delay from TRPs (not how TRPs schedule via s*DCI or m*DCI). So, Multi-TA is also important in TDMed

PUCCH or PUSCH and hence it should not be limited to the case of simultaneous UL only. We do agree that power control enhancements should be limited to simultaneous UL cases though, and actually it might be better to consider them in objective 7 instead.

We have concerns with the comments above on using unified TCI to reduce the scope. Actually, for multiple TAs the TCI states do not play a significant role. For power control aspects the TCI states play a role, but as said above, that topic seems to belong to objective 7 instead. We would like to remind that unified TCI states are not yet available for multi-TRP scenarios, and hence we cannot consider it for this topic unless we create a dependency between objectives 2 and 8, but that would not be efficiency. Hence we propose to continue this objective with the existing TCI framework.

5 – Apple GmbH

We are not supportive of this objective.

In Rel-17 PUSCH/PUCCH Multi-TRP reliability enhancement, up to two power control loop is already supported. In Rel-15/16, with regular PUSCH/PUCCH operation, multiple power control loop is also supported (CLPC is only 2). This can largely be used to handle the two UE multi-panel.

We do not think per-panel TA is needed, just like we do not think per-TRP TA is needed.

6 – Intel Corporation (UK) Ltd

We support the objective in Rel-18 NR and revisions from ZTE.

7 – Ericsson LM

The initial moderator version is unclear, since there is no panel entity defined in 3gpp specifications. The revision proposed by ZTE is clearer.

We support the revision proposed by ZTE.

8 – SHARP Corporation

We support the objective in Rel-18 NR and revisions from ZTE.

9 – Futurewei

We share the same view as companies that the original version of the objective is ambiguous. We are in general ok with the direction of ZTE's revision. Regarding multiple TAs, our view is similar to Nokia's that multiple TAs can arise with both sDCI and mDCI modes. So we suggest not limiting multiple TAs to multi-DCI only.

10 – Lenovo (Beijing) Ltd

We also feel the original wording is ambiguous. The revision from ZTE gives a clear scenario and scope for this objective. We support ZTE's version.

11 – NTT DOCOMO INC.

Support.

12 – Guangdong OPPO Mobile Telecom.

We are supportive of Objective #8. WE support ZTE's version in principle, and suggest a modification to include multi-DCI scenarios for power control (i.e., **power control for UL single DCI -> power control for UL single DCI and multi-DCI)**. For Objective#7, UL simultaneous operation is supported and there will be some requirement for the total maximum output power. Thus, for the simultaneous transmission, some work is needed for power control.

For Objective #8

Study, and if justified, specify ~~**panel-specific timing/power control**~~ **multiple TAs** for UL **multi-DCI and power control for UL single DCI and multi-DCI** multi-TRP~~/**panel**~~ scenario **where unified TCI state structure is reused.**

- **Simultaneous UL operation will only be considered limited to the Objective 7 scenarios.**

13 – NTT DOCOMO INC.

We are supportive of Objective #8.

Regarding to ZTE's modification, we agree with OPPO that we prefer to keep both single DCI and multi-DCI for TA enhancement and power control enhancement, at least for study.

14 – LG Electronics Inc.

We support this objective. On the ZTE's revision, we share similar view with Nokia that <u>different TA is mainly related to propagation delay difference</u> between each TRP-UEpanel pairs, as analyzed in our Rel-18 WS paper [**RWS-210240**], rather than inter-TRP backhaul delay condition. Thus, limiting to m-DCI does not technically make sense and this would make this feature less useful because mTRP PUSCH repetition is supported based on S-DCI. We also agree with Nokia's comment that <u>power control enhancement for STxMP is better to be included in obj#7, not in obj#8.</u> We suggest the following modification to narrow down the scope. We suggest to keep 'panel' since it will be common to manage TA per panel from UE implementation perspective, if introduced. Whether/how to specify panel-specific TA is up to WG decision.

Our suggestion for refinement is given below:

Study, and if justified, specify panel-specific timing~~/**power**~~ control for UL **multi-DCI and single DCI** multi-TRP/panel scenario

- **Only one TA value is applied at a time.**

15 – Sony Group Corporation

We think the original wording of Objective 8 is generic and agreeable at least to us.

16 – TELECOM ITALIA S.p.A.

we support the objective.

We think that some further work is needed to better define the text, by taking into account ZTE and Nokia comments as a basis.

17 – Spreadtrum Communications

We share similar view with Nokia that timing control should be TRP-specific rather than panel-specific. Regarding panel-specific power control, we wonder what is the relationship between this feature and TRP-specific power control specified in Rel-17.

18 – Deutsche Telekom AG

We support this objective with a well defined and narrow scope.

19 – NEC Corporation

We support Objective #8 and ZTE's revision.

20 – Asia Pacific Telecom co. Ltd

We support this objective

21 – Qualcomm Incorporated

For mTRP operation, multiple TA should be limited to multi-DCI. Furthermore, it still needs to be clarified that in conjunction with multiple TA, whether or not the support of DL timing differences greater than CP across TRPs is assumed.

For mTRP operation, the target use case for multiple power control needs to be clarified and needs to preclude multi-DCI or single-DCI TDM schemes since those are already supported.

22 – Xiaomi Communications

We support Objective #8.

Since the power control for single DCI has been solved in Rel-17 ,we think this objective can focus on Multi-DCI schemes mainly both for timing and power control.

23 – Nokia Corporation

Please find below one attempt to reformulate our previous comments in a more direct format (based on ZTE's version):

Study, and if justified, specify the following:

· ~~panel-specific timing/power control~~ **multiple TAs** [for UL **multi-DCI] for multi-TRP operation**

· ~~**and**~~ **power control for UL single-~~-~~DCI** for multi-TRP~~/panel scenario~~ operation **where unified TCI framework ~~state~~ extension in objective 2 ~~structure~~ is assumed~~reused~~.**

Simultaneous UL operation will only be considered limited to the Objective 7 scenarios.

This revision attempts to clearly separate the multiple TAs aspect from power control, because the former does not depend on objective 2, while the power control enhancements are dependent on the TCI framework extension in objective 2.

24 – LG Uplus

multi-TRP operation is more prioritized.

25 – CEWiT

We support ZTE's version.

26 – Samsung Research America Re Nokia's latest revision, we agree that the clarification on unified TCI extension seems valid and helpful. Meanwhile the content is identical to ZTE's proposed revision. Also with better way to organize the content to avoid misunderstanding that multi-TA depends on TCI framework
27 – New H3C Technologies Co. We are fine with the revision proposed by ZTE.
28 – CATT We are not supportive of this objective since the application scenario and benefits of panel-specific timing for multi-TRP/panel scenarios are unclear and panel-specific/beam-specific power control for multi-TRP/panel scenarios is already supported in Rel-17.
29 – vivo Communication Technology Thanks ZTE and Nokia for revisions which certainly clarifies the scope better. As commented by several companies, multiple-TA is applicable for both sDCI and mDCI based mTRP operation. And, we tend to agree with clarficiation on TCI framework from Nokia.
30 – InterDigital France R&D We generally support the scope of this objective. Regarding ZTE proposal, we have a similar view as Nokia about TA and TCI aspects. TA issue is not a function of the type of scheduling DCI, and also, there should not be any dependency on the unified R17 TCI framework for this objective.
31 – MediaTek Inc. We support the Nokia latest proposal in general.

1.4 Moderator Summary and Recommendation

Moderator summary and recommendation for initial round is provided in RP-213482 for discussion in the 1st GTW session of week 1.

2 Intermediate Round

Taking into account the discussion in the 1st GTW session in week 1, the moderator's suggested text for each objective in RP-213482 section 2 will be used for inviting feedbacks in the intermediate round discussion. The clean version of text proposals in RP-213482 are captured below for convenience.

Objective 1:

Study, and if justified, specify CSI reporting enhancement for high/medium UE velocities by exploiting time-domain correlation/Doppler-domain information to assist DL precoding, targeting FR1, as follows:

- Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis
- UE reporting of time-domain channel properties measured via CSI-RS (including CSI-RS for tracking)

Objective 2:

Specify extension of Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states to support multi-TRP using Rel-17 unified TCI framework

Objective 3:

Study, and if justified, specify larger number of orthogonal DMRS ports for downlink and uplink MU-MIMO (without increasing the DM-RS overhead), only for CP-OFDM,

- striving for a common design between DL and UL DMRS
- Up to 24 orthogonal DM-RS ports, where for each applicable DMRS type, the maximum number of orthogonal ports is doubled for both single- and double-symbol DMRS

Objective 4:

Study, and if justified, specify enhancements of CSI acquisition for Coherent-JT targeting FR1 and up to 4 TRPs, as follows:

- Rel-16/17 Type-II codebook refinement for CJT mTRP targeting FDD and its associated CSI reporting, taking into account throughput-overhead trade-off
- SRS enhancement to manage inter-TRP cross-SRS interference targeting TDD CJT via SRS capacity enhancement and/or interference randomization, with the constraints that 1) without consuming additional resources for SRS; 2) reuse existing SRS comb structure; 3) without new SRS root sequences
- Note: the maximum number of CSI-RS ports per resource remains the same as in Rel-17, i.e. 32

Objective 6:

Study, and if justified, specify UL DMRS, SRS to enable 6 and 8 Tx UL operation to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

- Note: Potential restrictions on the scope of this objective will be identified as part of the study.

Objective 7:

Study, and if needed, specify the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, targeting FR2 and multi-TRP

- UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission
    - The total number of layers is up to four and total number of codewords is up to two, considering single DCI and multi-DCI based multi-TRP operation.
- UL beam indication for PUCCH/PUSCH, where unified TCI framework extension in objective 2 is assumed, considering single DCI and multi-DCI based multi-TRP operation
    - For the case of multi-DCI based multi-TRP operation, only one physical channel/signal type is transmitted across different panels in a same CC.
- Feasibility of target device type and Tx configuration shall be identified as part of the study.

Objective 8:

Study, and if justified, specify the following

- multiple TAs for UL multi-DCI for multi-TRP operation
- power control for UL single DCI for multi-TRP operation where unified TCI framework extension in objective 2 is assumed.

For the case of simultaneous UL transmission from multiple panels, the operation will only be limited to the objective 7 scenarios.

2.1 Question on Objective 2

Regarding objective 2, the latest proposed version in initial round is as follows:

=== start ===

Specify extension of Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states to support multi-TRP using Rel-17 unified TCI framework

=== end ===

In order to reach a conclusion on the text for objective 2, companies are requested to provide their preference and view on Alt2-1 vs Alt2-2 below, including serious concern if any, and your reasoning.

- Alt2-1: The above wording as is, i.e. to support multi-TRP
- Alt2-2: Add sTRP in addition to multi-TRP, i.e. to support multi-TRP and single-TRP

Feedback Form 10:

1 – Samsung Research America

Since limiting work scope has become the controlling theme recently, we prefer Alt1 since the scope is clear. Regarding Alt2:

- Since Rel-17 unified TCI was designed specifically with sTRP in mind (M=N=1), the "sTRP" in Alt2 may cause confusion to other companies.

Regardless, based on the comments from Alt2 proponents, the following minor rewording of Alt1 should be acceptable: "Specify extension of Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states, **focusing on** ~~to support~~ multi-TRP **use case**, using Rel-17 unified TCI framework".

The proposed rewording is intended to state that the "multi-indication" scheme is designed with the focus on mTRP - but such solution may also be used for other purposes (since use cases are anyway not a part of the spec). So it is inclusive yet doesn't expand the scope.

2 – New H3C Technologies Co.

We prefer Alt.2-1 with the consideration on limited TUs and work load.

3 – Spark NZ Ltd

we would prefer multi TRP with more than one TRP . In our contribution we pointed out the gains that can be achieved by spatially separated TRPs- distributed MIMO. If the end goal of this agenda ietm is to look for enhancements for MIMO then ways to increase the channel rank by spatially separated TRPs should be given consideration.

4 – LG Uplus

Alt.2-1 is preferred.

5 – vivo Communication Technology

Our preference is original wording which includes both single TRP and multi-TRP scenarios and inter-band scenario. At least, Unified TCI framework for indication of multiple DL and UL TCI states in inter-band scenario should be included for both alternatives.

6 – Nokia Corporation

We prefer Alt 2-1 in general, because unified TCI for mTRP has not been addressed in Rel-17 and it is a pre-requisite to the work to be done in some other objectives in this WID. However, we are open to consider specific enhancements to sTRP if clearly identified in the WID. We do not support generic enhancements to sTRP in this objective though for the sake of managing the overall workload.

7 – CEWiT

We prefer Alt2-1 , as sTRP scope is not clearly defined on top of what has been done in Rel17.

8 – Spreadtrum Communications

In order to reduce the workload, Alt 2-1 is preferred.

9 – NTT DOCOMO INC.

Although we support Alt.2-2, but we can accept Alt.2-1 with Samsung's revision (i.e. **focusing on** ~~to support~~ multi-TRP **use case**).

For single TRP use-case, as we commented in today's GTW, there is a restriction in Rel.17, when Rel.17 TCI state is configured, other Rel.16/17 features using Rel.15/16 TCI state/spatial relation (e.g. positioning, above 52GHz, etc.) cannot be configured in the same band. This is because of working assumption of RAN1#107e (*UE does not expect to be configured with Rel.15/16 TCI state/spatial relation and Rel.17 TCI state in the same band*). In order to enable gNB to configure Rel.17 features (e.g. L1/L2 inter cell mobility) and other non-MIMO Rel.16/17 features using Rel.15/16 TCI state/spatial relation (e.g. positioning, above 52GHz, etc.) in the same band, we need to specify Rel.17 TCI state for the non-MIMO Rel.16/17 features. In this case, we can assume single TRP unified TCI state (i.e. N=M=1), and we think the specification impact is very small (i.e. just adding Rel.17 TCI state to the existing specification of Rel.15/16 TCI state/spatial relation for non-MIMO Rel.16/17 features).

10 – China Mobile Com. Corporation

We support Alt 2-1. The spirit of unified TCI for S-TRP is to work as M=N=1. Samsung's revision is fine to us.

11 – HuaWei Technologies Co.

Alt. 2-1 is preferred from our side. Single TRP case is unclear. The unified TCI framework for single TRP was done in Rel-17, the objective here is to extend unified framework to multi-TRP cases.

12 – NEC Corporation

We are fine with either alternative, slightly prefer to keep the scope smaller, i.e., Alt2-1.

13 – LG Electronics France

We prefer Samsung's suggested revision, i.e. to support multi-TRP à focusing on multi-TRP use case

14 – Beijing Xiaomi Mobile Software

We prefer Alt 2-1 since unified TCI framework for M-TRP was not addressed by Rel-17. While for single TRP, the scope is not clear. And in order for the workload control, we are fine to remove single-TRP use case.

15 – KT Corp.

KT prefers Alt 2-1.

16 – Sony Group Corporation

To narrow down the scope, our choice would be Alt 2-1.

In Rel.17, the multiple beam operation (M>1 and/or N>1) for single TRP was investigated and discussed, but it seemed not so convincing that the majority realized its benefits over that of multiple TRP.

One more editorial suggestion is listed as below. Since the sentence says "extension of Rel-17 unified TCI framework for...", in our reading, it surely implies Rel-17 unified TCI framework will be used. It seems no need to introduce the redundance for better clarity.

Specify extension of Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states to support multi-TRP ~~using Rel-17 unified TCI framework~~

17 – SHARP Corporation

We support Alt 2-1.

18 – ZTE Corporation

We prefer Samsung's suggested revision. As mentioned in first round, inter-cell/inter-band case in sTRP should be considered from our perspective. But, for progress, we can consider Alt2-1 as a starting point. But the above candidates should not be precluded by now, and then we may further study the necessity of related enhancements in WG.

19 – MediaTek Inc.

We prefer Alt. 2-1. M=N=1 could also be acceptable if S-TRP were included though.

20 – Fraunhofer IIS

We prefer Alt2-1.

21 – CAICT

We have preference on Alt2-1.

22 – Guangdong OPPO Mobile Telecom.

Support Alt.2-1.

Regarding Alt.2-2, the motivation and benefits for sTRP are not clear. One of the main goals of R17 signaling framework is to simplify the multi-beam operations. Introducing more complicated mechanisms on top of R17 design are conflicting with the original intention of R17 signaling.

Moreover, it is still very challenging for the group to keep a manageable scope with the capacity of 3TU. Thus, we prefer not to further up-scope Objective 2 by adding sTRP.

23 – CATT

Considering the number of available TUs in R18, smaller scope, i.e., Alt2-1 is preferred.

24 – SK Telecom

We agree Samsung's comment. We support Alt. 1.

25 – Apple GmbH

We are fine with either way

26 – AT&T

We think there are merits for considering both multi-TRP and single TRP use cases, and not limiting the feature only to multi-TRP, as discussed in Rel. 17 WG1. For the sake of progress, however, we can accept Samsung's proposed revision.

27 – Lenovo (Beijing) Ltd

We support Alt1 because of its limited work load and clearly defined scope. Single-TRP was specified in R17 and it is not clear what is required here.

28 – Ericsson LM

We support Alt2-1.

Support mTRP only. The only potential use case for sTRP is to optimize signaling to provide different TCI states for different channels, e.g., for PDCCH and PDSCH. Such differentiation is possible in Rel-15, but has not been implemented, since there are no benefits.

29 – InterDigital France R&D

We can support either of alternatives.

30 – Verizon UK Ltd

Support Samsung's revision. But can also accept Alt2-1 if it is the majority view.

31 – Intel Corporation (UK) Ltd

It should be common understanding in RAN1 that the scope of each objective in MIMO work item should be very focused and well defined. From this perspective Alt 2 is not acceptable to us since it effectively opens for consideration any transmission scheme without restriction. There is no sufficient number of TUs to handle such discussion.

In addition current formulation of objective doesn't assume any TUs for study phase which suggests that only the existing mTRP transmission schemes that were evaluated in RAN1 before e.g. as part of Rel-16/Rel-17 should be considered for specification. Any new transmission schemes should be precluded due to lack of TUs for their discussion and evaluations.

In summary we prefer Alt 1 and have concerns on Alt 2 due to unclear scope and extra TU required for evaluation work.

32 – Futurewei

Our view is that both sTRP and multi-TRP should be considered for this objective. However, for the sake of progress, we can accept the revision from Samsung.

33 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility:

On single-TRP support, we support Alt2-2 - to support multi-TRP and single-TRP which was the outcome of the Oct email discussion and included in the Chairman's proposed WID scope in RP-213469. We are ok to mention no optimization will be done for single-TRP.

Single-TRP support is beneficial specially for scenarios of multi-PDSCH/PUSCH scheduling, uplink multi-panel transmission, and inter-cell/inter-band case.

34 – Qualcomm Incorporated

Only Alt2-2 would be acceptable. In Rel-17, it is a compromise that unified TCI only considers sTRP with single beam operation (M=N=1) for dedicated control/data due to lack of time. This is highly suboptimal since at least two active TCIs can be supported for dedicated control even in Rel-15. So we believe achieving at least same level of robustness is needed for unified TCI in sTRP scenario.

2.2 Question on Objective 3

Regarding objective 3, the latest proposed version in initial round is as follows:

=== start ===

Study, and if justified, specify larger number of orthogonal DMRS ports for downlink and uplink MU-MIMO (without increasing the DM-RS overhead), only for CP-OFDM,

- striving for a common design between DL and UL DMRS
- Up to 24 orthogonal DM-RS ports, where for each applicable DMRS type, the maximum number of orthogonal ports is doubled for both single- and double-symbol DMRS

=== end ===

In order to reach a conclusion on the text for objective 3, companies are requested to provide their preference and view on Alt3-1 vs Alt3-2 below, including serious concern if any, and your reasoning

- Alt3-1. The above wording as is, i.e. only for CP-OFDM
- Alt3-2. Add UL DFT-s-OFDM in addition to CP-OFDM, i.e. for CP-OFDM and UL DFT-s-OFDM

Feedback Form 11:

1 – Samsung Research America Since limiting work scope has become the controlling theme recently, we prefer Alt1 since the scope is smaller. However we acknowledge that the additional spec work for supporting UL DFT-SOFDM, depending on the design, could be limited.
2 – New H3C Technologies Co. We prefer Alt3-1. In addition, it isn't necessary to mention specific the maximum number of orthogonal DM-RS ports because it depends on evaluation result to determine how many orthogonal DM-RS ports.
3 – LG Uplus Alt3-1 is preferred. The critical use case for the combination of DFT-S-OFDM and MU-MIMO is not found even with complexity.
4 – vivo Communication Technology Applicability for UL DFT-s-OFDM can be supported without additional work, if there is concern on additional work load, add something like "larger number of orthogonal DMRS ports for UL DFT-s-OFDM is supported with common design as for CP-OFDM". We are also fine without specific number of orthogonal ports.
5 – CEWiT We believe only CP-OFDM poses suitable use case for MU-MIMO and so we support Alt3-1

6 – Spreadtrum Communications

Enhancement for CP-OFDM should be enough. We support Alt 3-1.

7 – NTT DOCOMO INC.

We support Alt3-1, considering both the limited scope and more useful use case of CP-OFDM for MU-MIMO.

8 – China Mobile Com. Corporation

We support Alt3-1. We think CP-OFDM is the main use case for more orthogonal DMRS ports.

9 – HuaWei Technologies Co.

Alt. 3-1 is preferred. Increasing the number of orthogonal DMRS ports are for high order MU-pairing, where the use case is for CP-OFDM, but not for DFT-S-OFDM (DFT-s-OFDM is for coverage). Not clear for the reason to increase DFT-S-OFDM DMRS ports.

10 – NEC Corporation

We prefer Alt3-1 since we don't see use case to have 24 DMRS ports with DFT-s-OFDM.

11 – CAICT

We would Alt 3-1.

12 – China Telecommunications

We prefer Alt 3-1.

13 – LG Electronics France

We prefer Alt3-1.

14 – Beijing Xiaomi Mobile Software

We prefer Alt 3-1 to reduce the workload.

15 – KT Corp.

KT prefers Alt 3-1.

16 – SHARP Corporation

We prefer Alt 3-1.

17 – ZTE Corporation

We support Alt3-1. Then, we sympathize that the spec efforts for further addition of UL DFT-s-OFDM might be limited, and so we can be a little bit flexible for this issue.

18 – Fraunhofer IIS

We prefer Alt3-1.

19 – MediaTek Inc.

We see Alt 3-1 as more reasonable. We are not sure it is really needed even for CP-OFDM, but the justification for it was for high capacity MU-MIMO. We shouldn't introduce new configurations just because it is easy to do, it needs to be well justified.

20 – Guangdong OPPO Mobile Telecom.

Support Alt3-1.

The typical scenario for MU-MIMO with more than 12 layers are the dense deployment. It is not the coverage-limited case.

21 – SK Telecom

We support Alt 1, which has the clear work scope.

22 – Apple GmbH

We prefer Alt3-1

23 – VODAFONE Group Plc

In line with the views expressed by many others, we support Alt3-1. This is for high-capacity MU-MIMO. As DFT-S-OFDM is for coverage, it is not clear what the use case is for including it, other than the fact the additional spec work 'could' be minimal.

24 – AT&T

We are fine with Alt3-1

25 – Lenovo (Beijing) Ltd

We prefer Alt3-1. Enhancing the number of DMRS for PUSCH is mainly for capacity enhancement, where CP-OFDM is the main use case.

26 – Ericsson LM

We strongly support Objective 3. Note that MU-MIMO for PUSCH is used for both CP-OFDM and DFT-s-OFDM users. Hence, we support Alt3-2 if pi/2-BPSK based DMRS is excluded from this DMRS enhancement and adding the restrictions provided by Qualcomm:

- Multiplexing capability of CP-OFDM with DFT-S-OFDM is to be retained.
- The scope of enhancements is to be limited to extending the OCC and/or cyclic shift space, and it should exclude adding new root sequences or new tone mapping.

27 – InterDigital France R&D

We are ok with the proposed description of Objective #3, and prefer Alt1.

28 – Verizon UK Ltd

Agree with Ericsson - Alt3-2 with restriction to limit the scope.

29 – Intel Corporation (UK) Ltd

We prefer Alt 3-1 since it has smaller scope compared to Alt 3-2.

We note that due to different structure of Rel-16 DM-RS (based on pi/2-BPSK sequence), we think it would be very difficult task to support additional orthogonal DM-RS ports for DFT-s-OFDM waveform. In other words, if uplink DFT-s-OFDM waveform is considered, only Rel-15 DM-RS based on ZC sequences should be included in the scope with the same/similar DM-RS design extension as for CP-OFDM.

30 – Futurewei

We prefer Alt3-1. We share the same view as many other companies that the main use case for this objective is for high capacity MU-MIMO, therefore considering CP-OFDM only is sufficient.

31 – Qualcomm Incorporated

We prefer Alt3-2

2.3 Question on Objectives 1, 4, 6, 7, and 8

Share your view on how to further trim the scope, as instructed by the Chairman, on objectives 1, 4, 6, 7, and 8 (see above). Please focus on scope reduction, not expansion.

Feedback Form 12:

1 – Samsung Research America

In our view, objectives 1 and 4 have been aggressively trimmed in terms of scope. During the initial round and GTW session, some comments on adding more constraints were made for objective 4, that is, ideal backhaul, same # ports across TRPs. We are open to adding those constraints as they help to add focus for the work (thereby saving time and effort during WI).

2 – New H3C Technologies Co.

From our perspective, UL enhancements are more important than DL in Rel-18 considering coverage enhancement and the requirement from the market. We can focus on objective 6.7.8 with high priority.

3 – SoftBank Corp.

Again, UL enhancements are more important than DL in Rel-18, and we believe objective #6 can bring visible gain. We would propose give the highest priority to objective #6.

4 – Samsung Electronics Co.

Many companies provided quite many inputs stating what is most important to them. Such positions are now known very well and hence, there is no need for repetition. If, e.g., UL is the highest priority, then please try to help trim the scope there so that its scope becomes narrower and more concrete. As discussed in Tuesday GTW, as an example, objective 6 seems too broad. Better scope would provide better chance of success.

5 – LG Uplus

We support Samsung's opinion. We cannot deprioritize objective 1 and 4. As mentioning in the initial round, Rel-18 MIMO should enhance both DL and UL in order to improve eMBB customers, which is our real goal. Regarding DL MIMO, drastic performance gain can be achieved by C-JT, which is already verified commercially in indoor circumstances, and we would like to extend out-door, where we need several enhancements introduced by objective 1 and 4. Some companies have concerns for backhaul but most cases can be solved in C-RAN architecture. Regarding UL MIMO, we prioritize mTRP operation for UL. Multi-panel concept seems good but we are not convinced that the device with multi-panel can be obtained in time with this specification.

6 – vivo Communication Technology

In our view further trimming, clarification is needed on these objectives.

Objectives 1 and 4 are related CSI enhancement, for #1 SRS configuration enhancement (for example increasing number of SRS resources in a set) is simple solution, gNB can obtain Doppler domain information. For #4, further restriction as same number of ports per TRP, ideal backhaul needed, not sure what SRS enhancement in terms of capacity is needed.

Objective #6, antenna structure/coherence assumption is needed otherwise amount of work (simulations) in SI phase is too much.

Objective#7, based on proposal in RP-213482 "**UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission**" needs further restriction on total number of Tx as (1+1) and (2+2), and "**and total number of codewords is up to two**" should be clarified whether it is for sDCI or mDCI based mTRP operation.

Objective#8, multiple TA is also applicable for single TRP, we don't see it will lead to additional work.

7 – NTT DOCOMO INC.

We're okay with current scope of Objective 1,4,6,7,8. But, generally we believe UL enhancement objectives (e.g., 6,7,8) have higher priority than DL enhancement objectives, because UL enhancement is very important for Rel.18.

8 – NEC Corporation

We are fine with Objectives 7, 8.

We believe further trimming is needed for Objectives 1 and 4. For example, it is noted that if both objectives 1, 4 were accepted in their current form, we are expected in Rel-18 to develop another two new enhanced type-II CSI codebook, which may not be favorable especially considering tight TUs.

9 – China Unicom

We support the current version of objective 4 on enhancements for CJT. We also support to include CW mapping for more than 4 layers per UE in objective 6.

10 – Nokia Corporation

We agree with NTT Docomo, NEC, Softbank that UL should have priority and we need to ensure that DL enhancements are not eating the time away from these topics in the end. **It is not possible to accommodate both objectives 1 and 4 in the WID**, and only one of those objectives should be selected. **We would invite companies to provide their views on which of objectives 1 and 4 should be selected for inclusion.**

11 – LG Electronics France

In general, like many other companies, we think UL related Obj#6,#7,#8 should be prioritized.

For more details:

Regarding Obj#1:

- We think second bullet can be removed or should be fall-back to TRS at least.

Regarding Obj#7:

- We wonder what would increase the scope if we remove 'focus on FR2' restriction. As commented earlier, this feature is useful for vehicle UE applications, mainly operated in FR1.
- Regarding 'no new codebook' restriction, as commented during GTW, is it common understanding that STxMP is supported with different layer per panel with this restriction? If so, how PUCCH or other single port UL channel/signal can be transmitted? If not, how single layer PUSCH can be supported without UL codebook enhancement? In general, we think that it is premature to define such restriction which can limit the performance benefit of STxMP seriously.

12 – KT Corp.

KT believes that Objective #1, #4 has already been trimmed. We would like to see the objectives as written above (with no expansion). Object #7 seems to have common interests among many operators for UL enhancements. KT would like to keep this in the objective. For Objective #6, #8 unfortunately we do not have enough time budget to squeeze these two objectives.

13 – Sony Group Corporation

We are proponents of UL enhancement, i.e. prioritizing Objective 6, 7, and 8.

On Objective 7, we share similar assessment of LGE. If the inter-panel coherent transmission (one layer precoded across coherent panels) is possible, then it seems we need to investigate whether the legacy UL codebook is feasible. If not, then we may need to introduce new UL codebook. Hence, we feel it's too early to put down the constraint "where no new codebook is introduced for multi-panel simultaneous transmission".

On Objective 8, we are in principle fine with the direction, i.e. supporting TA/PC in a panel-specific manner. However, in terms of wording, we feel it seems not necessary to strongly couple the TA/PC with either sDCI-mTRP or mDCI-mTRP. In addition, if we get it right, RAN already supported multiple TA groups which can be applied for inter-cell mTRP. Since the TA/PC is implemented by UE panel(s), we tend to think the original wording "specify panel-specific timing/power control" can serve the purpose well.

14 – Beijing Xiaomi Mobile Software

For objective 1, we support it in general, but we want to further clarify the scope of these two bullets. For the first bullet, from our understanding, it means to refine the Rel-16/17 Type-II codebook by considering time domain information and we prefer to update the wording by adding "by considering time domain information" to make it clearer. While for the second bullet, if it means that based on the existed codebook without refinement, UE report the time-domain channel properties additionally, it is better to update the wording by adding "based on the existed codebook without refinement" to make it clearer. We are also fine to keep only one bullet after clarification.

For objective 4, we are supportive of the latest version.

For objective #6, #7 and #8, we share many companies' views that UL enhancements have higher priority in Rel-18. We are fine with the current scope of Objective #6 and #7. For Objective#8, we share similar view with Sony that not to restrict to either Single TRP or Multi-TRP at the current stage.

15 – CAICT

If further down-selection is required to fit the TU allocation, objective #4 for downlink and #6#7#8 for uplink are with the same priority.

16 – Guangdong OPPO Mobile Telecom.

We are genereally fine with these objectives with some specific comments as below:

Regarding Objective 6, we think only UL DMRS and SRS enhancement is not sufficient to support 6/8 Tx operation. At least UL codebook and control signaling enhancement is also needed. Otherwise, only non-codebook PUSCH can be supported. For practical UEs, codebook-based PUSCH is more common. Thus, we suggest the following modification

- Study, and if justified, specify UL DMRS, SRS, **TPMI (including codebooks) and SRI** to enable 6 and 8 Tx UL operation to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

Regarding Objective 8, we have the following comments

1. The multiple TAs are used for transmission with multiple UL panels. We should restrict the scope by avoiding the case that one panel with different TAs
2. There is no much difference between the power control for S-DCI and M-DCI, e.g., the limitation of the total output power. If M-DCI is not included, we propose to remove the sub-bullet of power control.

Thus, we suggest the following modification

Study, and if justified, specify the follow

- multiple TAs for UL multi-DCI for multi-TRP operation
- **Each panel is associated with one TA**
- **~~power control for UL single DCI for multi-TRP operation where unified TCI framework extension in objective 2 is assumed~~, or**
- **power control for UL multi-DCI and UL single DCI for multi-TRP operation where unified TCI framework extension in objective 2 is assumed**

For the case of simultaneous UL transmission from multiple panels, the operation will only be limited to the objective 7 scenarios.

17 – ZTE Corporation

First of all, we are okay with current scope of 1, 4, 6, 7, and 8 (as what we mentioned in GTW). After that, we have the following suggestions on Objectives 6, 7 and 8 and replies to corresponding comments.

- Regarding objective 6, in the first round, we have already provided the solution of further clarifying the scope, by adding 'TPMI (including codebooks), SRI and codeword-to-layer mapping' after 'UL

DMRS and SRS' in the objective, which seems to be supported by many companies including operators. But, if it does not work, we can live with current version. Then, regarding other comments on UE antenna framework, we believe that UE antenna framework is a very detailed issue (much relevant to subsequent products in 3 years) and definitely should be left to RAN WGs for further justification. If have to, from our perspective, coherent-type/partial-coherent-type should be prioritized, and 6Tx and 8Tx should be treated equally as a starting point.

- Regarding objective 7, we disagree that device type should be justified as in part of the study. Since now, we are not convinced by the reason why such device type limitation/feasibility is not described in the objectives of multi-panel operation in previous releases but suddenly this has to be emphasized in the objectives in this release. To compromise, we can live with "feasibility of target ~~device type and~~ Tx configuration shall be identified as part of the study" but we still do NOT think it is necessary to mention device type in the objectives. Tx configuration may need to be discussed for evaluation and consideration of device type can anyway be implicitly reflected in the discussion of Tx configuration.

- Feasibility of target ~~device type and~~ Tx configuration shall be identified as part of the study

- Then, regarding the total number of layers/CWs, we think that it is clear in the current version of objective 7, and the mentioned restriction in the sub-bullet should apply to both MDCI and SDCI as a starting point ('…., considering single DCI and multi-DCI based multi-TRP operation.'), but, of course, some further study/justification should be handled in RAN1 WG.

- Regarding objective 8, we prefer not to extend the scope again, based on current situation and guidance from the moderator.

18 – CATT

- For objective 4, it's still not clear to us why up to 4, rather than other number of TRPs are considered. In our opinion, the number itself should be studied first.

- For objective 6, we have one question for clarification: if codebook-based transmission is to be used for UL with 6 and 8 Tx, how can it work without enhancement of codebook? So, codebook enhancement should also be included in this objective.
- For objective 8, we are still not supportive of it. As mentioned in previous discussion, the application scenario and benefits of panel-specific timing for multi-TRP/panel scenarios are unclear and panel-specific/beam-specific power control for multi-TRP/panel scenarios is already supported in Rel-17. Also, considering the limited time budget in Rel-18, this objective should be removed.

19 – SK Telecom

We are fine with current version of Objectives #1 and #4.

20 – Apple GmbH

We prefer to downscope Objective #7 and #8.

For objective #7, our understanding is that the objective is for simultaneous multi-panel UL transmission for FR2 and we do not think this would be commercially attractive for majority of the NR market due to the device complexity, power consumption and thermal.

For objective #8, we do not think per panel TA is needed. Again, based on the past discussion, if there is any need for this study, it is for FR2 in which larger SCS is deployed, i.e., 120kHz, hence the CP is short. However, in the field, the issue of FR2 deployment with multi-panel is not the CP issue, or synchronization

issue. The main area that should be enhanced is the device power consumption, thermal, beam management overhead etc. The robustness also needs to be enhanced, but it should not be based on asynchronous assumption.

21 – VODAFONE Group Plc

Whilst we agree that UL enhancements are a priority for rel-18, objective 6 seems to be the only one that could provide real benefits for FR1. Objectives 7 and 8 are not of particular interest since the UL gains will only be useful for limited areas of dense FR2 deployment with a limited range of devices.
Between objectives 1 and 4, we are still strongly in favour of keeping objective 1. Whilst UL enhancement may have the higher priority, continuing to enhance CSI for effective DL precoding under mobility is key for maximising the gains of MIMO (particularly MU-MIMO) and thus eMBB performance across the network.

22 – SHARP Corporation

We support the current Objective 1,4,6,7,8. Objective 1 and 4 have been aggressively trimmed as mentioned by some companies.

23 – AT&T

As mentioned by other companies, objective 4 scope has been aggressively reduced, and we think the current version should be acceptable. Similarly, for UL enhancements, we think objective 6 and 7 are important, and should be included. We are open to further reduction of scope if it makes the discussion more focused and save time during the WG discussions.

24 – Lenovo (Beijing) Ltd

We believe the scopes of objective 1 and 4 have been sufficiently narrowed down to justify their inclusion in R18. We are fine with some companies' proposal to assume ideal backhaul between the TRPs for CJT.

We are fine with objectives 7,8 in their current forms.

Regarding Objective 6, we agree with the rapporteur's opinion that the scope is too wide. We propose the following to narrow down its scope:

· >4 layer only. A UE with 6 or 8 Tx can support 1-4 layers with implementation (antenna virtualization), and no spec change is required.

· CB-based PUSCH has higher priority than NCB-based.

· 8 Tx has higher priority than 6 Tx.

· Coherent and partial-coherent only.

25 – Fraunhofer IIS

We are in general supportive of Objective 1,4,6,7, and 8. We also think that Objective #1 and #4 have been down-scoped/trimmed aggressively as requested by the RAN chair, and are now acceptable.

26 – Continental Automotive GmbH

Here is our input:

- We are OK with the overall definition of the objectives, and

- objective 1 has higher priority for Continental than objective 4.

27 – China Mobile Com. Corporation

Both objective 1 and 4 are CSI related enhancement. To control the scope, only one of them should be selected. As commented in previous round, we support objective#4 and suggest to remove objective#1.

For UL enhancement, we think objective 6 has higher priority than 7 and 8. For objective 6, we support to include TPMI, SRI, and CW mapping enhancement in the detailed scope. For objective 7, ZTE's update is fine to us. For objective 8, we think different TAs is related to the propagation delay or the distance betweent the TRPs, and it can arise in both M-DCI and S-DCI. Considering the scope and spec efforts, we can accept to limit to M-DCI scenario in R18. Regarding the power control, we think it is mainly for simultaneous multi-panel UL transmission. For TDM-ed UL transmission, it seems that R17 power control mechanisim of unified TCI can already applied for this function.

28 – Verizon UK Ltd

We are in general fine with objectives, 1,4,6,7 and 8. Objection #7 we think is clearly needed. We like Object#4 a lot too - it is quite appealing for certain scenarios and is already trimed heavily. So we think including the trimed version is reasonable.

29 – Ericsson LM

On objective 1, performing time domain channel measurements on a general CSI-RS can be removed, since TRS is the only signal that provides enough quality for such measurements due to its dispersed two-dimensional RS structure.

Scope can be trimmed by removing objective 6 which has a huge impact on workload and there is no clear market need identified. In addition, since the targeted device form factor is not given, it is not possible to define a coherent/partial precoding codebook. Designing multiple codebooks for different possible device form factors is a huge task for the WI.

For objective 7, this can be removed: "Feasibility of target device type and Tx configuration shall be identified as part of the study." We don't see how RAN1/RAN4 could do that.

As a general remark, objectives 1,4, and 7 are big even with the current narrowed formulations, and any expansion must be avoided.

30 – Telia Company AB

We agree with Docomo and many other company views that UL enhancement objectives should have higher priority than DL enhancement objectives in Release 18 MIMO work.

31 – InterDigital France R&D

Objectives 1 and 4 – We agree with Nokia that we cannot afford both objectives in Rel-18 even after downscoping and the UL enhancements need to be prioritized. 3TU is already tight for the objectives other than 1 and 4 from our perspective. If one is to be selected, based on the level of support, Objective 4 seems to have a better choice at this point. However given the workload, in our view the best would be removing both objectives from the WI.

Objective 6 – We generally support the objective. To control the scope, we prefer to limit the scope to only CP-OFDM.

Objective 7 – We generally support the scope of this objective. The scope is sufficiently clear and focused as is.

Objective 8 – We generally support the scope of this objective. The scope is sufficiently clear and focused as is.

32 – MediaTek Inc.

Objective 7: Re removing "Feasibility of target device type and Tx configuration shall be identified as part of the study.", we believe it is important to understand what sort of device this SI is targeting and how we should make the design suitable for that. We have been asking this for the last 6 months and received very vague feedback from proponents. For Objective 6 everybody just agreed to indicate is targeting non-handheld devices only.

Possible alternatives:

1) In the WID we state that 4 Tx layers is targeting non-handheld devices only. As this seems to be more pain than gain in a handheld device.

2) We remove 4 layers altogether from the study.

We can accept to either keep the original sentence, or (1) or (2).

33 – Intel Corporation (UK) Ltd

In our view moderator's proposal for objectives 1, 4, 6, 7, and 8 provides reasonable reduction of the work scope for almost all objectives. We don't think down-scoping of any objective at current stage of discussion constructive and prefer to avoid this.

As a small suggestions :

(1) we think a bit clearer formulation may be needed for objective 6, e.g. whether all UE coherence types should be considered for specification, whether both full power and non-full power modes should be enhanced, whether UEs with maximum of 4 MIMO layers is also supported, whether both CB and NCB transmission modes should be enhanced for 6Tx and 8 Tx UEs, etc. At the same time, we also acknowledge that such discussion can be carried out in RAN1 directly as proposed by moderator.

(2) for objective 7, "Feasibility of target device type and Tx configuration shall be identified as part of the study" should be removed. Similar to 6Tx and 8Tx antenna configuration, we believe it is feasible to support corresponding enhancement for certain type of devices.

Overall, we support all objectives 1, 4, 6, 7, and 8 in the current formulation with small clarification captured above.

34 – Volkswagen AG

High speed scenarios are happening daily, therefore objective 1 should be prioritized over objective 4 as it's unclear when such deployments will happen.

35 – Deutsche Telekom AG

We clearly support objective 1 and think this has been downscoped and is appropriate for inclusion now. We restate that the benefits have been proven and this is an excellent enhancement for further adoption of NR in medium and high velocity scenarios, which are important for automotive and rail industry.

Objective 4 can be entirely dropped as CJT benfits might be visible on paper or in specific test deployments, but in commercial large scale deployments these can not be expected.

36 – Futurewei

We are in general supportive of Objectives 1, 4, 6, 7, and 8.

Regarding Objectives 1 and 4, we shared the same view as many other companies that their scope has been aggressively trimmed and should be supported.

Regarding Objective 6, our view is that the scope of this objective is too big and need some downscoping. It is unclear to us the need of 6TX UL operation which requires a new codebook design that is time consuming. We suggest removing 6TX from the objective.

Regarding Objective 8, we shared the same view as companies that multiple TAs can arise with both sDCI and mDCI modes. So we suggest not limiting multiple TAs to multi-DCI only.

37 – Qualcomm Incorporated

Will not repeat all our previous comments, please refer to the previous discussion round. Just highlighting the scope reduction related aspects here.

If overall scope management will be further considered, Objective 1 could be the first target for possible scope reduction.

For Objective 6, delete "to support more than 4 layers" or replace it with "to support 4 or more layers".

For Objective 7, we suggest the following simplifications:

- UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission

o The total number of layers is up to four and ~~total~~ number of codewords is one per PUSCH ~~up to two~~, considering single DCI and multi-DCI based multi-TRP operation.

- UL beam indication for PUCCH/PUSCH~~, where unified TCI framework extension in objective 2 is assumed~~, considering single DCI and multi-DCI based multi-TRP operation

o For the case of multi-DCI based multi-TRP operation, only PUSCH+PUSCH, PUCCH+PUCCH, and PUSCH+PUCCH is considered ~~one physical channel/signal type is transmitted across different panels~~ in ~~a~~ the same CC.

- Feasibility of target device type and Tx configuration shall be identified as part of the study.

For Objective 8, "multiple" can be replaced with "two" to avoid unnecessary discussions during the WI. In addition, the second bullet can be removed as it is already in the scope of Objective 2. Therefore, we suggest the following:

- ~~Multiple~~ Two TAs for ~~UL~~ multi-DCI for multi-TRP operation, and corresponding DL timing requirements

~~- power control for UL single DCI for multi-TRP operation where unified TCI framework extension in objective 2 is assumed.~~

38 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility:

On objective #1 and #4:

If we need to down-select between objective #1 and #4, our preference is to support objective #1.

On scope reduction:

Objective #1: To reduce scope, we are ok to remove the second bullet of Objective 1 (Related to UE reporting of reporting of time-domain channel properties/Doppler based on CSI-RS)

Objective #4: Is low priority. Second bullet on SRS enhancements can be removed to trim scope. There have been sufficient SRS enhancements in the previous releases and we are unclear of the need for further SRS capacity and interference randomization enhancements. Also, need to limit the objective #4 to ideal backhaul, same # ports across TRPs, and focusing on indoor and small ISD deployments.

With scope reduction for CSI objectives #1 and #4, they can be combined in to one CSI objective.

2.4 Moderator Summary and Recommendation

2.4.1 Summary of Intermediate Round Email Discussion

2.4.1.1 Question on Objective 2

Companies' views are summarized as follows

Alt2-1. The above wording as is, i.e. to support multi-TRP, or rewording "focusing on multi-TRP use case"

- Support (36): Apple, APT, AT&T (focus), CAICT, CATT, CEWiT, CMCC, DT, Ericsson, H3C, Fraunhofer IIS/HHI, Futurewei (focus), Huawei/HiSi, IDC, Intel, KT Corp, Lenovo, LG, LG Uplus, MediaTek, NEC, Nokia/NSB, NTT Docomo (focus), OPPO, Samsung, Sharp, SKT, Sony, Spark, Spreadtrum, Verizon, Xiaomi, ZTE (focus)
- Serious concern: Qualcomm

Alt2-2. Add sTRP in addition to multi-TRP, i.e. to support multi-TRP and single-TRP

- Support (3): vivo, MotM, Qualcomm
- Serious concern: Intel

Proponents of Alt2-1 (at least 36 companies) mainly argue that sTRP has been the focus in Rel-17 and hence adequately supported. Including "sTRP" in objective 2 causes ambiguity in scope which can lead to additional and unpredictable amount of works during the WI phase – which goes against the spirit of containing the scope per RAN Chairman's instruction. In addition, some proponents of Alt2-2 are willing to accept rewording proposed by Samsung, i.e. "focusing on multi-TRP use case".

Two proponents of Alt2-2 argue that some additional optimization for sTRP (e.g. Qualcomm claiming sub-optimality in sTRP over Rel-15) can be beneficial although this is disputed by some of the comments (e.g. Ericsson and Intel claiming the case pointed out by Qualcomm is not used in practice even for Rel-15).

Given the overwhelming majority for Alt2-1 and that Alt2-1 is in fact a subset of Alt2-2 (thereby making Alt2-1 the common denominator between the two alternatives), fully taking into account the instruction on reducing the scope from the RAN Chairman, the moderator proposes that Alt2-1 be agreed with the minor rewording as follows:

Moderator Proposal on Objective 2:

Specify extension of Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states focusing on ~~to support~~ multi-TRP use case**,** using Rel-17 unified TCI framework

2.4.1.2 Question on Objective 3

Companies' views are summarized as follows

Alt3-1. The above wording as is, i.e. only for CP-OFDM

- Support (33): Apple, AT&T, CAICT, CATT, CEWiT, CMCC, DT, H3C, Fraunhofer IIS/HHI, Futurewei, Huawei/HiSi, IDC, Intel, KT Corp, Lenovo, LG, LG Uplus, MediaTek, NEC, Nokia/NSB, NTT Docomo, OPPO, Samsung (ok with 3-2 if limited), Sharp, SKT, Sony, Spreadtrum, Vodafone, Xiaomi, ZTE (ok with 3-2 if limited)

Alt3-2. Add sTRP in addition to multi-TRP, i.e. for CP-OFDM and UL DFT-SOFDM

- Support (4): Ericsson (if pi/2 BPSK is excluded + some restriction), Qualcomm, Verizon (agree with Ericsson), vivo

Proponents of Alt3-1 (at least 33 companies) mainly argue based on the work scope and limited motivation of increasing the number of orthogonal ports for DFT-SOFDM (used for coverage-limited scenarios, not for high multiplexing gain). Two proponents of Alt3-1 acknowledge, however, that the additional spec work for Alt3-2 can be small depending on the solution.

Three (out of four) proponents of Alt3-2 condition their supports on the exclusion of pi/2 BPSK and adding additional restrictions for DFT-SOFDM (originally proposed by Qualcomm):

Multiplexing capability of CP-OFDM with DFT-S-OFDM is to be retained. The scope of enhancements is to be limited to extending the OCC and/or cyclic shift space, and it should exclude adding new root sequences or new tone mapping.

Given the overwhelming majority for Alt3-1 and that Alt3-1 is in fact a subset of Alt3-2 (thereby making Alt3-1 the common denominator between the two alternatives), fully taking into account the instruction on reducing the scope from the RAN Chairman, the moderator proposes that Alt3-1 be agreed as follows (no change compared to the moderator proposal for start of intermediate round):

Moderator Proposal on Objective 3:

Study, and if justified, specify larger number of orthogonal DMRS ports for downlink and uplink MU-MIMO (without increasing the DM-RS overhead), only for CP-OFDM,

- striving for a common design between DL and UL DMRS
- Up to 24 orthogonal DM-RS ports, where for each applicable DMRS type, the maximum number of orthogonal ports is doubled for both single- and double-symbol DMRS

2.4.1.3 Question on Objectives 1, 4, 6, 7, and 8

Scope reduction (expansion not included) and wording refinement:

On objective 1, two companies suggest to remove the second bullet. One company suggests to add clarification "considering time-domain information" to the first bullet. One proponent company suggests to narrow down CSI-RS to TRS only.

On objective 4, one proponent company suggests to add two additional constraints to further focus the work and reduce the scope (ideal backhaul and synchronization, same number of ports across TRPs). One company suggests to remove the 2nd bullet.

On objective 6, one company suggests to include antenna structure/coherence assumption. Two companies suggest to clarify that TPMI (including codebook), SRI, and layer mapping enhancements are inevitably needed and hence should be captured to avoid ambiguities. Two companies suggest to narrow down the scope to >4 layers only (no spec change on <=4 layers). Two companies suggest 8Tx only, and one company coherent/partial-coherent CB-based prioritizing on CB-based.

On objective 7, one company suggests to include restriction on the number of TX ports to 1+1 and 2+2 (note: moderator is not sure what these numbers refer to). One company suggests to remove "device type" from the note to avoid misunderstanding while two companies suggest to remove the note altogether (unclear if RAN1/4 can do so) but one company still prefers to keep this. One company suggests to restrict to one CW, and 3 combinations of channel types (PUSCHx2, PUCCHx2, and PUSCH/PUCCH)

On objective 8, one company suggests to replace multiple with two, and remove the PC bullet since it is already covered in objective 2.

Down selection of objectives:

Most companies are supportive of (fine with) keeping all the five objectives. Many have expressed that the objectives 1 and 4 have been sufficiently or aggressively trimmed.

Two companies suggest to select only one of objectives 1 and 4, while a number of companies support to retain both. One company suggests to remove both. If 1 or 4 is to be selected, some companies prefer 1 while other 4.

Two companies propose to remove objective 6. Two companies propose to remove objective 7. Four companies (one operator) propose to remove objective 8.

Other comments simply reiterate previously stated positions on "high" priority items without specific proposals to further trim the scope of such priorities.

Furthermore, there are a number of suggestions to expand the scope (e.g. remove restrictions, add new components) of the five objectives which, unfortunately, are not aligned with the instruction received from the RAN Chairman.

In short, the views on down selection of objectives are diverging. Meanwhile, some of the additional constraints on objective 1 and 4 (although many have expressed that these two have been very much trimmed) as well as 6/7/8 can be incorporated to further focus the scope and are likely agreeable.

Therefore, the moderator proposes to refine the texts for objectives 1, 4, 7, and 8 as follows. The text for objective 6 is not refined since the suggestions are diverging and may not be agreeable to strong proponents of objective 6.

Moderator Proposal on Objective 1, 4, 7, and 8:

Objective 1:

Study, and if justified, specify CSI reporting enhancement for high/medium UE velocities by exploiting time-domain correlation/Doppler-domain information to assist DL precoding, targeting FR1, as follows:

- Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis
- UE reporting of time-domain channel properties measured via ~~CSI-RS (including~~ CSI-RS for tracking~~)~~

Objective 4:

Study, and if justified, specify enhancements of CSI acquisition for Coherent-JT targeting FR1 and up to 4

TRPs, assuming ideal backhaul and synchronization as well as the same number of antenna ports across TRPs, as follows:

- Rel-16/17 Type-II codebook refinement for CJT mTRP targeting FDD and its associated CSI reporting, taking into account throughput-overhead trade-off
- SRS enhancement to manage inter-TRP cross-SRS interference targeting TDD CJT via SRS capacity enhancement and/or interference randomization, with the constraints that 1) without consuming additional resources for SRS; 2) reuse existing SRS comb structure; 3) without new SRS root sequences
- Note: the maximum number of CSI-RS ports per resource remains the same as in Rel-17, i.e. 32

Objective 7:

Study, and if needed, specify the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, targeting FR2 and multi-TRP

- UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission
  - The total number of layers is up to four and total number of codewords is up to two, considering single DCI and multi-DCI based multi-TRP operation.
- UL beam indication for PUCCH/PUSCH, where unified TCI framework extension in objective 2 is assumed, considering single DCI and multi-DCI based multi-TRP operation
  - For the case of multi-DCI based multi-TRP operation, only PUSCH+PUSCH, or PUCCH+PUCCH ~~one physical channel/signal type~~ is transmitted across ~~different~~ two panels in a same CC.
- ~~Feasibility of target device type and Tx configuration shall be identified as part of the study.~~

Objective 8:

Study, and if justified, specify the following

- ~~multiple~~ two TAs for UL multi-DCI for multi-TRP operation
- power control for UL single DCI for multi-TRP-operation where unified TCI framework extension in objective 2 is assumed.

For the case of simultaneous UL transmission from multiple panels, the operation will only be limited to the objective 7 scenarios.

2.4.2 Recommendation

Considering the current status of discussion, the followings are proposed.

Proposal 1: Agree by email on the moderator proposals for objective 2 and 3 as below, considering that there are overwhelming majority (35 vs 3 for objective 2 and 33 vs 4 for objective 3), the instruction from RAN chairman to limit/reduce scope, and they reprsenting the agreeable common ground (intersection between two views).

Moderator Proposal on Objective 2:

Specify extension of Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states focusing on ~~to support~~ multi-TRP use case**,** using Rel-17 unified TCI framework

Moderator Proposal on Objective 3:

Study, and if justified, specify larger number of orthogonal DMRS ports for downlink and uplink MU-MIMO (without increasing the DM-RS overhead), only for CP-OFDM,

- striving for a common design between DL and UL DMRS
- Up to 24 orthogonal DM-RS ports, where for each applicable DMRS type, the maximum number of orthogonal ports is doubled for both single- and double-symbol DMRS

Proposal 2: Discuss in GTW session if any of the moderator proposals on the wording/scope of objective 1, 4, 7, and 8 can be agreed.

Moderator Proposal on Objective 1:

Study, and if justified, specify CSI reporting enhancement for high/medium UE velocities by exploiting time-domain correlation/Doppler-domain information to assist DL precoding, targeting FR1, as follows:

- Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis
- UE reporting of time-domain channel properties measured via ~~CSI-RS (including~~ CSI-RS for tracking~~)~~

Moderator Proposal on Objective 4:

Study, and if justified, specify enhancements of CSI acquisition for Coherent-JT targeting FR1 and up to 4 TRPs, assuming ideal backhaul and synchronization as well as the same number of antenna ports across TRPs, as follows:

- Rel-16/17 Type-II codebook refinement for CJT mTRP targeting FDD and its associated CSI reporting, taking into account throughput-overhead trade-off

- SRS enhancement to manage inter-TRP cross-SRS interference targeting TDD CJT via SRS capacity enhancement and/or interference randomization, with the constraints that 1) without consuming additional resources for SRS; 2) reuse existing SRS comb structure; 3) without new SRS root sequences
- Note: the maximum number of CSI-RS ports per resource remains the same as in Rel-17, i.e. 32

Moderator Proposal on Objective 7:

Study, and if needed, specify the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, targeting FR2 and multi-TRP

- UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission
    - The total number of layers is up to four and total number of codewords is up to two, considering single DCI and multi-DCI based multi-TRP operation.
- UL beam indication for PUCCH/PUSCH, where unified TCI framework extension in objective 2 is assumed, considering single DCI and multi-DCI based multi-TRP operation
    - For the case of multi-DCI based multi-TRP operation, only PUSCH+PUSCH, or PUCCH+PUCCH ~~one physical channel/signal type~~ is transmitted across ~~different~~ two panels in a same CC.
- ~~Feasibility of target device type and Tx configuration shall be identified as part of the study.~~

Moderator Proposal on Objective 8:

Study, and if justified, specify the following

- ~~multiple~~ two TAs for UL multi-DCI for multi-TRP operation
- power control for UL single DCI for multi-TRP-operation where unified TCI framework extension in objective 2 is assumed.

For the case of simultaneous UL transmission from multiple panels, the operation will only be limited to the objective 7 scenarios.

Proposal 3: Continue discussion on the wording and potential scope reduction for objective 6.

3 Final Round

It is necessary to continue discussion on objectives 1, 4, 6, 7, and 8 in the final round.

The latest status of the text for objectives 1, 4, 6, 7, and 8 in intermediate round is as follows, where changes marks are kept.

Objective 1:

Study, and if justified, specify CSI reporting enhancement for high/medium UE velocities by exploiting time-domain correlation/Doppler-domain information to assist DL precoding, targeting FR1, as follows:

- Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis
- UE reporting of time-domain channel properties measured via ~~CSI-RS (including~~ CSI-RS for tracking~~)~~

Objective 4:

Study, and if justified, specify enhancements of CSI acquisition for Coherent-JT targeting FR1 and up to 4 TRPs, assuming ideal backhaul and synchronization as well as the same number of antenna ports across TRPs, as follows:

- Rel-16/17 Type-II codebook refinement for CJT mTRP targeting FDD and its associated CSI reporting, taking into account throughput-overhead trade-off
- SRS enhancement to manage inter-TRP cross-SRS interference targeting TDD CJT via SRS capacity enhancement and/or interference randomization, with the constraints that 1) without consuming additional resources for SRS; 2) reuse existing SRS comb structure; 3) without new SRS root sequences
- Note: the maximum number of CSI-RS ports per resource remains the same as in Rel-17, i.e. 32

Objective 6:

Study, and if justified, specify UL DMRS, SRS to enable 6 and 8 Tx UL operation to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

- Note: Potential restrictions on the scope of this objective will be identified as part of the study.

Objective 7:

Study, and if needed, specify the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, targeting FR2 and multi-TRP

- UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission
    - The total number of layers is up to four and total number of codewords is up to two, considering single DCI and multi-DCI based multi-TRP operation.
- UL beam indication for PUCCH/PUSCH, where unified TCI framework extension in objective 2 is assumed, considering single DCI and multi-DCI based multi-TRP operation
    - For the case of multi-DCI based multi-TRP operation, only PUSCH+PUSCH, or PUCCH+PUCCH ~~one physical channel/signal type~~ is transmitted across ~~different~~ two panels in a same CC.
- ~~Feasibility of target device type and Tx configuration shall be identified as part of the study.~~

Objective 8:

Study, and if justified, specify the following

- ~~multiple~~ two TAs for UL multi-DCI for multi-TRP operation
- power control for UL single DCI for multi-TRP-operation where unified TCI framework extension in objective 2 is assumed.

For the case of simultaneous UL transmission from multiple panels, the operation will only be limited to the objective 7 scenarios.

3.1 Question on Objectives 1, 4, 7, and 8

Please share your views on any additional *wording refinement* and/or potential *scope reduction* (please, no proposal on scope expansion, following instruction from RAN Chairman) on the latest wording of objectives 1, 4, 7, and 8.

- Note: This doesn't imply that objectives 1, 4, 7, and 8 are automatically included in the WID. The goal is to finalize the scope of each objective with sufficient clarity to facilitate final decision whether or not to include them in the WID.

Feedback Form 13:

1 – Samsung Research America

Re **objectives 1 and 4**, as we said in the last round, these two proposals have been aggressively trimmed in terms of scope. After adding even more constraints (the above revised version from the moderator), these two objectives are by far the most aggressively trimmed, narrowest, and the most specific scope-wise compared to, e.g. 6, 7, 8. The current wording and scope are clear, and can be finalized. Briefly repeating our view, we **propose to include BOTH these two objectives 1+4 in the WID in this version.**

Re **objectives 7**, the current wording and scope seem clear although we are open to further refinement (wording, scope reduction), if any The 3rd bullet (removed by the moderator) can perhaps be reinserted with different formulation. We understand the concern from, e.g. Ericsson, that this may not manifest in any normative work in RAN1/4. But perhaps some reformulation in terms of ”target devices” similar to objective 6 can be used. The intention from MediaTek is to ensure that the types of devices for this STXMP feature (an advanced feature) are aligned with the context of the associated enhancements.

Re **objective 8**, the current wording and scope seem clear although we are open to further refinement (wording, scope reduction), if any,

2 – vivo Communication Technology

Regarding **objective 1**, we have commented multiple times that SRS configuartion enhancement is essential for reciprocity based operation. In current spec (38.214) following is specified ”For 1T=1R, or 2T=2R, or 4T=4R, up to **two SRS resource sets each with one SRS resource,** where the number of SRS ports for each resource is equal to 1, 2, or 4.” Increased number of SRS resource sets e.g. 4 or 6 for 1T=1R, or 2T=2R, or 4T=4R is straighforward enhancement and if the max number 4 or 6 is captured in WID, this is already RAN1 level agreement, which doesn’t consume any fraction of TU.

Regarding **objecetive 7**, proposal from moderator captures ”UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission”. As we commented in initial and intermediate round, **this could lead to maximum 8Tx UL transmission** with 2 panels if there are 4 Tx on each panel, this should be excluded. For example, thare are 2 panels for simultaneous transmission, then it could be 1 port panel, or 2 ports per panel. Hence, further restriction should be placed, ”UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission **with assumption of total number UL antenna ports is 2 or 4**”. And, we haven’t received clarification on up to two codewords is intended for sDCI or mDCI based mTRP operation.

3 – Samsung Research America

@vivo on objective 7:

- Now we finally understand your previous proposal :-) (i.e.1+1 = 1 port per panel and 2+2 = 2 ports per panel) Your proposed additional restriction makes sense considering FR2 as a target of this objective.
- My understanding of the ZTE text proposal (ZTE can correct me) is that ”up to 2 CWs” is intended for sDCI

4 – Samsung Research America

@vivo on objective 1: Given that so much spotlight is being put on objectives 1+4 (despite the fact that the proponents of 1 and 4 have been taking extensive measures to aggressively trim the scope), from Samsung perspective, unfortunately we are reluctant to expand the scope by any amount - which, due to the spotlight, could lead to unintended outcome for objectives 1+4.

5 – ZTE Corporation

Regarding objective-7, from our perspective, the up to 2 CWs applies to SDCI (same views with Samsung) and is definitely needed for facilitating simultaneous transmission cross multiple panels, but, of course, we are open to consider MDCI herein as mentioned in the sub-bullet ('…., considering single DCI and multi-DCI based multi-TRP operation.'). Some further justification should be handled in RAN1 WG. Similarly, as in restriction bullet, up to 4 layers apply per PUSCH, regardless of SDCI or MDCI scheme, and then the UE may provide its individual capabilities within the feature.

Regarding objective-8, as we mentioned before, the one important target of **power control for UL single DCI for multi-TRP operation** is relevant to objective-7, i.e., simultaneous Tx by single DCI. Compared with already Rel-17 TD-repetition for PUCCH/PUSCH or unified TCI framework, in such case, we need to further consider how to handle **more than one** PC settings/PL-RSs and corresponding power control procedure for a **single UL channel (PUSCH/PUCCH).** We may experience functionality enhancements for power control, rather than just signaling more than one settings. Therefore we disagree that this bullet of power control in objective-8 has already been in the scope of Objective 2, which, of course, may have own power control enhancements, if needed, as usual. BTW, being merging with objective-7 or not may be just editorial issues especially with the current note in objective 8, and we prefer to current version considering that it has been well reviewed for several rounds.

6 – NTT DOCOMO INC.

We're okay with current scope of Objective 1,4,7,8.

But, generally we believe UL enhancement objectives (e.g., 6,7,8) have higher priority than DL enhancement objectives, because UL enhancement is very important for Rel.18.

7 – HuaWei Technologies Co.

As mentioned by many companies in previous rounds, Coherent joint transmission is very important in practical scenarios. The current version of Objective 4 and Objective 1 are aggressively trimmed, where the scope seems smaller than other objectives already. So, Objective 4 and 1 should be acceptable, **we support both Objective-1 and 4 with current version.**

For Objective 7 and 8, the two objectives were discussed several rounds as well, different companies may have different considerations on priority or implementation. But, current wording for Objective 7 and 8 is also limited with reasonable constraints. So, as a compromise, **we also can support the current version of Objective 7 and 8.**

8 – New H3C Technologies Co.

We are fine with current revised description of Objective 1,4,7,8.

9 – China Telecommunications

We support current Objective 1 and 4.

10 – Sony Group Corporation

On Objective 7, we are generally fine with the revision from moderator.

For UL precoding, we would like to repeat our concern that inter-panel coherent Tx should be considered as well, i.e. no constraint on UL codebook design at current stage.

For UL beam indication with mDCI based mTRP, it says only PUSCH + PUSCH, or PUCCH + PUCCH is transmitted across two panels in a same CC. Our understanding is that up to 2 panels can be used for

simultaneous UL transmission, targeting up to 2 TRPs, while Objective 4 can support up to 4 TRPs. It seems not well aligned. If companies are not incline to limit the maximum number of UE panels as 2 for STxMP in RANP level, we could suggest to add an ”e.g.” in front of this case.

11 – SK Telecom

We support Objective #1 and #4 of current versions. We think that the current versions are clear.

12 – CEWiT

After multiple iterations of trimming the scope of Objective 1 & 4, we believe it is in right shape to maintain the workload. So we support the current Objective 1 & 4 as such. Also we have no objection towards Objective 7 & 8

13 – LG Electronics France

- Regarding FR2, we still think it is not necessary to exclude FR1 in the work. Does “targeting FR2” mean excluding FR1 from the scenario? If not, we think it is better to say “focusing on”.

- Regarding physical channel combinations for simultaneous transmission, we think SRS+SRS should be also included if we are to list up the combinations explicitly.

14 – LG Electronics France

Sorry, just to clarify my comment above was regarding objective 7.

15 – Guangdong OPPO Mobile Telecom.

There are many companies having strong interests on Objective 1 and 4. Moreover, after several round of discussion, the scope of Ojbective 1 and 4 is quite focused. Thus, we think it is reasonable to include both of them in the WID.

In summary, we are supportive of these objectives (i.e., 1,4,7,8).

16 – Intel Corporation (UK) Ltd

We support current formulation of objective 1, 3, 7 and 8.

Several comments:

1. We think that all technical concerns related to feasibility of implementation of the enhancement on certain device types (UE power classes) should be handled as part of RAN4 discussion. From this perspective capturing device types for objective 6 and 7 as part of RAN1 objective is not critical. We are open to mention this aspect (i.e. applicable device types or UE power classes) as part of RAN4 objective to address company’s concerns.

2. Regarding vivo’s comment on SRS enhancement for objective 1. We technically agree with the proposal. However, given situation with limited TUs, we propose to consider further enhancement for high mobility scenarios (including SRS) in the next NR releases.

3. Reagrding vivo’s comment on objective 7. We think current formulation suggest that there are at most 4 MIMO layers and at most 2 CWs across all PUSCHs. This understanding should be straightforward due to word ”total”.

17 – Spark NZ Ltd

We are in support of Objective 1 and 4 together agree to include them in scope.

18 – Intel Corporation (UK) Ltd

There is typo in our earlier reply, that should be corrected as follows: ”We support current formulation of objective 1, ~~3,~~ 4, 7 and 8.”

19 – Spreadtrum Communications

We support the current form of Objective 1 & 4.

20 – LG Uplus

We support the current version of Objective 1, 4, 7 & 8 from moderator.

21 – MediaTek Inc.

Objective 1 and 4 proposals look ok.

Objective 7: Regarding the issue about device types in Objective 7, as some companies did not like the previous text, we would propose to add one of the following options:

Option 1: ”This objective is only targeting CPE/ FWA/vehicle/Industrial devices.”

Option 2: ”Whether or not this objective shall target only CPE/ FWA/vehicle/Industrial devices shall be decided as a part of the study.”

Please note that for Objective 6 we clarified the target device types.

MediaTek will strongly object to having no clarification on applicable device types as part of this study. So if companies are not happy with Option 1, then Option 2 can be seen as a compromise.

22 – Telstra Corporation Limited

We are ok with objectives 1,4,7,8 as proposed

23 – NEC Corporation

We support moderator proposed objectives 7 and 8.

24 – CAICT

We support the the objectives 1,4,7,8.

25 – Nokia Corporation

Formulation of objectives is good in general, and whatever objectives we agree to pursue further are expected to be in their current form. In any case we must say our understanding is that the WID is too heavily loaded and that limits our ability to make thorough and meaningful work on all objectives. The heavy trimming mentioned by many is an evidence of that. As mentioned before, we think priority should be given to UL-related objectives, i.e. 2, 3, 6, 7, 8.

26 – Asia Pacific Telecom co. Ltd

We are supportive of objectives 7 and 8.

27 – TELECOM ITALIA S.p.A.

To move forward we can accept the moderator’s proposal on 1, 4, 7 and 8 plus obj 6, with clear priority on UL enhancements

28 – KT Corp.

KT would like to support current objective 1, 4 and 7.

29 – CATT

We are supportive of objective 1, 4 and 7.

30 – China Unicom

Coherent joint transmission is very important in practical scenarios, we support the current version of objective 4 and 1.

31 – Xiaomi Communications

For objective1 and 4, we support these two objectives since the scope in the latest version is clear and limited.

We also support the current verson of objective 7 and 8.

32 – ROBERT BOSCH GmbH

We are fine withObjective 1, 4, and 8.

Regarding **objective 7**; we cannot support excluding FR1 and targeting FR2 only. In our understanding, **Objective 7** was mainly useful feature for some UE types, including vehicle UEs, i.e., for improving reliability/throughput. Commercially, we do not have FR2 supported vehicle connectivity, and vehicular communication may continue using FR1 for quite some years.

Therefore, if we need ST and MP to be commercially useful for automotive, we prefer to delete restriction to FR2 or, otherwise, remover vehicles from the target UE examples.

33 – Deutsche Telekom AG

We support 1, 6 and 7 (with the removal of FR2 restriction as proposed by Bosch)

34 – VODAFONE Group Plc

We support the current scope for objective 1. Keeping this objective is still the highest priority for us overall. Whilst we agree with Vivo that SRS configuration enhancement is key for reciprocity based operation, given the situation with limited TU's it is perhaps best to consider this in a later release. We would rather not see objective 1 dropped altogether because of scope expansion, as Samsung eluded to.

Whilst we agree that UL enhancement is important for rel-18, objective 7 is lowest priority from our perspective considering the UL gains will be limited to FR2 scenarios. We prefer to focus on FR1 UL enhancements that can benefit the wider network overall.

35 – Ericsson LM

We support the moderator edits for the final round

36 – AT&T

We support the current formulation of objectives 1,4, 7, and 8. To reiterate our previous views, objective 4 has been considerably trimmed so far and should be included in the WID. Objective 7 formulation from the moderator makes the objective more focused and should be included in the WID, we share the view of Intel that discussion on device type can be handled by RAN4 discussion.

37 – China Mobile Com. Corporation

As commented before, CJT is promising for cell edge and cell average performance improvement. We support the current version of objective 4.

Considering the workload, we suggest to further reduce the scope of objective 1. Since UE reporting of time-domain channel properties can be applied to both TDD and FDD, we prefer the following modification

Objective 1:

Study, and if justified, specify CSI reporting enhancement for high/medium UE velocities by exploiting time-domain correlation/Doppler-domain information to assist DL precoding, targeting FR1, as follows:

- ~~**Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis**~~
- UE reporting of time-domain channel properties measured via ~~CSI-RS (including~~ CSI-RS for tracking~~)~~ **with reusing R17 CSI-Reporting framework**

38 – Fraunhofer IIS

As stated in the previous round we are in general supportive of Objective 1,4,6,7, and 8. The Objective #1 and #4 have been down-scoped/trimmed aggressively as requested by the RAN chair and can be considered with this reasonable work load for the WID. For the other objectives there maybe still room for down scoping.

As the majority of companies agreed to the formulation of objective 1 it is reasonable to remain as follows:

Study, and if justified, specify CSI reporting enhancement for high/medium UE velocities by exploiting time-domain correlation/Doppler-domain information to assist DL precoding, targeting FR1, as follows:

· Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis

· UE reporting of time-domain channel properties measured via ~~CSI-RS (including~~ CSI-RS for tracking~~)~~

39 – MediaTek Inc.

@Intel/AT&T, Option 7. So if we take MediaTek Option 2 approach, RAN4 would need to identify whether this is applicable to other device types during the study phase, because MediaTek would like to understand the overall target usage of this feature before RAN1 goes ahead and designs it.

Otherwise, if nobody wants to spend time on that, then we just indicate the MediaTek proposed Option 1 approach and keep it simple.

40 – Futurewei

We are supportive of the current version of Objectives 1, 4, and 7.

Regarding Objective 8, our view is that both sDCI and multi-DCI should be included for multiple TAs. However, for the sake of progress, we can accept the current version of Objective 8.

41 – MediaTek Inc.

@ #37 - We believe that the Objective 1 should remain as it is, as it seems quite stable now. Down-scoping it further at the last minute is not reasonable in our view.

42 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility:

On objective #1 and #4:

If we need to down-select between objective #1 and #4, our preference is to support objective #1.

Objective #1: We support objective #1 and limiting the scope of measuring channel properties to CSI-RS for tracking only. If need to reduce scope further due to TU limitation, we support to remove the second bullet - UE reporting of time-domain channel properties measured via CSI-RS for tracking.

Objective #4: Is low priority. Second bullet on SRS enhancements can be removed to trim scope.

Objective #7: On wording refining, we support Qualcomm's proposal on one CW per PUSCH for the first sub-bullet of first bullet.

Objective #8: The power control bullet can be removed as panel/beam-specific power control is supported in Rel-17.

43 – InterDigital France R&D

Objectives 1&4:

We maintain our concern that we cannot afford both objectives in Rel-18 even after the proposed down-scoping. As also expressed by other companies, UL enhancements should be priority in Rel-18. Without Objectives 1&4, the allocated 3TU is already tight, and it would be best to remove both objectives. Having said that if one is to be selected, based on the level of expressed support and interest, Objective 4 seems to be a better choice at this point.

Objectives 7&8: We support the proposed updated scope by the moderator.

44 – Verizon UK Ltd

We support objectives 1,4, 7, and 8. For objective 4, we agreed that it has been trimmed enough to be included in the WID.

45 – SHARP Corporation

We support objectives 1,4, 7, and 8.

46 – Telia Company AB

We support moderator's proposal on 1, 4, 7 and 8. Higher priority on UL enhancements still reminded.

47 – Qualcomm Incorporated

Regarding Objective 4, as a further scope reduction, we propose to add the limitation that the up to four TRPs are associated with no more than two distinct QCL sources. This is because TCI indication for PDSCH with more than 2 TCI states is not supported in Rel-16/17 and considering more TCI states for CSI-RS is not meaningful in the absence of corresponding enhancement for PDSCH.

Regarding Objective 7, it should be clarified that "total number of codewords is up to two" is only applicable to multi-DCI. For single-DCI, CW/layer mapping change for UL would be needed with two CWs, which would result in a substantially increased scope. Also, CW-to-layer mapping was discussed before, and we do think it is appropriate to bring it back again through either Objective 6 or Objective 7. As an additional note regarding the organization of the work, the text "unified TCI framework extension in Objective 2 is assumed" will obviously result in a delay for Objective 7, as Objective 2 needs to be stable for this work to even start.

Regarding Objective 8, power control is still unclear as the intention from companies seem to be either related to Objective 2 (power control with unified TCI) or Objective 7 (simultaneous Tx). Such inter-dependency between distinct objectives does not help with the efforts of trying to reduce the scope.

48 – Samsung Research America

In terms of inclusion in the WID, we support the inclusion of objectives 1, 4, 7, and 8. In addition, the above texts from the moderator are acceptable to us. Re objective 7, we are fine with some additional clarification (same scope) on 2 panels and 2 TRPs proposed above by several companies (this doesn't seem to reduce the scope, but at least it brings clarity).

Finally we would like to comment that while the resulting workload seems imposing and challenging, it can be observed that there is some common parts among several objectives which can lend itself to lessen the work with some proper WG-level work management. Therefore, while we acknowledge the significant challenge given 3 TUs (and potential eMeeting style for the early part of Rel-18), our view is that the resulting scope is doable,

49 – Samsung Research America

@Qualcomm re inter-dependency of objectives 7 and 8, also dependence of 7 and 8 on objective 2, it seems your concern on delay is rooted in the assumption that the three objectives will be managed in the WG level as 3 separate agenda items. As we noted above, due to some common parts, proper WG-level work management can reduce workload. We would like to add that this can also avoid the potential delay you mentioned. Note that this is not a unique problem in MIMO - it has taken place in Rel-16 and Rel-17, and was handled successfully.

50 – Samsung Research America

@Qualcomm re objective 4, since QCL/TCI enhancement is clearly out of scope here, it doesn't seem necessary to introduce "no more than 2 distinct QCL sources" - especially since the text has been stable for a while. In addition, this could cause some confusion that some QCL/TCI work is needed. Thanks

3.2 Question on Objective 6

During the intermediate round, regarding objective 6,

- Several proposals were made on wording and potential scope reduction for objective 6. Some examples include: 1) max number of layers = 4 vs 8; 2) 6Tx and 8Tx vs. 8Tx only; 3) CB-based + NCB-based vs

CB-based only vs NCB-based only; 3) For CB-based, coherence assumption; 4) for >4 layers, reuse the existing DL CW-to-layer mapping

- Several scope clarification proposals were made, including: 1) adding "SRI, TPMI (including codebook) enhancements", 2) adding "CW-to-layer mapping enhancement"

Please share your views on the above two issues.

- Note: This doesn't imply that objective 6 is automatically included in the WID. The goal is to finalize the scope of each objective with sufficient clarity –to facilitate final decision whether or not to include them in the WID.

Feedback Form 14:

1 – Samsung Research America

Re **scope clarification**, we agree that SRI and/or TPMI need to be added - depending on whether both codebook-based and non-codebook-based UL transmission schemes are extended to port/layer configuration in objective 6. SRI enhancement is needed for non-codebook UL TX (increased bitwidth of SRI, upgrade on the max number of ports per SRS resource and/or resources per resource set, and max number of resource sets) while TPMI enhancement (including increased bitwidth of TPMI and perhaps TPMI format depending on codebook structure, codebooks for 6/8Tx) is needed for codebook-based UL TX.

2 – ZTE Corporation

Regarding issue 1 (scope reduction), we have the following reply

- For #1, we share the same views with many companies, including operators, that more than 4 layers are definitely needed, otherwise the motivation/benefits of the whole objective become very weak. For progress, we are fine to have the QC's suggestion of replacing 'to support more than 4 layers' with 'to support 4 or more layers', which seems reasonable.

- Then, for #2, #3 and #3', we believe that CB and nonCB transmission should be both considered, and then UE antenna framework and coherent-assumption are a very detailed issue (much relevant to subsequent products in 3 years) and definitely should be left to RAN WGs for further justification. If have to, from our perspective, coherent-type/partial-coherent-type should be prioritized, and 6Tx and 8Tx should be treated equally as a starting point.

- Finally, for 4, support of 4 or less layers at 6Tx and 8Tx is straightforward and necessary, we prefer not to touch detailed solution. Considering that there are many differences between DL and UL transmission, it is difficult for us to understand the exact meaning of 'reusing…' herein.

Regarding issue 2 (scope clarification), we have the following reply

- For 1, we can support it. We share the same views with above comments from Samsung.

- For 2, we can support it. Then, considering the previous discussion, if all companies are on the same page that CW-to-layer mapping enhancement can be considered with the assistance of 6 and 8 Tx transmission by default, we can be a little bit flexible for adding it or not.

Based on above, we have the following suggestion for Objective 6.

Objective 6:

Study, and if justified, specify UL DMRS, SRS, **SRI, and TPMI (including codebook) enhancements** to enable 6 and 8 Tx UL operation to support **4 or** more ~~**than 4**~~ layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

- Note: Potential restrictions on the scope of this objective **(e.g., coherence assumption)**, will be identified as part of the study.

3 – vivo Communication Technology

To further reduce the scope, number of supported layers is restricted max 4 is reasonable, even in DL more than 4 layers is never used.

It is better to have restriction on coherence assumption in the WID in order to save time and effort during SI phase.

4 – NTT DOCOMO INC.

- More than 4 layers are needed, otherwise the motivation/benefits is too small. Supporting more than 4 layers can improve the peak UE throughput for uplink.
  - On the other hand, we understand Qualcomm's concern. Since we don't intend to mandate UE with 6/8Tx to support 6/8 rank, we are fine to have the UE capability to indicate up to 4 rank.
- We believe that CB and NCB transmission should be both considered.
- Coherence assumption can be discussed in WG level.
- "SRI, and TPMI (including codebook) enhancements" should be included in WID for clarification.
- **We support the original objective 6, and we also support the following modification**

  Objective 6:

  Study, and if justified, specify UL DMRS, SRS, **SRI, and TPMI (including codebook) enhancements** to enable 6 and 8 Tx UL operation to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices
  - Note: Potential restrictions on the scope of this objective **(e.g., coherence assumption)**, will be identified as part of the study.
  - **Note: it does not imply that all 6/8 Tx UEs are mandated to support more than 4 layers.**

5 – HuaWei Technologies Co.

For Objective-6, we can support more than 4 layers for high data rate in the enhancement, which is the motivation from commercial deployment. Changed to 4 or more layers seems confusion. So, we can support ZTE's version with "or" changed to "and", or using the original wording.

6 – New H3C Technologies Co.

Regarding Objective 6, we support more than 4 layers for UL MIMO enhancement with potential demand from market so we prefer current description with ZTE's modification

7 – China Telecommunications

We support ZTE's version of Objective 6.

8 – Sony Group Corporation

On Objective 6, we think it's the essential part of UL enhancement for Rel.18 MIMO.

Regarding UL precoding and beam indication, we believe the addition of SRI and TPMI from ZTE looks more concrete on the scope. We are supportive to it. And the note added by DCM on optional support of >4 layers for UEs with 6/8 Tx is also reasonable in our view.

9 – Spreadtrum Communications

ZTE's revised proposal is fine for us. More than 4 layers is important for this feature, and we don't need to mention 4 or less layers because it's not reasonable that UE should always transmit PUSCH with >4 layers if it supports >4 Tx. Maybe we can change 'more than 4 layers' to 'up to 8 layers'.

10 – CEWiT

Regarding Issue list 1 :

- max number of layers - We believe since the target devices is supporting upto 8 Tx antennas, having more than 4 layers is very natural to exploit the rank benefit.
- We are fine including both 6Tx and 8Tx , considering the design scope is similar
- If relevant enhancements are handled for SRI field in the DCI and SRS configurations, NCB will be very beneficial. So we support handling both NCB and CB
- As the coherence assumption primarily affects the codebook design and so we have no issues in including it as an eg.
- For CW mapping, we believe making any assumption now is pre-mature and leave it for the study.

Regarding Issue list 2 :

- Since SRI and TPMI enhancements are obvious considering we agree for SRS enhancements adapting to 6Tx and 8Tx, we agree to include them
- Regarding CW mapping , as mentioned in the previous issue list, we believe making any assumption now is pre-mature . So we agree to include it as a part of the study.

11 – Guangdong OPPO Mobile Telecom.

The uplink enhancement is the most important part of R18 MIMO. Accordingly, a relatively complete design for Objective 6 is quite beneficial for UL data rate boosting.

1. We support to up to 8 layers PUSCH transmission. High-layer UL transmission is the key enabler to better data rate. If the max number of layers is restricted to 4, there is no motivation for a UE to support 6Tx/8Tx.

2. 8Tx has higher priority. Meanwhile, We can keep open to 6Tx.

3. At least CB-based PUSCH should be supported since it is the most popular scheme for NR UEs. The non-codebook based PUSCH is not widely used for commercial UEs. Thus, it is not reasonable to support NCB-based PUSCH only. In summary, we are ok with either CB-based only or CB-based + NCB based.

4. Regarding the coherent assumption, we support to include full coherent, partial-coherent and non-coherent. These types of coherent assumption have been adopted to 4Tx transmission. It is straightforward to support them. Supporting of different UE implementation will encourage the emergence of more UE with more than 4 UL layers

Since we think CB-based PUSCH should be supported, the component ”SRI, TPMI (including codebook) enhancements” cannot be missing. Otherwise, the system cannot support CB-based PUSCH with more than 4 layers.

12 – Intel Corporation (UK) Ltd

We support ZTE’s revision of Objective 6 with small revision. We think it is also important to discuss whether non full power mode should be also considered.

Objective 6:

Study, and if justified, specify UL DMRS, SRS, **SRI, and TPMI (including codebook) enhancements** to enable 6 and 8 Tx UL operation to support **4 or** more ~~**than 4**~~ layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

- Note: Potential restrictions on the scope of this objective **(e.g., coherence assumption, full / non full power modes)**, will be identified as part of the study.

13 – Ericsson LM

Currently, the scope of objective implies that RAN1 needs to define solutions and codebooks for at least the following configurations of the UE. To add on top of this is potential differences for FR1 and FR2. Since the device form factor is unknown, it is not known whether the antennas are directional and whether they are placed in a linear uniform array or if they are spread out across in device, pointing in different directions. This needs to be known to define a codebook. Since this is an uncertainty, RAN1 need to make assumptions, at least two antenna configurations should be made by RAN1 to make specifications less sensitive to implementation, denoted here as (A,B,C,D).

Clearly, this is too much for RAN1 to manage in one release, so we urge proponents to significantly reduce the scope if this objective is to be included in the WID.

14 – NEC Corporation

We support to add “SRI, TPMI enhancements” to make the scope clear.

15 – Ericsson LM

To further elaborate on our comment, our understanding is that these are the 20 combinations RAN1 will have to look at:

- Non-codebook for 6 TX for 1-6 layers
- Non-codebook for 8 TX for 1-8 layers
- Non-coherent codebook for 6 TX for 1-6 layers, full power Mode 0
- Non-coherent codebook for 8 TX for 1-8 layers, full power Mode 0
- Non-coherent codebook for 6 TX for 1-6 layers, full power Mode 1
- Non-coherent codebook for 8 TX for 1-8 layers, full power Mode 1
- Non-coherent codebook for 6 TX for 1-6 layers, full power Mode 2

- Non-coherent codebook for 8 TX for 1-8 layers, full power Mode 2
- Partially coherent codebook for 6 TX for 1-6 layers for antenna placement assumption A, full power Mode 0
- Partially coherent codebook for 6 TX for 1-6 layers for antenna placement assumption B, full power Mode 0
- Partially coherent codebook for 8 TX for 1-8 layers for antenna placement assumption C, full power Mode 0
- Partially coherent codebook for 8 TX for 1-8 layers for antenna placement assumption D, full power Mode 0
- Partially coherent codebook for 6 TX for 1-6 layers for antenna placement assumption A, full power Mode 1
- Partially coherent codebook for 6 TX for 1-6 layers for antenna placement assumption B, full power Mode 1
- Partially coherent codebook for 8 TX for 1-8 layers for antenna placement assumption C, full power Mode 1
- Partially coherent codebook for 8 TX for 1-8 layers for antenna placement assumption D, full power Mode 1
- Fully coherent codebook for 6 TX for 1-6 layers for antenna placement assumption A, full power mode 0
- Fully coherent codebook for 6 TX for 1-6 layers for antenna placement assumption B, full power mode 0
- Fully coherent codebook for 8 TX for 1-8 layers for antenna placement assumption C, full power mode 0
- Fully coherent codebook for 8 TX for 1-8 layers for antenna placement assumption D, full power mode 0

16 – KDDI Corporation

Regarding Issue 1:

- we think that the performance gain of UL becomes too small if the maximum number of layers is limited to 4, so more than 4 layers are needed.
- We believe that CB-based and NCB-based transmission should be both studied.
- For coherence assumption and CW mapping, making any assumptions is premature, so we think that we should make decisions based on the study.

Regarding Issue 2:

- we think that “SRI, and TPMI (including codebook) enhancements” should be included in WID.

17 – MediaTek Inc.

We propose to keep the scope Objective 6 scope to 4 layers. We had understood from the previous discussion that there may not actually be that much benefit in going to >4 layers, and doing that would mean higher cost for not much gain.

However, if companies plan to go to >4 layers, we agree with others that we would need to include **SRI, and TPMI (including codebook) enhancements.**

18 – Asia Pacific Telecom co. Ltd

We are supportive of ZTE's version. DOCOMO's note is acceptable to us as well.

19 – Nokia Corporation

We think the scope is good actually, and much more detailed than what is proposed in similar type of objectives in other work items under discussion already. It seems that the main reason we are discussing further narrowing down the scope is because we are assuming an overloaded WID with too many objectives, and that hurts our ability to make thorough work on each individual objective. Having said that, we have the following considerations on the scope, and on how to narrow it down further.

The main point linking all the necessary design elements together is the number of layers, and on this objective we believe 8 layers is the right goal. One may see it ambitious, but in practice products will scale towards 8 or less layers, with the actual number of layers to be based on their capabilities, whether we define it explicitly in the WID or not. Also, we do not have the luxury to increment the number of layers in every release, so better to use the group's expertise in one exercise, in a scalable manner.

One aspect where we can perhaps simplify matters is by focusing on some specific number of Tx antennas, i.e. drop optimizations for 6TX from the scope. On the codebook side we would prefer to prioritize NCB-based, considering the specification effort CB would bring and the difficulty to find practical arrangements of antenna arrays at UE side that would be agreeable to all. Other enhancements in the areas of SRI, etc, should be left to the RAN1 study as these are hard to foresee before the work is being started and we should not pre-empt RAN1 work in RAN by making technical selections here.

Finally we would like to remind this is a "study and if needed..." objective, and once focus directions are clear RAN can further narrow down the scope *before* the normative phase of this objective, including aspects such as full power modes etc. This applies to all other such type of objectives in this WID too, naturally.

20 – LG Uplus

ZTE's version of this round is agreeable. SRI and TPMI would be essential in the intention of objective 6. One small concern is that we are not sure whether 6TRx is critical.

21 – TELECOM ITALIA S.p.A.

We tend to agree with Nokia comments.

In addition, in practical applications, we believe the antenna configuration may not be defined and adopting an antenna configuration in the study is going to severely limit the development of this kind of devices. Therefore we suggest to limit / prioritize to non-codebook operation, with the hope this will also greatly reduce the workload

22 – China Unicom

We support the objective 6 updated by ZTE.

23 – Xiaomi Communications

We support Objective 6. Either ZTE's version or Intel's version is fine to us.

24 – ZTE Corporation

Thank you so much for constructive discussion. We are also fine with Huawei's nice suggestion and DOCOMO's newly added notes, both of which try to clarify the scope well.

Regarding Ericsson's comments, we fail to understand which's the exact meaning of antenna placement assumption A D, and not sure why we need to consider so many combination cases herein. Generally speaking, NR is always striving to have a unified solution which can apply to different types or combination as a baseline, rather than an individual solution per combination (like one type of DL-CSI codebook can well apply to different types of gNB Tx), and we do believe this principle will apply to this objective-6 by default. For instance, we do not understand why we need to redesign full power features (i.e., mode0/1/2) for respective combinations for 'TX configuration, layers, and antenna placement assumption', and reusing current solution as much as possible seems straightforward. We do share the same views with Nokia that we should not pre-empt RAN1 work in RAN by making technical selections herein.

Based on above companies' inputs, having both CB and nonCB as a starting point seems to have good majority support (due to nearly all of companies supporting the addition of 'SRI and TPMI' including some opponents). It should be noticed that, for current NR system, it seems that only CB based transmission is in the market now.

From our perspective, UE antenna framework and coherent-assumption are a very detailed issue (much relevant to subsequent products in 3 years) and definitely should be left to RAN WGs for further justification. If have to, from our perspective, coherent-type/partial-coherent-type should be prioritized, and CB and nonCB should be treated equally.

25 – CATT

To balance the experience of UL and DL, as mentioned by many companies, enhancement of UL is one of the most important issues of MIMO in Rel-18. However, without more Tx at UE side, such goal could not be achieved. Therefore, **supporting 6/8 Tx and more than 4 layers in UL is essential to the system**.

For UL, **codebook-based and non-codebook-based operations are equally important**. The enhancements for both of them are needed in Rel-18. Consequently, **enhancements on TPMI/codebook and SRI should be studied** for codebook-based and non-codebook-based cases respectively.

For more than 4 layers, **new codeword-to-layer mapping rules are needed**. Even for no more than 4 layers, as more Tx could be supported in UL, study of codeword mapping rule is still necessary.

For codebook-based transmission, **coherence assumption can also be included as a part of this study.**

26 – China Mobile Com. Corporation

It is essential to enable >4 layer transmission for 6/8 Tx UEs to achieve performance gain of UL. Otherwise, the gain will be small. Both CB and NCB should be studied, hence we agree to add SRI, and TPMI (including codebook) enhancements in the WID. For the restriction of coherence assumption and full power mode, we believe it can be discussed in RAN1. **We support ZTE's version with the following modification**

Objective 6:

Study, and if justified, specify UL DMRS, SRS, SRI, and TPMI (including codebook) enhancements to enable 6 and 8 Tx UL operation to support **more than 4 layers** per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

- Note: Potential restrictions on the scope of this objective **(e.g., coherence assumption, full power mode)**, will be identified as part of the study.

27 – VODAFONE Group Plc

We support ZTE's version of objective 6.

28 – Lenovo (Beijing) Ltd

On scope reduction, we think only more than 4 layers shall be considered. UE with 6Tx or 8Tx can support 1-4 layers with the current spec through antenna port virtualization as implementation. We agree that not all UEs with 6Tx or 8Tx UE are requried support more than 4 layers. We are open to consider 6&8 Tx or 8Tx only, the latter as a further reduction of the work load. CB-based scheme has higher priority than NCB-based scheme. Only full-coherence and partial coherence are required for CB-based scheme. The CW-to-layer mapping scheme needs to be studied for >4 layer. However, it is premature to decide to reuse the same scheme as DL, especially when considering multi-panel UE.

The scope clarification part shall include features required to support these features (6/8Tx, CB-based >4Tx transmission, >4 layer CW-layer mapping). We support both points (1) adding "SRI, TPMI (including codebook) enhancements", 2) adding "CW-to-layer mapping enhancement").

29 – Ericsson LM

The codebook design for DL CSI for 4 ports and beyond used the uniform linear 2D array assumption for an array structure. For UL codebook design of 6 and 8 ports, some assumption on array structure is needed to be able to design a coherent codebook. with decent performance. We don't believe we can define such a giant codebook that covers all implementation cases. Hence, we support Nokias proposal to define only the non-codebook based UL and for 8 TX. This will focus the work of objective #6 to the same level as was done in the other objectives

30 – AT&T

We believe that this objective is important to be included in the WID as part of necessary UL enhancements in Rel. 18. The number of layers should not be restricted to 4, and more than 4 layers should be part of the objective. We support adding scope clarification on SRI, TPMI enhancements and CW-layer mapping enhancements. We are open to prioritizing a given number of Tx antennas, e.g. 8Tx if it helps in focusing the scope.

31 – Futurewei

As we commented in previous rounds, the scope of this objective is too big and need some downscoping. It is unclear to us the need of 6Tx UL operation which requires a new codebook design that is time consuming. We suggest removing 6Tx from the objective, i.e., supporting 8Tx only.

32 – SHARP Corporation

We support more than 4 layers and also support adding SRI and TPMI enhancements.

33 – InterDigital France R&D

Objectives 6: In principle, we support the scope of Objective 6. However, we don't agree with the note. If we want to keep it, we need to have a better clarity and focus on the scope, otherwise it would be very difficult to handle and control the workload during the WI.

Here is the suggested revision:

Suggested Objective 6:

Study, and if justified, specify UL DMRS, SRS, **and CW-to-layer mapping to enable ~~6 and~~ 8 Tx UL non-codebook operation** to support more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices

− Note: Potential restrictions on the scope of this objective will be identified as part of the study.

34 – Qualcomm Incorporated

Regarding Objective 6, it would not be acceptable to us to increase the scope now by adding CW-to-layer mapping changes.

As we have commented a number of times already, the following change would be required to make the feature actually attractive for practical use:

"Study, and if justified, specify UL DMRS, SRS to enable 6 and 8 Tx UL operation to support 4 and more than 4 layers per UE in UL targeting CPE/ FWA/vehicle/Industrial devices."

3.3 Moderator Summary and Recommendation

See RP-213539.