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RAN

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Source: Moderator(CMCC)

Title: Moderator's summary of discussion for [RAN94e-R18Prep-01] MIMO Evolution for Downlink and Uplink

Agenda item: 8A.1

Document for: Report

1 Introduction

As per the guidance from RAN#93[1], the topic of MIMO Evolution for Downlink and Uplink is one of the set of email threads for the email discussion during October 20th to 29th with the following guidance:

- The goal of the email discussion is to focus on potential scope/areas for each potential WI or SI, with NO intention to update the set and the organization of the topics as endorsed in RP-212608
  - Any further update/consolidation of the topics/structure is to be handled in RAN#94-e Aim to identify whether a topic should be a SI, or WI (including possibly a study phase for some scope(s))
  - Aim to identify on the leading WG (including if any change compared with those in RP-212608) and the secondary WG(s)
  - Aim to identify on the potential interaction with SA/CT
  - Critical to keep all items under rigorous check; important to avoid "number counting" driven discussion, but focus on tangible commercial interests (near & longer terms)

Based on the September email discussion as concluded in [2] and the UL aspects in [3], this email discussion aims at consolidating areas and objectives and formulating the WID to be agreed in RAN#94.

Please provide your proposals/comments with motivation/benefits/scenarios and assessment of workload of the objectives that you are interested in, and avoid inputs simply indicating "support/not support", as well as avoid providing too generic proposals or objectives.

2 Initial Phase

The goal for initial phase is to collect proposals from companies for selecting and refining objectives in different areas, which will be used for potential objectives convergence in the intermediate round.

For this topic, moderator believes we can skip the discussion on leading group and SI/WI.

2.1 DL Aspects

2.1.1 Area 1: Further enhancements for CSI (e.g., mobility, overhead, etc.)

Based on summary [2], further discussion could focus on

- Enhancement for high/medium mobility, (Not controversial in framework), including, e.g.,
  - Time-domain correlation/doppler-domain based CSI feedback or overhead reduction (Controversial)
  - Enhancement of CSI acquisition for TDD via SRS enhancement (Controversial)
- Enhancement for M-TRP URLLC (Controversial)

Feedback Form 1: Comments on each objective with motivation/benefits/scenarios and assessment of workload in related working group(s)

1 – Intel Corporation (UK) Ltd

We support further CSI enhancement in Rel-18. However, we would prefer more general formulation especially for the first objective:

1. Study and specify (if sufficient gains are shown), CSI enhancements for high/medium mobility scenarios. Consider enhancements to both codebook based and reciprocity-based precoding [RAN1].

~~Enhancement for high/medium mobility, (Not controversial in framework), including, e.g.,~~

~~• Time-domain correlation/doppler-domain based CSI feedback or overhead reduction (Controversial)~~

~~• Enhancement of CSI acquisition for TDD via SRS enhancement (Controversial)~~

2. Specify CSI Enhancement for M-TRP URLLC downlink transmission schemes (2a/2b/3/4) [RAN1]

Motivation: We want to clarify potential questions on necessity of the second objective on multi-TRP CSI enhancements. In particular, the existing per-TRP CSI feedback is not sufficient to accurately represent CSI for multi-TRP transmission schemes (2a/2b/3/4). More specifically due to independent RI selection per each TRP, it is common case that the actual reported RIs per TRPs are different. Since in URLLC transmission scheme the number of scheduled MIMO layers should be common for both TRPs, NW has to perform RI overriding procedure requiring recalculation of PMI/CQI for the reported RI value to the precoder / MCS of the selected MIMO layers. RI overriding is highly inaccurate (may not be even feasible) to satisfy URLLC requirements of link adaptation accuracy with target BLER of 0.00001. We note that standard outer loop link adaptation techniques are not efficient for URLLC scheme due to low error probability.

Study phase: We think that study phase is required to the first objective to asses performance benefits and specification impact.

Workload nd response WG: We think the CSI enhancement would consume 0.25-0.5 TUs with RAN1 leading WG

2 – Spark NZ Ltd

Comments from Spark NZ

It is worthwhile to look at CSI enhancements by exploiting temporal correlation techniques. Temporal correlation is inversly proportional to Doppler frequency. Say if this 100 Hz, then temporal correlation is 10 ms ie less frequent updates

before 10 ms. But higher mobility , say 100 km/hr or more the coherence time will be sub ms. This means much more frequent CSI acquision need to made including estimate of RI/CQI/PMI etc. Also the CSI must be updated proportionally to the coherence bandwidth. The later is inversely proportional to the delay spread of the channel.

We agree with comments of Intel on URLLC based applications for precoding based on estimated CSI

3 – LG Electronics Inc.

Overall, we prefer to minimize DL scope in Rel-18 like many other companies but current DL scope is too large. We think that CSI enhancement is not urgent topic so we prefer to deprioritize this in Rel-18.

4 – Nokia Corporation

1. Enhancement for high/medium mobility

Given that RAN1 has enhanced CSI feedback for a few releases already, we tend to agree with Intel that for CSI enhancements we need to perform studies first to characterize well the problem to be solved and the possible solutions. For example, in addition to Doppler-domain enhancements, we should consider the use of DMRS for CSI acquisition, to reduce the measurement delay, CSI calculation delay (e.g., fewer ports to measure), as well as improving timeline for certain CSI quantities. In that respect we would prefer a more generic formulation of the objective as well.

One aspect to be clarified also is that CSI is one of the main use cases being considered for AI/ML studies, and the potential overlap needs to be considered carefully.

2. Enhancement for M-TRP URLLC

We are in general supportive of developments for improving URLLC performance, but given that we already had two releases of URLLC enhancements, we believe this area has lower priority in Rel-18.

5 – InterDigital France R&D

- In our view, the scope is very heavy, and we don't agree to support all items. In our view at most 2 items from the list should be selected.
- Here is the priority for items from our perspective
  - Enhancement for high/medium mobility or accuracy
  - Time-domain correlation/doppler-domain based CSI feedback or overhead reduction
  - Enhancement for M-TRP URLLC
  - Leftover (R17 leftover)
  - SRS enhancement for TDD
- Also, as noted by other companies, further justification and clarification of the scope and benefits needed for R17 leftover, URLLC CSI and SRS enhancement.

Suggest to consider a vote for priority of each item before moving to the next round.

6 – ZTE Corporation

Firstly, we have similar views with LG that the title on 'enhancement for high/medium mobility' is too wide, and some detailed objectives are very necessary.

Then, the motivation and benefits for 'Time-domain correlation/Doppler-domain based CSI feedback' in the first sub-bullet are both unclear for us.

- Generally speaking, for CSI codebook enhancement, we should hold on a bit to see the market's response for the previous three releases (TypeII CSI, eTypeII CSI, FR1 FDD reciprocity based CSI).
- The proposed compression in Doppler domain can be seen as forward-looking investigation without urgent need. Compared with issues identified from real deployment, this type of forward-looking investigation should have lower priority.
- Also, we share the same views with Nokia that a potential AI/ML based study item for air interface also discusses CSI compression feedback. We can do forward-looking study there.

After that, we think that 'the enhancement of CSI acquisition for TDD via SRS enhancement' can be considered with C-JT together, like TD-OCC based SRS capability enhancement.

Finally, we are open to have further enhancement for M-TRP URLLC that is an interesting topic.

- It is important to enhance CSI triggering flexibility for fast CSI feedback targeted for URLLC service. In the current specification, if CPU is occupied, i.e., a CSI is being processed, there is no chance for gNB to trigger another fast CSI. This causes high CSI latency for URLLC service. It needs to be relaxed considering UE processing complexity.

7 – Apple GmbH

Regarding CSI enhancement for high/medium mobility, we are open to have Rel-18 study or work on it.

Regarding CSI enhancement for TDD via SRS enhancement, we prefer to clarify the scope before we can agree to study or work on it in Rel-18. In general, our preference is that this is low priority item

For the Multi-TRP URLLC enhancement. Again, we feel the scope needs to be clarified. One of the issue we have in Rel-17 for CSI enhancement is that we only consider the Single-DCI Multi-TRP scheme 1a. In reality, the deployment interest, if there is any, is actually the multi-DCI multi-TRP scheme. Therefore, CSI enhancement for multi-DCI multi-TRP scheme can be one of the topics considered in this area.

8 – Futurewei

We support the direction of further enhancements for CSI enhancement for high/medium mobility. We believe this enhancement is essential for MU-MIMO performance enhancements in high/medium mobility scenarios. Regarding the more detailed example solutions, we support enhancement of CSI acquisition for TDD via SRS enhancement as it is a straightforward solution for TDD.

Regarding time-domain correlation/doppler-domain based CSI feedback or overhead reduction, we think a study phase is needed to first study the possible solutions and evaluate the potential gain, if any. Based on the outcome of the study, the group can then decide if this could be included in the WI.

Regarding "Enhancement for M-TRP URLLC", since CSI enhancements for M-TRP and URLLC has been discussed and specified under Rel-17 FeMIMO and NR_IIOT_URLLC_enh WIDs respectively, it is unclear what the scope is and what additional gain this can bring. Based on our studies and evaluation results provided under Rel-17 NR_IIOT_URLLC_enh WID, we believe the key issue that impact the URLLC

performance is the high volatility of interference, and enhanced CSI feedback by reporting interference statistics can significantly improve the system performance. Therefore, we believe that if further work is needed to enhance CSI feedback for URLLC in Rel-18, the group should rather work on solutions such as interference statistics reporting, which can work for both S-TRP and M-TRP.

9 – MediaTek Inc.

1. CSI enhancement for high/medium mobility

We believe that the scope of this objective can be more focused.

We believe that CSI feedback enhancement exploiting time-domain correlation should be the clear target and priority. It would bring clear performance benefits for high/medium mobility UEs by enabling a higher accuracy reporting with a reduced (and acceptable) overhead. We also understand that what needs to be done is quite clear and focused.

Regarding SRS enhancements for TDD, the current objective seems quite broad and we are unclear whether all proponents have a common understanding on the type of enhancement, so difficult also to understand the impact e.g. in terms of battery life and complexity.

Regarding consideration of AI/ML approaches, we believe that they will inevitably lead to higher complexity at the UE, and that firstly we should optimize performance with ”traditional” approaches to CSI reporting in high/medium speed scenarios, to allow more accurate verification of the performance gain vs pain of defining AI/ML-based approaches for that operating scenario.

2. Enhancement for Multi-TRP URLLC

We have had 2 sets of email discussion on this objective, and from the discussion it seems that there is still no clear consensus on what exactly needs to be done. This suggests that the need for enhancements here is not so obvious, so would suggest that work on this objective is given a lower priority in Rel-18.

10 – Samsung Research America

· **Enhancement for high/medium mobility**: After the discussion in the previous round, it is clear that there are a few approaches to enhance NW performance at high/medium speed. It seems that the most urgent NW issues at high/medium speed is mostly related to access/link maintenance procedure (inter-cell mobility/RRM, beam management for FR2, QCL enhancements, RS) rather than CSI acquisition. Although this item is worthy of study, it is of low priority given the urgency and market needs.

· **Enhancement for M-TRP URLLC**: Currently we see neither justification nor urgency given that this has been discussed in past releases and the lack of needs concluded. We should not be repeating on discussions on schemes that are rejected in earlier releases (e.g. URLLC WI, mTRP CSI). Unless there is something new and clearly beneficial/urgent, we don’t support having this item in the WI.

11 – vivo Communication Technology

In general we are supportive of CSI enhancement for high/medium mobility, from our point of view SRS enhancement should also be considered together. We have carried out preliminary evaluation, for example, SRS transmitted in 2, 4, 6, 8 slots (one symbol in each slot) which is used for CSI prediction for next slot. From initial evaluation, SRS transmitted in 4 slots performs better than 2 slots SRS, and 6, 8 slots performs better than 4 slots. (unfortunately it is not possible to post figures here). However, the scope should be specific and limited as UL MIMO enhancement in Rel-18 is important.

On enhancement for mTRP URLLC, we don’t strong justifcation for including it in Rel-18 scope.

12 – NTT DOCOMO INC.

We are generally fine with Intel's revision on two main bullets for high/medium mobility CSI and MTRP URLLC CSI. For the 1st bullet, enhanced directions should be identified like original summary. For the details of the 1st bullet, which Intel removed, if we need to select between codebook based tx. or reciprocity-based precoding, we'd like to prioritize codebook based tx, because codebook based tx. is more useful for our deployment. If we use reciprocity-based precoding, it requires accurate SRS measurement. However, considering inter-cell interference of SRS measurement in high dense scenario, measurement result of SRS is not accurate. Hence, we don't want to rely on the reciprocity-based precoding by SRS measurement to determine DL pre-coder.

It can be WI led by RAN1. We think the necessary TU is 0.5TU or less.

13 – vivo Communication Technology

repost with some revision...

In general we are supportive of CSI enhancement for high/medium mobility, from our point of view SRS enhancement should also be considered together. We have carried out preliminary evaluation, for example, SRS transmitted in 2, 4, 6, 8 slots (one symbol in each slot) which is used for CSI prediction for next slot. From initial evaluation, SRS transmitted in 4 slots performs better than 2 slots SRS, and 6, 8 slots performs better than 4 slots. (unfortunately it is not possible to post figures here). In addition, we are also supportive of enhancing CSI report for MTRP schemes other than NCJT and multi-DCI-based MTRP scenarios with non-ideal backhaul. However, the scope should be specific and limited as UL MIMO enhancement in Rel-18 is important.

On enhancement for mTRP URLLC, we don't see strong justifcation for including it in Rel-18 scope.

14 – Spreadtrum Communications

Regarding CSI enhancement for high/medium mobility, we support CSI enhancement to improve MIMO performance by exploring time-varying property. However, overhead reduction is not the main target of this feature. For enhancement of CSI acquisition for TDD via SRS enhancement, more justification is needed. If possible, a study phase can be used to identify the potential issue of current SRS design.

Regarding CSI enhancement for M-TRP URLLC, we have not seen the benefit clearly, and prefer as low priority. The typical rank for M-TRP URLLC is 1 for both TRPs. By configuring the RI restriction for the single TRP CSI, the measurement result can be used for M-TRP URLLC scenario, e.g., PDSCH scheme 2a/2b/3/4. Terrible RI overriding event would not happen.

15 – Huawei Tech.(UK) Co.. Ltd

We agree with the first bullet (with the two sub-bullets) that CSI enhancements on mobility should be for both FDD and TDD. The reason and scenarios are explained as follows: There are mobility UEs in both TDD and FDD scenarios. Indeed, much NW and UEs for 5G now are deployed with TDD system, so it is important to include enhancements on TDD. As we know, FDD CSI acquisition is mainly based on CSI-RS measurement and CSI feedback, and TDD CSI acquisition is based on SRS, while the current design for CSI and SRS are not robust for high speed cases.

Then, for second bullet, it is still not clear what the contents are. We are fine to do some enhancements on CSI acquisitions (including codebook based and SRS based) for MTRP for coherent joint transmission, but these should be included in Area-2 MTRP enhancements.

For other URLLC part, the enhancements for MTRP URLLC are already discussed and specified in Rel-16 and Rel-17, including PUCCH/PDCCH/PUSCH/PDSCH and CSI. So, we do not think these discussions are necessary.

We propose the following updates:

Specify the enhancement for high/medium mobility, **focusing on**

- Time-domain correlation/Doppler-domain based CSI feedback, **and CSI-RS** overhead reduction
- Enhancement of CSI acquisition for TDD via SRS enhancement

~~Enhancement for M-TRP URLLC (Controversial)~~*(move to CJT in Area2)*

16 – Huawei Tech.(UK) Co.. Ltd

For CJT:

Coherent joint transmission could be enabled for a lot of NR networks, including the cases of inter-site indoor (corresponding to industry factories scenarios), inter-site outdoor (corresponding to C-RAN structure based Macro deployments), and intra-site outdoor (corresponding to intra-site gNB cooperation cases). However, the coherent joint transmission are not well specified in NR. Actually, with coherent joint transmission from multiple TRPs, the NW could benefit from beamforming gain with more cooperated antennas from different TRPs, interference mitigation/avoidance from joint scheduling, much more MU gain because more UEs could be jointly scheduled in the cooperated areas. As shown in (RP-212150), in our preliminary simulation results, the benefits of CJT are also proven.

In previous discussion, some companies asked why CJT is not so successful in LTE systems. Indeed, one reason is that LTE systems are based on CRS. Even with antennas cooperation in CJT, the interference due to the cell-specific always-on signals is difficult to mitigate and increase the overhead when CJT is used. But in NR system, there is no such cell-specific always-on signals. Furthermore, C-RAN structure and industry deployment are used more and more in NR, where multi-TRPs are shared with the same baseband (or basebands are together), so it is easier to enable coherent joint transmission.

We would like to clarify which specific objectives should be included in the enhancements for CJT. CJT enhancement should be for both FDD and TDD, including: CSI enhancements and CSI-RS overhead reduction for FDD, SRS enhancement for CSI acquisition for CJT, more than 12 orthogonal DMRS ports, interference measurement enhancements, and smaller precoding granularity (PRG).

As discussed above, coherent joint transmission for M-TRP should be high priority in Area-2.

For DMRS enhancement:

As discussed above (in CJT), since more UEs could be jointly scheduled in the cooperated areas for CJT, more orthogonal layers are required for MU transmission for high spectrum efficiency. In RP-212150, the required number of orthogonal layers is more than 12. So, the enhancement on orthogonal DMRS ports is necessary. Since higher probability of pairing more users happens in mTRP scenarios, we would be fine specifying the DMRS enhancements under the objective of mTRP or CJT.

For beam management:

For extending R17 unified TCI and overhead/latency reduction for multi-beams, the unified TCI is for overhead/latency reduction, so the Unified TCI state should be a sub-bullet for overhead/latency reduction. The deployment of mmWave should consider commercial values. Reusing the site locations and providing contiguous coverage for mmWave is more valuable in the real deployment, and this requires large array antennas. So, the enhancements for beam management should consider the use case of large antenna array.

For Asynchronous MTRP and multi-TA:

The typical use cases and benefits are unclear. Normally, as discussed in previous email discussion, the cooperated TRPs are well synchronized between each other. Some companies mentioned that TA is longer than CP for the case of very large scale multi-TRPs in cooperation, i.e., very remote TRPs are within the cooperated area. But, such case happens with very small probability for a UE. So, at this stage, we do not think asynchronous case should be a priority.

Proposals: support the following updates:

- **Overhead and/or Latency reduction for beam management for large antennas array, including UE-initiated beam management,** and extend Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and [inter-band]) [RAN1]

~~· Combined MTRP schemes, more generic (Controversial)~~

~~Increasing the number of orthogonal DL [and UL] DMRS ports both for S-TRP and M-TRP~~ *(focus on mTRP case, so moved under CJT)*

- Enhancement for Coherent-JT/D-MIMO **for FDD and TDD**, including codebook, CSI reporting, spatial domain interference avoidance, **SRS enhancements for CSI acquisition, smaller PRG size and increasing the number of orthogonal DL and UL DMRS ports. [RAN1]**

~~Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic (Controversial)~~ *(move to the first bullet)*

~~Asynchronous M-TRP/Multiple TA for M-TRP~~

17 – Continental Automotive GmbH

We would like this important issue to be discussed and studied in Rel. 18, and hopefully specify some enhancements. Features targeting moderate to high mobility scenarios is essential in our view to provide better support to automotive use cases. In addition, we also consider this would benefit the overall MU-MIMO framework. Thus, we support this (Enhancement for high/medium mobility) to be included in Rel. 18.

We also consider convenient to study (if solutions and results are provided by companies) Time-domain correlation/doppler-domain based CSI feedback or overhead reduction.

18 – Beijing Xiaomi Mobile Software

- Regarding to enhancement for high/medium mobility, we support this direction. But considering the workload, we prefer to down-select one between time-domain correlation/doppler-domain based CSI feedback or overhead reduction and enhancement of CSI acquisition for TDD via SRS enhancement. And the objective for enhancement of CSI acquisition for TDD via SRS enhancement is not very clear.

- Regarding CSI enhancement for M-TRP URLLC, we prefer to clarify the scenario first, if it is focus on the S-DCI PDSCH transmission scheme 2a/2b/3/4, it is better to clear the scenario and the corresponding objective.

19 – SHARP Corporation

- CSI enhancements for high/medium mobility
  We basically support CSI enhancement for medium/high mobility, and it is beneficial especially for MU-MIMO. Our view is that both codebook-based and reciprocity-based CSI enhancements should be considered.
- Enhancement for M-TRP URLLC
  We don't have a strong need to have CSI enhancement for MTRP URLLC, but we are open to discussing it if the workload is allowed. (Low priority)

20 – Guangdong OPPO Mobile Telecom.

- Support time-domain correlation/doppler-domain based CSI feedback. SD and FD compression have been supported in NR, it is beneficial to further extend CSI feedback by exploiting time-domain/doppler-domain information.
- Regarding the SRS enhancement, the current objective is quite vague. SRS has been enhanced in several releases from various aspects, including capacity, triggering flexibility, coverage and so on. we cannot see the requirement/urgency for further enhancement. It would be better to discuss whether some specific enhancement is needed or not, rather than a general enhancement without specific mechanism/approach.
- Not support the CSI for M-TRP URLLC. M-TRP URLLC can be well supported by current CSI framework. Furthermore, M-TRP URLLC is targeting higher reliability instead of spectrum efficiency. The motivation of CSI enhancement is unclear to us. Moreover, the current wording is too vague with any specific target mechanism(s).

21 – CATT

As mentioned by some companies in previous discussion, scenarios with high/medium mobility are of great importance for the network to further enhance the performance regarding user experienced data rate, spectral efficiency and so on. To achieve that, one of the essential issues is the accuracy of CSI in high/medium mobility scenarios. Furthermore, reduction of overhead is equally important to the system. So, we are supportive to utilize time-domain correlation/doppler-domain based CSI feedback for the enhancement of high/medium mobility scenarios.

For SRS enhancement, the objectives seem to be pretty broad now. therefore, further clarification on the motivation and justification are still needed, especially considering the potential workload in Rel-18.

Based on the framework introduced in Rel-17 for CSI of NC-JT, enhancement for m-TRP URLLC is a straightforward and natural extension to what we already have currently. So, the enhancement of CSI acquisition for m-TRP URLLC can be considered in Rel-18.

22 – Telekom Deutschland GmbH

We think ‘Enhancement for high/medium mobility or accuracy, Time-domain correlation/doppler-domain based CSI feedback or overhead reduction’ is an important topic for high velocity scenarios in the near future. For example, in Germany - and maybe in other European countries too - the authority will force the network operators to cover tracks for high speed train with high performance and reliable mobile communication services.

23 – China Mobile Com. Corporation

We are supportive of CSI enhancement for high/medium mobility UEs. In our view, SRS enhancement is beneficial for TDD CSI acquisition. The enhancement can be focused on SRS capacity enhancement and inter-cell interference mitigation for more accurate CSI.

Regarding Time-domain correlation/doppler-domain based CSI feedback, some companied suggest a study phase to justify the performance gain, but it implies a large workload, we prefer to consider it as low priority.

Worload: We suggest 0.5 TU on Area 1

24 – NEC Corporation

We are interested in the following objective.

- Enhancement for high/medium mobility

- Time-domain correlation/doppler-domain based CSI feedback or overhead reduction

We believe with this enhancement it would not only reduce the feedback overhead for high mobility, but also reduce the RS overhead for CSI acquisition.

The estimated workload is 0.5 TU in RAN1.

25 – VODAFONE Group Plc

We see the enhancements for high/medium mobility as the priority. This includes CSI feedback overhead reduction and enhanced CSI acquisition for TDD via SRS.

We have enhanced URLLC for a couple of releases and it seems that our standards are ahead of market developments, so we would be OK to deprioritise enhancements for M-TRP URLLC.

26 – Huawei Tech.(UK) Co.. Ltd

Sorry that our second response in area 1 was supposed to be in area 2.

27 – Fraunhofer IIS

NR Type-II codebooks are pivotal for SU/MU-MIMO transmissions. However, all Type-II codebook variants so far mainly targeting static or very low UE mobility scenarios. For mid- to high-mobility UEs, the following is observed in deployment scenarios: (i) large performance loss especially in fast varying channels due to insufficient CSI update rate, (ii) need for increased CSI update rate to efficiently handle the fast channel variations, and (iii) increased use of UL/DL resources due to frequent PMI measurements and reporting because of high CSI update rate. To overcome all these issues, time-domain correlation/Doppler-domain based CSI feedback is needed for UE mobility scenarios.

Therefore, we think that time-domain correlation/Doppler-domain based CSI feedback and CSI-RS related enhancements should be the main target and should have the highest priority for the R18 CSI enhancements.

The current objective of the SRS enhancement is quite broad and not clear to us. The proponents should clarify what kind of specific enhancements are foreseen.

We don't see sufficient justification for CSI for M-TRP URLLC. It is not clear if there is a need in real deployments for specific enhancements. Therefore, we suggest that CSI for M-TRP URLLC is given a lower priority.

The estimated workload for Area 1 is 0.5 TU in RAN1.

28 – Volkswagen AG

For automotive use cases CSI enhancements in high mobility use cases are of importance. Thus it is proposed to keep this in scope of Rel-18.

29 – CEWiT

- Regarding CSI enhancement for high /medium mobility, we support a SI on doppler domain compression to find potential gain. And for the second sub-bullet, we support a WI on possible SRS enhancements.

- Regarding the CSI enhancements for MTRP, we believe there is a potential scope of work which will benefit the MTRP schemes from Rel16/17. Though CSI adaptation is still possible with the current framework as a part of gNodeB, having proper CSI for MTRP will complete the enhancements on the physical channels. Hence we propose a WI for the objective

30 – AT&T

Out of the proposed areas for further enhancements on CSI in Rel. 18, we think CSI enhancements that exploit Doppler domain and target CSI feedback overhead reduction are important. These are beneficial for CSI acquisition for low and high mobility applications.

31 – Ericsson LM

Ericsson strongly support enhancements of CSI feedback to be more resilient to higher UE velocities (up to 100 km/h). It has been observed in real deployments that DL MU-MIMO performance reduces significantly at medium and higher UE velocities. To increase the operator's return on investment of massive MIMO antenna technology, we believe that extending the downlink MU-MIMO feature to higher velocities is a high priority issue that needs to be solved for both reciprocity based operation and for CSI feedback based operation. Hence, we see an urgency and a market need for this proposal.

Since the problem is clearly defined, the solutions to achieve this can be left to the working groups to investigate and specify while at the same time taking into account UE and network complexity, signaling and RS overhead and standardization effort.

Ericsson support CSI enhancements of M-TRP URLLC. As mentioned by other companies, the motivation for introducing CSI enhancements for M-TRP URLLC is to ensure accurate link adaptation while meeting stringent BLER target requirements in the order of 10^-6. Note that the MTRP CSI introduced in NR REL-17 is specific to NC-JT where different layers are transmitted from different TRPs. For M-TRP URLLC schemes, the PDSCH layers are transmitted from both TRPs and reusing the Rel-17 M-TRP CSI would result in highly inaccurate CSI.

A second issue that needs to be considered under M-TRP URLLC is to improve CSI triggering flexibility for URLLC CSI. As discussed by ZTE above, the current spec does not allow the possibility to trigger a URLLC CSI when there is an ongoing CSI computation which occupies the UE's CPU. As a result, an urgent URLLC CSI will be delayed due to the limitation in the current specification. Hence, relaxation of such limitations are motivated in Rel-18.

We support the following two specific items under M-TRP URLLC CSI:

- Specifying CSI reporting for multi-TRP URLLC schemes
- Specifying flexible URLLC CSI triggering

32 – Verizon UK Ltd

To enhance NW performance at high/medium speed:

There is a great need for that. Very supportive. From our experience, for higher frequency where analog beams are used, the bottlenect seems to be like Samsung said, the access/link maintenance procedure such as inter-cell mobility/RRM, beam management for FR2, QCL enhancements, RS. For lower frequency, it seems to be about CSI feedback - whenver speed goes higher, throughput signficantly degrades, much lower than what can be achieved with the best PC.

33 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

- In general, we are supportive of CSI enhancements for high/medium mobility which has several use cases, e.g., users in highways and high-speed trains.

- We support the first sub-bullet: "Time-domain correlation/doppler-domain based CSI feedback or overhead reduction" in which exploiting the channel correlation in time can be studied with the objective of reducing the CSI feedback overhead and/or CSI measurement and reporting complexity at the UE. Performance evaluation can be based on legacy CSI reporting configuration and/or codebook configurations.

- For the second sub-bullet "Enhancement of CSI acquisition for TDD via SRS enhancement", we are unclear regarding the scenarios. The proponents should clarify whether the proposed enhancements target high/medium mobility use cases, or target all use cases regardless of mobility.

- Regarding the bullet on M-TRP URLLC enhancements, in our view this should be low priority. In our understanding, Rel-17 M-TRP CSI framework can be reused for M-TRP URLLC, via forcing the same number of layers across both TRPs via RI restriction, with some sub-optimality due to reporting a pessimistic CQI value. Therefore, more justifications and a study is needed to evaluate and show sufficient gains of the potential schemes over Rel-17 M-TRP CSI framework prior to any agreement on specifying such enhancements in Rel-18.

34 – LG Uplus

- Time-domain correlation/doppler-domain based CSI feedback or overhead reduction is not urgent to us.
- Enhancement of CSI acquisition for TDD via SRS enhancement is interested.
- Regarding enhancement for M-TRP URLLC, Rel-17 seems sufficient to us.

35 – Qualcomm Incorporated

Although Doppler-domain CSI compression has the potential to improve beamforming, several issues need to be considered towards practical implementation, such as UE complexity, CQI definition for bundled CSF, etc.

We believe that similar work may be performed in AI-ML, which can motivate not focusing on general CSI enhancements in the Rel-18 MIMO work.

36 – Telstra Corporation Limited

We see a need for improved network perfromance for high/medium speed UE's. Therefore, time-domain correlation/Doppler-domain based CSI feedback and CSI-RS related enhancements should be included.

2.1.2 Area 2: Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam, further discussion could focus on following items

Based on summary [3], further discussion could focus on

- Extend 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]) (Not controversial in framework)

- Combined MTRP schemes, more generic (Controversial)

- Increasing the number of orthogonal DL [and UL] DMRS ports both for S-TRP and M-TRP (Not controversial in framework)
- Enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance (Controversial)
- Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic (Controversial)
- Asynchronous M-TRP/Multiple TA for M-TRP (Controversial)

Feedback Form 2: Comments on each objective with motivation/benefits/scenarios and assessment of workload in related working group(s)

1 – Intel Corporation (UK) Ltd

1. Regarding the first objective on TCI framework extension. We are fine to include this objective as part of Rel-18 MIMO enhancements. However, we prefer more general formulation of this objective as extension of unified TCI framework to support multi-TRP transmission schemes. We think that the actual mTRP schemes should be clarified. More details are also needed for "combined m-TRP transmission scheme" objective. If the goal is to enable sDCI and mDCI schemes simultaneous, we don't think this combination is valid and requires further discussion.

Extend Rel-17 unified TCI framework~~, e.g~~ to support multi-TRP transmission schemes including FFS support of combined multi-TRP transmission schemes [RAN1]

~~· for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and [inter-band]) (Not controversial in framework)~~

~~· FFS Combined MTRP schemes, more generic (Controversial)~~

2. Regarding the second objective on increased number of orthogonal DM-RS ports. We support this enhancement in Rel-18 MIMO. However, since the objective is listed as multi-TRP enhancement, it would be better to focus on multi-TRP scenarios first with possible extension to single-TRP with minimum specification change.

Increasing the number of orthogonal ~~DL [and UL]~~ DMRS ports in multi-TRP with possible extension to single-TRP transmission scheme [RAN1]

3. Regarding the third objective on coherent JT. We are fine to include this objective as part of Rel-18 MIMO enhancements with focus on dense deployment scenarios

Enhancement for Coherent-JT/D-MIMO in dense deployment, including e.g., codebook, CSI reporting, spatial domain interference avoidance

4. Regarding the fourth objective on overhead and/or latency reduction. We support this enhancement in Rel-18 MIMO. However, since beam indication latency and overhead reduction were already addressed in

Rel-17, the description of objective should be more precise and focus on beam acquisition latency only.

Overhead and/or Latency reduction for ~~beam management procedure/~~beam acquisition procedures~~, more generic~~

5. Regarding the fifth objective on asynchronous M-TRP/Multiple TA for M-TRP. We support this enhancement in Rel-18 MIMO. We believe this would be a common scenario especially in FR2. We don't think there are fundamental problems with performance (due to inherent spatial isolation between links to different TRPs) and UE complexity (the implementation is feasible, e.g., just requires per-panel FFT setting).

Specify enhancement to support asynchronous M-TRP including support of multiple TA [RAN1]

Workload: We think the multi-TRP / multi-beam enhancement may require 1-1.5 TUs on average with RAN1 leading WG

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2 – Spark NZ Ltd

Comments from SPARK NZ

Regarding:

Increasing the number of orthogonal DL [and UL] DMRS ports both for S-TRP and M-TRP (Not controversial in framework)

we agree with this proposal. Howver we note that for both single and multi TRP scenarios, the number of orthogonal DL and UL DMRS ports would clearly depend upon the number of streams per user and the total number of layers a base staion can support in an MU MIMO context. This should be added to the study. It is critical to do this as otherwise all layers could have the same DMRS SNR.

Enhancement for Coherent-JT/D-MIMO in dense deployment, including e.g., codebook, CSI reporting, spatial domain interference avoidance

We support this proposal. However we would like to add the fact that the perfprmance of distributed MIMO must be assesed with timing offsets duw to errors in clock drifts of different access points which are free running without cabled interfaces between the access points. This has serious consequences in coherent transimssion and reception since teh assumption is that perfect timing alignment and synchronisation is available.

In the frequency domain carrier freq offset compensation is also required.

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3 – LG Electronics Inc.

Overall, we prefer to minimize DL scope in Rel-18 like many other companies but current DL scope is too large. Among the listed five topics, we are supportive on 1st, 3rd, and 5th topics. On 4th topic (overhead-/latency reduction), the scope is unclear and we already addressed this topic in Rel-16 and Rel-17. We are not convinced that further enhancement on BM overhead/latency is deemed necessary.

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4 – Nokia Corporation

- **Extend Rel-17 Unified TCI framework, e.g.,**

While this is an interesting topic for further development, with the potential of leading to simpler specifications of TCI-related aspects, there is a need to clarify the potential impact of this objective on real-life deployments before assessing its relative priority.

- **Increasing the number of orthogonal DL [and UL] DMRS ports both for S-TRP and M-TRP (Not controversial in framework)**
  As currently formulated this objective is too open, leading to work on all DM-RS modes, DL and UL, single- and multi-TRP optimizations. This is much broader than what has been proposed by the proponents even, and we believe it requires much more focus before it can be considered for Rel-18.

- **Enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance (Controversial)**
  We do not support further work on Coherent-JT in Rel-18, given that some level of C-JT can be supported already by the specifications, in a transparent manner to UEs. In any case the current formulation is way too broad, and it is difficult to see how such objective could fit in the Rel-18 WI.

- **Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic (Controversial)**
  More focused proposals needed here, otherwise scope is too large. For example, consider UE-initiated beam selection, which has been suspended for the remaining of Rel-17, as per RAN1#106-bis-e agreement.

- **Asynchronous M-TRP/Multiple TA for M-TRP (Controversial)**
  In our view this is clearly highest priority work for mTRP in Rel-18, given that it enables practical deployments of mTRP, in particular in FR2. This includes, e.g. support to different TA.

5 – InterDigital France R&D

- In our view, the scope is very heavy, and we don't agree to support all items. In our view at most 2 items from the list should be selected.
- Here is the priority for items from our perspective
  - Extend Rel-17 Unified TCI framework to M-TRP, e.g.,
    - For indication of DL and UL TCI states (e.g., M>1 and/or N>1)
    - Combined MTRP schemes, more generic [need to converge]
  - Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic [need to converge]
  - Asynchronous M-TRP/Multiple TA for M-TRP
  - Increasing the number of orthogonal DL [and UL] DMRS ports
  - Enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance

Suggest to consider a vote for priority of each item before moving to the next round.

6 – ZTE Corporation

Firstly, we can support to further extend Rel-17 unified TCI framework for indication of multiple DL and UL TCI state(s) (including M>1 and/or N>1, and repurposing the field in DCI without DL assignment). Some justification on how to combine MTRP schemes (involving too many TDM/FDM/SDM schemes for

PDCCH/PDSCH/PUSCH/PUCCH) with unified TCI should be well justified, and we prefer to consider Rel-16 mDCI/sDCI-mTRP as a starting point.

Then, we suggest to merge the second bullet (for DMRS) and third bullet (for Coherent-JT/D-MIMO) together. Then, for C-JT and D-MIMO, TDD-related enhancement (e.g., increase of DMRS ports and improvement on SRS capability, e.g., TD-OCC) should be considered with high priority.

After that, regarding 'Overhead and/or Latency reduction', we think that some further clarification on candidate examples may be needed; otherwise, this bullet seems too wide. In Rel-17, through several meeting discussion for issue-6 that was mentioned by several companies, the following examples besides for 'UE initiated beam management' (i.e., Option 1-A) are popular and can be captured for next-round discussion:

- Beam measurement/reporting/refinement/selection triggered by beam indication (without CSI request), i.e., Option 1-B
- Aperiodic beam measurement/reporting based on multiple resource sets for reducing beam measurement latency, i.e., Option 1-C
- Latency reduction for MAC CE based TCI state activation, or frequency/time/beam tracking, i.e., Option 2-A
- Latency reduction for MAC CE based PL-RS activation, i.e., Option 2-B

Finally, We are open to consider more realistic assumptions for asynchronous M-TRP. Specifically it may involve dynamic indication for beam specific TA, and PDCCH-order RACH enhancement (e.g., for inter-cell mTRP), etc.

7 – Apple GmbH

Regarding to extend Rel-17 unified TCI framework, we are supportive of this work. However, we think the scope should be limited only to extend the Rel-17 unified TCI framework for Multi-TRP. The key benefit for Rel-17 unified TCI framework is beam indication overhead reduction when the same beam is used for multiple PHY channels/signals/CCs etc. It may not be that beneficial to indicate multiple beams (DL/UL TCI states), and such functionality can already be achieved by Rel-16 BM framework.

Regarding increasing the number of orthogonal DMRS ports, we are open for it.

For Coherent JT/D MIMO, we feel it is low priority issue. What we heard from the deployment is mostly on the concern of backhaul between TRPs. Even with the non-ideal backhaul, multi-TRP has not picked up in real deployment since LTE COMP.

For Overhead/latency reduction for BM, we are supportive of this work especially on the UE initiated beam selection and event triggered beam report

For asynchronous M-TRP/Multiple TA for M-TRP, we are against this work. Ever since LTE COMP, the assumption of multi-TRP is that the deployment is synchronous. A synchronous deployment can perform better than asynchronous deployment for sure, but it still does not attract enough deployment interest. Asynchronous Multi-TRP is even more difficult for the device to support, with worse interference situation due to the break of OFDM properties and with less potential benefit, we do not see how it can be deployed at all and the performance motivation to deploy it.

8 – Futurewei

Regarding "Combined MTRP schemes, more generic", it is unclear what the scope and the potential gain is for this scheme. We suggest putting this in low priority for Rel-18.

We support the rest of the listed objectives. They are either leftover issues from Rel-17 FeMIMO discussions or enhancements that can potentially provide high performance gain.

9 – Samsung Research America

· **Extend Rel-17 Unified TCI framework**: We support specifying extension of the Rel-17 unified TCI framework, in particular, indication of multiple DL (M) and UL (N) TCI states based on the Rel-17 unified TCI framework. This can include support of mTRP, e.g., measurement/reporting, BFR, URLLC related aspects. The need for "combined mTRP schemes" however in unclear (can be achieved by NW implementation) and shouldn't be included.

· **Increasing number of orthogonal DMRS ports**: We support specifying larger number of orthogonal DMRS ports for, e.g. higher order MIMO operations, especially under C-JT/D-MIMO setup.

· **Enhancements for C-JT/D-MIMO**: We support specifying enhancements for C-JT/D-MIMO targeting FR1. The need has been clearly articulated by a number of operators. The scope includes CSI acquisition for FDD (codebook for distributed RRH) and TDD (SRS enhancements and related), as well as the support for > 32 CSI-RS ports

· **Overhead and/or Latency reduction for beam management**: We support studying and, if needed, specifying advanced beam refinement/tracking based on Rel-17 unified TCI framework (discussed inRel-17 but suspended due to lack of time). UE-initiated beam management can be a starting point. If a larger scope is allowed, we can include, e.g. UE-group beam reporting

· **Asynchronous m-TRP/multi-TA for mTRP**: We support studying and, if needed, specifying enhancements for this purpose such as beam-dependent TA values, aspects related to DL asynchronous MTRP transmission including DL timing difference larger than CP.

10 – vivo Communication Technology

In general the list is too big for overall scope of MIMO WI, and UL MIMO enhancement should be allocated with large chunk of TUs. We are supportive of extension of Rel-17 unified TCI framework in multi TRP scenario. For other sub-items in this area, overall scope and market need should be taken into account.

11 – NTT DOCOMO INC.

- We are fine to extend Rel-17 Unified TCI framework (e.g., M>1 and/or N>1), but 'combined MTRP schemes' is not needed. The motivation/benefit to enable sDCI and mDCI schemes simultaneously is not clear.
- We are fine to include overhead and/or Latency reduction for beam management procedure/beam acquisition procedures. It is suggested to include the detailed enhanced directions to avoid diverse views in WI phase, like issue6 in AI8.1.1. in Rel-17. At least UE-initiated/event-triggered TCI state activation/indication can be included.
- We are fine to include Asynchronous M-TRP/Multiple TA for M-TRP if the work load is acceptable.
- We think coherent-JT/D-MIMO is low priority. Rel.18 DL MIMO scope should be limited compared to UL MIMO. However, we have concern that coherent JT/D-MIMO has potential large spec. impact. Also, **it is better to carry out some evaluations to verify the performance before** specifying coherent-JT/D-MIMO**, which requires additional effort and TU.**

- It can be WI led by RAN1. We think the necessary TU is 1TU or less.

12 – vivo Communication Technology

repost with some revision..

In general the list is too big for overall scope of MIMO WI, and UL MIMO enhancement should be allocated with large chunk of TUs. We are supportive of extension of Rel-17 unified TCI framework in multi TRP and for inter-band scenarios. Rel-17 unified TCI framework is limited to intra-band cases, introduction of the framework for inter-band cases would also be of necessary considering potential deployment in FR2. If coherent JT/D-MIMO is not in Rel-18 scope, we don't see the need for the increasing the number of orthogonal DL DMRS ports.

For other sub-items in this area, overall scope and market need should be taken into account.

13 – Spreadtrum Communications

Regarding the 1st bullet, we support the extension of Rel-17 unified TCI framework. For the 1st sub-bullet, we suggest to explicitly say multiple DL and UL TCI states for M-TRP. For the combined MTRP schemes, we need more clarification on the intended combination(s).

Regarding the 2nd bullet, we are fine to increase the number of DMRS ports to achieve better tradeoff between overhead and performance.

Regarding the overhead and/or latency reduction for beam measurement/reporting, we think it's an important feature especially when the number of beams is large. Therefore, the term 'beam acquisition procedure' is more accurate than 'beam management procedure'.

For coherent-JT/D-MIMO and asynchronous M-TRP/Multiple TA for M-TRP, we think they should be low priority. The main reason for coherent-JT/D-MIMO is that the similar feature called CoMP in LTE was not widely deployed due to practical reasons. While for asynchronous M-TRP/Multiple TA for M-TRP, the scenario is not justified and we don't see the necessity to support it.

14 – Beijing Xiaomi Mobile Software

- Regarding to extend Rel-17 Unified TCI framework, we are supportive of indication of multiple DL and UL TCI states. While for combined MTRP schemes, we prefer to make it clear, e.g., replaced by combination of S-DCI and M-DCI based PDSCH transmission.

- Regarding to overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, we support it including beam management during random access, UE initiated beam switching, and event-based beam reporting.

- As for C-JT/D-MIMO, we think it should be low priority. And we share similar view as Apple and Spreadtrum, LTE CoMP was not widely deployed.

15 – SHARP Corporation

We support the following topics

- Extension of Rel-17 unified TCI framework
- Increasing the number of orthogonal DMRS ports.
- Asynchronous M-TRP/Multiple TA for M-TRP.

We are open to discussing the rest of the topics if the workload is allowed but these are low priority

16 – Asia Pacific Telecom co. Ltd

We agree with comments from many companies that the scope of current listed items are a bit large. The followings are our high-priority items:

- Extend Rel-17 unified TCI framework to support M>1 and N>1
- Overhead and/or latency reduction for beam management procedure/beam acquisition procedures

These two items have been well discussed in Rel-17, but RAN1 couldn't finish it due to limited time. We suggest we include these items first since they are already present with clearer scope. Regarding combined M-TRP schemes, it can start from simultaneous S-DCI/M-DCI configuration, and SDM/FDM/TDM schemes across physical channels. However, as companies mentioned, more justifications are needed.

17 – Guangdong OPPO Mobile Telecom.

- Extend Rel-17 Unified TCI framework: Extending Rel-17 Unified TCI framework to all of Rel-16/17 M-TRP transmission needs significant standardization effort and will make spec very complicated. It may make the DL MIMO part overloaded. For Rel-18, we should make it clear to what/which target use cases and scenarios the unified TCI framework is extended. Thus, we need to clarify the use case for M> 1 and/or N >1 to avoid unnecessary work in the future. One use case we think it muti-DCI based mTRP transmission. For the inter-band rel-17 unified TCI framework, we do not support.
- The motivation of increasing the number of orthogonal DL/UL DMRS ports is still unclear for us. We cannot see the number of orthogonal DMRS ports to be the bottleneck of current network. However, we are open to it and study is needed.
- Enhancement for Coherent-JT/D-MIMO have been studied for a long time in LTE, but not used in real deployment. From our perspective, there are some other more important features than it. Thus, we think it should be of low priority.
- Not support Overhead and/or Latency reduction. Overhead/Latecny reduction has been discussed in two releases (i.e., Rel-16, Rel-17). The motivation and use case are not clear. We should not include it again in Rel-18.
- Not support asynchronous M-TRP/Multiple TA for M-TRP. Synchronous M-TRP/single TA should be the main deployment of M-TRP. The mTRP without time synchronization would suffer obvious system performance and unnecessarily significantly increase the UE complexity. Also, this objective has some overlapping with UL enhancement for TA, and should be deleted from DL.

18 – Sony Group Corporation

Regarding Area 2, we would like to share our views as follows

- **Extend Rel-17 Unified TCI framework, e.g.,**
  for indication of multiple DL and/**or** UL TCI states (e.g., M>1 and/or N>1, and ~~[~~inter-band]~~)~~ (Not controversial in framework)
  We are supportive to extend Rel.17 unified TCI state framework to M-TRP. First, one editorial suggestion is as above, since Rel.17 unified TCI framework includes both joint TCI state and separate DL/UL TCI state and also to get aligned with the e.g. part M>1 **and/or** N>1. In addition, for the inter-band operation, we think we could remove the bracket. The reason is that common beam operation across bands within FR2 can be beneficial and as far as we know that RAN4 is still working on the inter-band independent/common beam management within FR2.

- **Enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance (Controversial)**

  For coherent-JT/D-MIMO, the enhancement may include codebook design and introduce new CSI reporting mechanism, which in our view can be considered to be merged into Area 1 (targeting on CSI enhancement). As for spatial domain interference avoidance (literally not quite clear to us), but it seems the next level details to be listed when compared with codebook and CSI reporting.

- **Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic (Controversial)**

  We are supportive to this objective and we do hope it could be more specific, so that each related WG can be guided with more helpful information. Hence we suggest to add an sub-bullet which was discussed in previous meetings

  - UE initiated beam management

  In addition, during RAN1#106bis-e, one conclusion was made that due to lack of time, RAN1 will not further investigate the overhead and/or latency issues (Issue 6 in AI 8.1.1), so we hope the remaining issues can be moved to Rel.18 accordingly.

- **Asynchronous M-TRP/Multiple TA for M-TRP (Controversial)**

  For M-TRP scenario, multiple TAs should be evaluated and supported for higher SCS (c.f. SCS=15kHz) as future proof solution, as the higher SCS corresponds to shorter CP duration.

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19 – NEC Corporation

We are interested in the following objectives.

- Extend Rel-17 Unified TCI framework

We would like to specifically mention the details in the WID objectives as follows, otherwise the scope may be too vague.

- For indication of DL and UL TCI states (e.g., M>1 and/or N>1)
  - Identify and specify beam failure recovery enhancement based on unified TCI framework
  - Identify and specify reliability and robustness enhancement based on unified TCI framework
- Combined M-TRP schemes, e.g.,
  - SDM/FDM/TDM schemes for PDCCH/PDSCH based on unified TCI framework

In addition, this objective should be targeting both intra- and inter-cell.

- Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures

The motivation is to improve BM efficiency, and to reduce BM overhead and latency, especially for fast moving UE. In particular, UE-initiated/assisted BM can reduce the resources needed for beam training and it could better reflect the change in channel condition. It was actually discussed in Rel-17 NR-FeMIMO but then the discussion was suspended due to lack of time. Also, if considering a predictive/fixed trajectory of UE movement, BM and beam acquisition procedures can both be significantly simplified.

With that being said, we would like to specifically mention the details in the WID objectives as follows, otherwise the scope may be too vague.

- UE-initiated/assisted BM
- Prediction-based BM for cases with fixed/predictable trajectories

In addition, this objective should be targeting both intra- and inter-cell.

- Asynchronous M-TRP/~~Multiple TA for M-TRP~~

The motivation is to support more realistic M-TRP deployment in FR2.

We suggest to move 'Multiple TA for M-TRP' to UL Aspects Area 4.

The estimated workload is 1-1.5 TU in RAN1.

20 – CATT

We share similar view as some companies that the workload is too heavy for multi-TRP and multi-beam related items. In our opinion, only those can be well justified are really necessary to be considered. To be specific, extension of unified TCI framework and CJT can be included as areas for MIMO enhancements in Rel-18.

Regarding the number of orthogonal DL [and UL] DMRS ports both for S-TRP and M-TRP, one of the motivations seems to be the enhancement for the combination of m-TRP and MU. Actually, we already have extensive discussion in previous on this scenario, and such combination was precluded, and the same question on whether such combination is practical should be answered before making decision.

For overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, such optimization is already available based on current spec. We don't see the urgent need on further enhancement for beam management procedure.

For asynchronous deployment of m-TRP, it's also questionable of whether this is a practical scenario for coordination transmission.

21 – China Mobile Com. Corporation

Regarding the extension of Rel-17 Unified TCI framework, we support to consider M>1 and N>1 for M-TRP scenario only, since the motivation to enable multiple DL and UL TCI states for other scenarios is not clear to us.

We support enhancement for TDD C-JT since it is promising for cell edge and cell average performance improvement. With the potential to support more UEs, we would like to focus on DMRS and SRS enhancement.

Regarding overhead and/or latency reduction for beam management, more detailed description is needed. We suggest to focus on UE-initiated and/or group-based beam reporting.

Worload: We suggest 1.5 TUs on Area 2.

22 – Huawei Tech.(UK) Co.. Ltd

For CJT:

Coherent joint transmission could be enabled for a lot of NR networks, including the cases of inter-site indoor (corresponding to industry factories scenarios), inter-site outdoor (corresponding to C-RAN structure based Macro deployments), and intra-site outdoor (corresponding to intra-site gNB cooperation cases). However, the coherent joint transmission are not well specified in NR. Actually, with coherent joint transmission from multiple TRPs, the NW could benefit from beamforming gain with more cooperated antennas from different TRPs, interference mitigation/avoidance from joint scheduling, much more MU gain because

more UEs could be jointly scheduled in the cooperated areas. As shown in (RP-212150), in our preliminary simulation results, the benefits of CJT are also proven.

In previous discussion, some companies asked why CJT is not so successful in LTE systems. Indeed, one reason is that LTE systems are based on CRS. Even with antennas cooperation in CJT, the interference due to the cell-specific always-on signals is difficult to mitigate and increase the overhead when CJT is used. But in NR system, there is no such cell-specific always-on signals. Furthermore, C-RAN structure and industry deployment are used more and more in NR, where multi-TRPs are shared with the same baseband (or basebands are together), so it is easier to enable coherent joint transmission.

We would like to clarify which specific objectives should be included in the enhancements for CJT. CJT enhancement should be for both FDD and TDD, including: CSI enhancements and CSI-RS overhead reduction for FDD, SRS enhancement for CSI acquisition for CJT, more than 12 orthogonal DMRS ports, interference measurement enhancements, and smaller precoding granularity (PRG).

As discussed above, coherent joint transmission for M-TRP should be high priority in Area-2.

For DMRS enhancement:

As discussed above (in CJT), since more UEs could be jointly scheduled in the cooperated areas for CJT, more orthogonal layers are required for MU transmission for high spectrum efficiency. In RP-212150, the required number of orthogonal layers is more than 12. So, the enhancement on orthogonal DMRS ports is necessary. Since higher probability of pairing more users happens in mTRP scenarios, we would be fine specifying the DMRS enhancements under the objective of mTRP or CJT.

For beam management:

For extending R17 unified TCI and overhead/latency reduction for multi-beams, the unified TCI is for overhead/latency reduction, so the Unified TCI state should be a sub-bullet for overhead/latency reduction. The deployment of mmWave should consider commercial values. Reusing the site locations and providing contiguous coverage for mmWave is more valuable in the real deployment, and this requires large array antennas. So, the enhancements for beam management should consider the use case of large antenna array.

For Asynchronous MTRP and multi-TA:

The typical use cases and benefits are unclear. Normally, as discussed in previous email discussion, the cooperated TRPs are well synchronized between each other. Some companies mentioned that TA is longer than CP for the case of very large scale multi-TRPs in cooperation, i.e., very remote TRPs are within the cooperated area. But, such case happens with very small probability for a UE. So, at this stage, we do not think asynchronous case should be a priority.

Proposals: support the following updates:

- **Overhead and/or Latency reduction for beam management for large antennas array, including UE-initiated beam management,** and extend Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and [inter-band]) [RAN1]

~~- Combined MTRP schemes, more generic (Controversial)~~

~~Increasing the number of orthogonal DL [and UL] DMRS ports both for S-TRP and M-TRP~~ *(focus on mTRP case, so moved under CJT)*

- Enhancement for Coherent-JT/D-MIMO **for FDD and TDD**, including codebook, CSI reporting, spatial domain interference avoidance, **SRS enhancements for CSI acquisition, smaller PRG size and increasing the number of orthogonal DL and UL DMRS ports. [RAN1]**

~~- Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic (Controversial)~~ *(move to the first bullet)*

~~Asynchronous M-TRP/Multiple TA for M-TRP~~

23 – VODAFONE Group Plc

The non-controversial points (multiple DL & UL TCI states; increased number of orthogonal DMRS ports) seem worthwhile.

On the controversial points, ”overhead and/or latency reduction for beam management procedure/beam acquisition procedures” and ”codebook/CSI reporting enhancements” are of the most interest to us.

24 – Fraunhofer IIS

We support extending the Rel-17 unified TCI framework to support multi-TRP transmission schemes. We think that the specific targeted multi-TRP scheme(s) should be clarified.

The objective as well as potential gains of the second point “Combined MTRP” schemes are not clear to us. We suggest to remove it or give it a lower priority.

The current objective of increasing the number of orthogonal DL/UL DMRS ports is not clear to us. However, we are open to further study it.

We think that the workload and specification impact for C-JT/D-MIMO is very large. For performance evaluations of C-JT/D-MIMO, real-world hardware limitations (e.g., distributed sync, etc.), deployment constraints, complexity and cost should be taken into account. As one of the main targets of R18 is UL-related enhancements, C-JT/D-MIMO should be of low priority for R18.

We are not clear if asynchronous M-TRP/Multiple TA for M-TRP is a use case in real deployments. It involves high UE complexity and performance gains are very limited in our view. We therefore think that it should have a low priority for R18.

The estimated workload for Area 2 is 0.5 TU in RAN1.

25 – CEWiT

- Regarding unified TCI framework, we believe indication of more than one TCI states in UL and DL will be beneficial at the UE and support the objective to be a part of Rel18. But the sub-bullet on combined schemes needs more clarity and since Rel18 is UL heavy and already we have more on the plate for DL, we propose to remove this sub-bullet

- Regarding increased orthogonal DMRS ports, we are in support of the objective. We believe with enhancements related to CJT in DL and UL enhancements targetting CPE devices, it is evident that we need to handle case of MU-MIMO pairing beyond 12 layers. Hence we believe going for more number of orthogonal ports is very useful

- Regarding CJT, we believe the current MTRP feature will be improved if we support CJT. Even though in the current framework, it is possible to do CJT transparent to the UE, having a framework supporting CJT will help in ensuring the design targets of MTRP enhancements. Hence we support this objective

- Regarding the overhead and/or latency reduction for beam management procedures, we have a neutral stance.

- Regarding async MTRP, we believe the feature is useful only under UL MTRP and in DL we always assume we co-operate among the TRPs which are within CP and hence synchronized. Hence we are not supportive of this objective.

26 – MediaTek Inc.

- We are supportive to **extend the Rel-17 Unified TCI framework** for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1) for M-TRP. This would seem to be useful in providing some overhead reduction and simplifying UE operation for M-TRP.

- **Combined M-TRP schemes**: we do not believe that the use cases are so clearly beneficial, so consider it as low priority.

- **Extension of orthogonal DL/UL DMRS ports:** We have not seen any rationale provided for DL DMRS port extension beyond supporting C-JT, so this should be coupled with C-JT in our view. For UL DMRS ports, we think more justification & discussion would be needed on the problem scenario, and more focused targets to focus any work. Currently overall low priority.
- **Coherent-JT/D-MIMO:** We see enhancements for this as a low priority. This requires more stringent network requirements than basic multi-TRP, and some companies are claiming that even that is not achievable.
- **Beam management overhead & latency reduction:** We believe that this work can be much more focused. We suggest to focus on UE initiated beam management, which was not completed in Rel-17.
- **Asynchronous M-TRP/Multiple TA for M-TRP:** This feature will cause large UE complexity due to the timing misaligned interference experienced by the UE. It is claimed (above) that the main issue is for FR2 due to shorter CP, and that somehow the UE can completely isolate any interference between antenna panels. To us this seems like wishful thinking at least for a handheld device. The whole commercial use case is completely unclear to us. So we do not support this work.
- Regarding **UL different TA,** please see our comments in the ”UL Aspects” section.

27 – AT&T

For this item, we are supportive of

. Extension of the Rel. 17 unified TCI framework, in particular indication of multiple DL (M) and UL (N) TCI states under the unified TCI framework. This can be applicable to mTRP, as well as sTRP use cases.

. Enhancements for C-JT/D-MIMO: specifying enhancements for C-JT/D-MIMO targeting FR1. From our perspective, we see a need for such enhancements, especially for low FR1 bands, which have clear form factor limitations. This can greatly benefit from C-JT/D-MIMO to improve performance. Enhancements here can include CSI acquisition enhancements for the distributed panels/RRHs.

. Overhead and/or latency reduction for beam management. This is an important item that was downscoped in Rel. 17. We support studying and specifying advanced beam refinement/tracking

. Asynchronous m-TRP/multi-TA for mTRP: we support studying and if needed specifying enhancements for asynchronous m-TRP/multi-TA targeting FR2 if work load is permissible

28 – Ericsson LM

Ericsson support extension of Rel-17 unified TCI framework to multiple DL and UL TCI states. The main foreseen use case is multi-TRP, where there is already a fair amount of functionality introduced for the Rel-15/16 TCI framework, Support for M-TRP in the Rel-17 framework is an important building block to ensure that Rel-17 TCI framework is future proof.

Regarding combined M-TRP schemes, we support specifying mixed mode single-DCI and multi-DCI multi-TRP scheme. The motivation for this to support high reliability with improved spectral efficiency

for intra-UE multiplexing of eMBB and URLLC traffic. Without this, if single-DCI M-TRP is used for scheduling a very small URLLC packet in FR2, the spectral efficiency will be reduced for eMBB.

Ericsson support increasing the number of UL DMRS ports without increasing the DMRS overhead as we see issues with shortage of orthogonal ports for UL MU-MIMO. We believe this is a rather small but product relevant enhancement, e.g. solution may be to increase the FD-OCC length from two to four. For symmetry reasons, we also support the same enhancement for DL DMRS as a separate capability. Note that this enhancement is not related to multi-TRP (although listed by the moderator under multi-TRP)

On C-JT, we believe this is an interesting feature, especially for the intra-site case, however, we haven't seen an urgent market request for this feature, and it is also noted that the pre-cursor NC-JT have not yet emerged in deployments. Although a future looking technology, we think this should have low priority to be included.

Rel-16 introduced overhead reduction for beam management, and Rel-17 introduced further overhead reduction as well as significant latency reductions. With the recently improvements that have been introduced, it is not clear to us what changes, if any, would be motivated.

29 – Futurewei

Regarding "Enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance", we saw some questions/comments on why similar scheme such as CoMP does not work well for LTE and the concern on the large standard impact.

Regarding why similar scheme such as CoMP does not work well for LTE, in addition to the always-on CRS in LTE as mentioned in previous response by other companies, another reason is that in LTE, it is difficult to handle inter-cell interference using channel information of neighboring cells as the number of interfering links to consider is generally large and it is difficult to obtain reliable interfering link channel information.

To resolve these issues and obtain the promised gain from the massive number of antennas, we have proposed a spatial-domain interference avoidance approach via Bi-directional Training (BiT), where DL interference probing and mitigation based on semi-statically coordinated SRS resources among gNBs is employed in TDD, which provides significant performance gain (e.g., please see RP-212456). Please note that compared to the conventional Coherent-JT/D-MIMO, BiT requires no or little information exchange between the cooperating gNBs and the DL transmission is from one single transmission point, therefore the synchronization requirement among transmission points can be relaxed.

The standard impact of BiT are mainly SRS enhancements with dynamically indicated parameters associated with corresponding DL transmissions. Further study can be done for various flavors of cooperative MIMO technologies with different assumptions on backhaul, coordination, and transmission schemes among TRPs, etc.

30 – Verizon UK Ltd

Supportive of the proposal. This is related to the more important NW KPIs.

We think all non-controversial ones should be accepted.

For the controversial ones, we would like to support them in this order:

1. overhead/latency reduction - yes, need more specifics but there are some good ideas already to start with
2. C-JT/D-MIMO: we see the need for some deployment scenario
3. Asynchronous m-TRP/multi-TA for mTRP
4. combined m-TRP schemes: not very clear

31 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

- For the Rel-17 Unified TCI framework extension, we are supportive of the first sub-bullet "for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1)" which is applicable to both S-TRP and M-TRP. For M-TRP, all Rel-16/17 multi-TRP schemes should be supported.

- Regarding "Combined MTRP schemes", we believe more discussion is needed on potential enhancements, e.g., which schemes can be combined (combination of single-DCI and multi-DCI based scheduling for MTRP or a combination of SDM/FDM/TDM schemes), as well as the potential gains/tradeoffs of such combining need to be first studied and evaluated and only specified if significant gains are observed. Proponent companies have not yet convincingly shown the potential advantages/gains of supporting such combined MTRP schemes. Also, in our view, such combine MTRP schemes are expected to have an impact beyond unified TCI framework and so, if considered as an area for study in Rel-18, it should be listed as a separate objective main bullet and not a sub-bullet under "Extend Rel-17 Unified TCI framework". The unified TCI framework enhancement bullet can be updated as:
  - **Extend Rel-17 Unified TCI framework for indication of multiplex DL and UL TCI states (e.g., M>1 and/or N>1) for single-TRP and multi-TRP scheduling**

- Regarding increase in the number of orthogonal DMRS ports for DL as well UL, generally, we are fine but would like to also consider DMRS overhead reduction in Rel-18 for some special cases. So, we propose to add to the end objective bullet "..and enhancement for DMRS overhead reduction"
  - **Increasing the number of orthogonal DL [and UL] DMRS ports both for S-TRP and M-TRP <u>and enhancement for DMRS overhead reduction</u>**

- For CJT/D-MIMO enhancements, further elaboration of the use case is necessary, e.g., whether the scope is limited to <1 GHz carrier, which can question the potential narrow impact (and hence priority) of this objective. Also, the expected gains of CJT over Rel. 17 NCJT CSI reporting framework need to be first assessed and studied and CJT/D-MIMO only specified if significant gains are observed. Accordingly, this objective should have a low priority with a study item performance evaluation component.

- Regarding the bullet on overhead and/or latency reduction for beam management, it needs to be clarified with a clear objective and enhancement relative to Rel-17 beam management. Advanced beam management techniques discussed in Rel-17 but not be specified due to lake of time should be taken as a starting point. In addition, other new scenarios and mechanisms can be included. In our view, following objective specific to overhead and latency reduction for beam-management procedure should be supported:
  - **Sharing/grouping-based beam measurement and reporting**
  - **Event based beam measurement and beam reporting at least for mobility scenario**
  - **UE initiated beam update**
  - **Multi-beam sequence indication for fixed and/or deterministic UE mobility**
  - **Overhead and latency reduction for beam acquisition procedure**

- For asynchronous M-TRP/multiple TA for M-TRP, we are supportive to relax the synchronization requirement for real multi-TRP deployment.

32 – LG Uplus

C-JT should be prioritized. We have commercialization experience for indoor situation, where C-JT has **significant gain**.

Regarding C-JT, we can agree that several TUs are needed for evaluation but don't believe it is too big. Evaluation is quite general step in 3GPP and the size of TU depends on the scope of study.

As many companies comment, LTE protocol by itself has some issue to enable C-JT. NR can support C-JT in indoor circumstance but need some enhancement for outdoor circumstance.

We could not agree that non-ideal backhaul assumption is more general. C-RAN architecture is more general for now.

33 – Qualcomm Incorporated

"Combined MTRP schemes, more generic" is not clear, and should be removed. During Rel-16 discussions, combinations of TDM+FDM+SDM schemes were discussed and not agreed. We do not see enough justification to revisit that. If the combined mTRP schemes refers to allowing for both sDCI and mDCI based frameworks together, then it is unrelated to unified TCI framework.

"Increasing the number of orthogonal DL [and UL] DMRS ports both for S-TRP and M-TRP": We do not see the urgency for this, and also, the relationship of this enhancement to M-TRP is not clear.

For CJT, we would like to have a clear scope if it is included. If this is about CSI codebook enhancements, it should be moved to "Further enhancements for CSI" with a study phase to justify introducing another CSI codebook.

Regarding "Asynchronous M-TRP/Multiple TA for M-TRP", we would like to limit this enhancement to multi-DCI based mTRP. This is because the UE complexity associated with asynchronous operation can be handled in a proper way with multi-DCI framework (based on CA from UE capability point of view). Furthermore, this is consistent with inter-cell mTRP in Rel-17 that is based on multi-DCI framework. With ideal backhaul (i.e., single-DCI based framework), it is more likely that TRPs are also synchronized. At the same time, for async M-TRP, we suggest clarifying that this includes inter-cell M-TRP and inter-cell BM as well, which could be a typical use case.

For R17 unified TCI extension, support both sTRP and mTRP. Applying more than one used beam for sTRP is also critical to ensure reliability. To our understanding, the BFR may have to be triggered if the single used beam for all control/data channels gets blocked. The multi-beam diversity for sTRP is supported since Rel-15. In addition, the unified TCI enhancement can also include inter-cell BM, which is essentially sTRP operation. The current MAC-CE based TCI switching between non-UE-dedicated and UE-dedicated channels for UE supporting a single active TCI is inefficient.

Support overhead/latency reduction for BM, e.g. UE initiated BM, which has been suspended in Rel-17 due to insufficient time. There are also a few items under this topic that have not been discussed in Rel-17, e.g. UE-group beam reporting, beam measurement/reporting/refinement/selection triggered by beam indication.

34 – China Telecommunications

We are fine with the non-controversial parts. For the controversial ones, we are supportive of enhancement for Coherent-JT/D-MIMO, overhead and/or Latency reduction for beam management procedure/beam acquisition procedures.

2.1.3 Area 3: Other CPE(customer premises equipment)

Based on summary [3], further discussion could focus on what specific consideration is needed for CPE.

Feedback Form 3: Any specific consideration on CPE with motivation/benefits/scenarios and assessment of workload in related working group(s)

1 – Intel Corporation (UK) Ltd

We support objective related to CPE enhancements. In terms of detailed scope, the modulation enhancement is the most promising in our view considering support of 4096QAM by other wireless technologies:

1. **Study techniques to improve performance of PDSCH with 4096QAM modulation such as non-uniform constellation, constellation shaping, etc.**
2. **Based on the study, specify support of 4096QAM for downlink**

2 – CableLabs

We support CPE enhancements and consider 4096QAM as a very promising feature for NR Fixed Wireless Access. This feature would put NR on par with other access technologies (IEEE802.11be and DOCSIS3.1/4.0) supporting 4096QAM.

3 – Comcast

Comcast supports Area 3: CPE, more specifically the CPE support of 4kQAM.

4 – LG Electronics Inc.

Overall, we prefer to minimize DL scope in Rel-18 like many other companies but current DL scope is too large. We don't prefer to include CPE-specific enhancements in Rel-18

5 – Nokia Corporation

We support CPE enhancements in general, however in our view the UL enhancements considered below for CPEs have higher priority than the DL enhancements proposed so far.

6 – InterDigital France R&D

No specific preference, as we consider this a low priority item.

7 – ZTE Corporation

No clear objective for DL CPE enhancement is identified from our side. We suggest to consider it as a low priority item.

8 – Apple GmbH

CPE is very low priority for us. We would also prefer the scope to be further clarified

9 – Futurewei

It is unclear to us what the scope is for CPE. If it is for supporting 4096QAM, our view is that: first, supporting 4096QAM is not MIMO related and "MIMO Evolution for Downlink and Uplink" is not the right place to discuss it; second, it is unclear what the possible gain and the related increased complexity are. So we suggest putting CPE in low priority for Rel-18.

10 – MediaTek Inc.

We do not see DL enhancements for CPE as a key focus area, and see no particular performance gaps, so would consider this a low priority enhancement area for Rel-18.

11 – Samsung Research America

The DL enhancements for CPE is low priority in our view and we don't support having this in the WI.

12 – vivo Communication Technology

If the scope is only to introduce higher order modulation, it is better to consider as RAN4 item.

13 – Spreadtrum Communications

We are fine to consider DL MIMO enhancement for CPE as low priority. UL MIMO enhancement for CPE will be discussed separately.

14 – CableLabs

It seems that, for good reasons, there is some confusion concerning 4096QAM objectives. In our opinion, this feature supports directly NR Fixed Wireless Access use case. In that regard, it represents a CPE feature but it is not related to DL MIMO, hence the confusion. Perhaps a better place for this feature is IAB but other venues could be discussed. We would like to respectfully ask for chair's guidance here.

15 – Huawei Tech.(UK) Co.. Ltd

To enhance the spectrum efficiency for CPE/FWA is beneficial in the real network for both UL and DL. If time allows, we prefer to include some simple and efficient enhancements for CPE as well, such as DMRS overhead reduction, which is clearly beneficial for the slow-changing channels from CPE.

Proposals:

Specify DMRS overhead reduction for CPE. [RAN1]

16 – Beijing Xiaomi Mobile Software

We prefer to consider CPE as a low priority item.

17 – SHARP Corporation

In our view, DL enhancement for CPE is low priority.

18 – Asia Pacific Telecom co. Ltd

We deem that CPE is low priority area.

19 – NEC Corporation

We don't see strong motivation for this objective. It is more important to enhance UL aspects for CPE.

20 – China Mobile Com. Corporation

In our view, the market share of CPE is not large. We prefer to consider it as a low priority item.

21 – CATT

Suggest to consider this as a low priority item in Rel-18.

22 – CATT

We support enhancement for > 4Tx operation. Higher peak data rate for UL could play a significant role in short-range applications such as home entertainment, video surveillance/monitoring in industrial/health-care/safety, IAB, and other applications where devices power/form-factor/cost are not as stringent as in traditional handheld devices. UL transmission with >4Tx is useful to bridge the gap between DL and UL spectral efficiency, in both FR1 and FR2.

For > 4Tx operation, the following enhancements can be considered:

- Support up to 8 UL layers for codebook and non-codebook based PUSCH, including design of codebooks for up to 8 layers, enhancements on the number of codewords and necessary control signaling;
- Enhancement of SRS for UL CSI acquisition, possibly support SRS with up to 8 ports;
- Enhancement of DMRS, e.g. support DMRS with up to 8 ports;
- Enhancement of SRS switching with up to 8Tx.

23 – VODAFONE Group Plc

We are not sure that 4096QAM for downlink fits under the MIMO topic, but if the work load is small for FWA, it could be considered as a lower priority item (somewhere) in Rel 18.

24 – Fraunhofer IIS

DL enhancement for CPE is low priority for us.

25 – CEWiT

For Rel18, we believe CPE related enhancements under DL is of lower priority.

26 – AT&T

We support DL enhancements for CPE for fixed wireless access applications. In particular, we support studying and if needed specifying techniques to improve PDSCH performance with 4096QAM modulation

27 – Ericsson LM

Although CPE is an important use case, we don't see a need for further specification enhancement.

28 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

In the RAN#93e email discussion, most companies agreed with Moderator's proposal that CPE-specific enhancements should be a low priority. Some CPE-specific considerations for fixed CPEs as well as mobile CPEs that can be studied, TU permitting, include 4096-QAM, DMRS overhead reduction and modification to the codeword to layer mapping.

29 – LG Uplus

CPE scenario is low priority to us.

2.2 UL Aspects

This part is mainly referred from RP-21165.

2.2.1 Area 4: > 4 Tx UL operation

Based on summary [3], further discussion could focus on

- Study and if necessary specify >4 Tx UL operation, e.g., for CPE/FWA/vehicle/Industrial devices

Feedback Form 4: Comments on each objective with motivation/benefits/scenarios and assessment of workload in related working group(s)

1 – Intel Corporation (UK) Ltd We don't think UL with > 4Tx targeting CPE like devices is urgent enhancement in Rel-18, due to lack of DL enhancement for the same case. If TU budget is limited, we prefer to consider this enhancement as low priority for Rel-18.
2 – SoftBank Corp. We see a strong demand on UL enhancements for CPE/FWA/industry use cases. Therefore, this item should be treated as high priority topic in Rel-18.
3 – TELECOM ITALIA S.p.A. Same view as Softbank. This is a strong market requirement (much more than many other Rel 18 proposals). And there is no need for a study phase, since it was already done in previous releases. It can be a very short WI, with RAN4 lead group
4 – LG Electronics Inc. We are supportive on this topic considering various UE form factors other than hand-held devices.
5 – Nokia Corporation We support enhancements for higher rank transmission in UL, which also match well with clear request for UL capacity enhancements in Rel-18 given in the June workshop, and the views expressed by operators above.
6 – InterDigital France R&D The exact scope of this item and its necessity is not clear to us. We are open to have further discussion.
7 – ZTE Corporation We support the enhancements for higher rank and >4 Tx-port transmission in UL, which has a very clear market requirement, e.g., for industrial IOT. Scenarios:

- We share the same views on the identified scenarios captured in the above bullet, i.e., CPE/FWA/vehicle/Industrial devices (for both FR1 and FR2).

Motivation/benefits:

- To enable > 4 layer UL transmission, e.g., up to 8 layer for SU-MIMO, and up to 12 layers or more for MU-MIMO and UE-aggregation.
- Significant performance gains (especially enable >4 layer UL transmission) can be observed. Some SLS results can be found in our contribution RP-212375.

Detailed objectives/enhancements:

- Support >1 CWs for both >4 layers and ≤ 4 in UL
- For CB, Type-I like UL codebook as a starting point (for both >4 layers and ≤ 4).
- For NCB, re-design of DCI SRI codepoint (for both >4 layers and ≤ 4).
- Increase of #. of DMRS ports per UE.
- SRS design for supporting 6 or 8 Tx (e.g., for CB, NCB, and antenna switching (e.g., 6T6R, 6T8R, 8T8R)).

Assessment of workload: We think the > 4 Tx UL operation enhancement may require 0.75 1 TUs on average with RAN1 leading WG

8 – Apple GmbH

Support of >4 Tx UL operation is very low priority for us

9 – Futurewei

In our view, it is difficult for general UE devices to support >4 Tx and hence the benefit and urgency of such a feature are not clear. We suggest putting this in low priority for Rel-18.

10 – MediaTek Inc.

We are fine to consider >4Tx antennas for CPEs. However, we believe that further verification is needed on whether it is beneficial to specify >4 MIMO layers for this.

11 – Samsung Research America

· We support studying and, if necessary, specifying this enhancement, targeting non-handheld devices.

· The maximum number of layers is 4, and it should be limited to 6 and 8 ports (the need for 5 and 7 ports is unclear based on the current non-handheld UE antenna architecture). This implies that RS enhancement (increased # SRS ports, DMRS optimization) would be needed.

· Codebook-based UL transmission should receive higher priority than non-codebook-based UL transmission). This implies that codebook design for 6 and 8 ports is needed.

12 – vivo Communication Technology

We don't see use case for >4Tx in UL, if the special devices such as CPE/FWA/vehicle/Industrial devices are targeted, specific scenario including antenna structure should be clarified in order to narrow down scope. For example, asssuming linear cross-pole Tx antenna, where DL codebook designs can be used. Work scope should take overally available TUs for MIMO WI into account.

13 – NTT DOCOMO INC.

We support as it is useful to improve UL performance.

It can be WI led by RAN1. We think the necessary TU is 0.5TU or less.

14 – Spreadtrum Communications

We support to specify >4 Tx UL operation. The main motivation is to increase the UL transmission capability especially for non-handheld devices.

15 – Huawei Tech.(UK) Co.. Ltd

CPE/FWA/Vehicle/Industrial devices can be equipped with more than 4Tx, such as 8Tx. For these devices, enabling more than rank-4 is beneficial. The benefits of more than 4Tx is obvious, we don't think there is a need for a study phase.

Proposals:

~~Study and if necessary s~~ Specify >4 Tx UL operation **and support more than rank 4,** e.g., for CPE/FWA/vehicle/Industrial devices [RAN1]

16 – SHARP Corporation

We support > 4 Tx MIMO to improve UL performance.

17 – Guangdong OPPO Mobile Telecom.

Support to specify >4Tx UL operation. It is key feature to improve the UL performance, e.g., higher data rate

18 – KDDI Corporation

We support > 4 Tx uplink MIMO as we believe it is very beneficial in CPE/FWA/vehicle use cases.

19 – DENSO CORPORATION

Supportive of > 4 Tx MIMO, in particular for vehicle/industrial devices.

20 – NEC Corporation

We suggest to limit the scope to FR1 only.

The estimated workload is 0.25-0.5 TU in RAN1.

21 – China Mobile Com. Corporation

As we commented, the total amount is not large for the non-handheld devices. We suggest consider it as a low priority item

22 – CATT

We support enhancement for > 4Tx operation. Higher peak data rate for UL could play a significant role in short-range applications such as home entertainment, video surveillance/monitoring in industrial/healthcare/safety, IAB, and other applications where devices power/form-factor/cost are not as stringent as in

traditional handheld devices. UL transmission with >4Tx is useful to bridge the gap between DL and UL spectral efficiency, in both FR1 and FR2.

For > 4Tx operation, the following enhancements can be considered:

- Support up to 8 UL layers for codebook and non-codebook based PUSCH, including design of codebooks for up to 8 layers, enhancements on the number of codewords and necessary control signaling;
- Enhancement of SRS for UL CSI acquisition, possibly support SRS with up to 8 ports;
- Enhancement of DMRS, e.g. support DMRS with up to 8 ports;
- Enhancement of SRS switching with up to 8Tx.

23 – VODAFONE Group Plc

We see this as useful, and suspect that it might also become useful for smartphone form factors operating in the 6-7 GHz range

24 – CEWiT

We are supportive of the objective as such with the eg devices. For >4 Tx antennas we also propose to work on relevant enhancements on >4 layers with >1 CW and also SRS related enhancements

25 – Lenovo (Beijing) Ltd

We support this topic. We believe >4 layer shall be supported with sufficient justification. It shall support both multi-panel UEs and single-panel UEs, and both CB and NCB-based transmissions. Corresponding enhancements, SRS/DMRS/TPMI/Codeword-to-layer mapping/DCI enhancements shall be included.

26 – Telia Company AB

We support and see mostly need to specify >4 Tx UL operation for CPE/FWA/Industrial form factor UEs.

27 – AT&T

We see a strong need for UL enhancements for fixed wireless access applications. We support specifying >4Tx UL operation with rank greater or equal to 4

28 – Xiaomi Communications

We support the enhancements for >4Tx UL operation mainly for non-handheld devices, and this should be led by RAN1. We also suggest to start up the RAN4 work on 4Tx as well.

29 – Ericsson LM

We are OK with the study in principle.

Given the heavy load for Rel-18 MIMO work, it would be good to prioritize which of the many MIMO modes we will enhance. That is, we should downselect among e.g. {codebook, non-codebook}, {full-, partial-, and non-coherent}, {full power mode 1, 2}, etc.

We'd suggest that the list of devices be square bracketed (i.e. "[CPE/FWA/vehicle/Industrial devices]"), since not all of these devices may be targeted in the study. The devices can be selected either when the WI/SI is agreed or as part of the study.

Identifying use cases / scenarios with realistic antenna configurations and proper channel models will be key to such a study. While this can be addressed later in the more detailed discussion stage, these aspects need to be called out in objectives if a WI/SI including >4 Tx is approved

Regarding earlier proposals to limit to at most 4 layers: this is highly dependent on the scenarios and antenna configurations to be supported. Further clarity on these is needed before limiting to 4 layers, and such a decision may need to be taken as part of the study.

30 – Verizon UK Ltd

For us, 4Tx is ok, if not >4Tx.

31 – LG Uplus

Deprioritized to us.

32 – Qualcomm Incorporated

We envision the use case of 6 or 8 Tx UL is for CPE/FWA devices, not for handheld mobile devices. In case more than 4 Tx UL is supported, it should be limited to the cases where the supported maximum rank does not exceed 4. The reason is because the UL channel of CPE/FWA devices is normally not rich enough to support more than 4 layer transmission.

2.2.2 Area 5: Enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation

Based on summary RP-211652, further discussion could focus on

- Specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, potentially including fast UL panel selection, separate UL timings/power controls for different panel/TRP and/or simultaneous multi-panel UL transmission

Feedback Form 5: Comments on each objective with motivation/benefits/scenarios and assessment of workload in related working group(s)

1 – Intel Corporation (UK) Ltd

We support objective related to enhancements to multi-panel/multi-TRP operation in uplink. In particular Rel-18 should specify support of simultaneous transmission from the UE in multi-panel/multi-TPR scenarios to improve peak data rate (eMBB) and reliability of the transmission (URLLC). The enhancement should consider both FR1 and FR2 and PUSCH/PUCCH/SRS physical channels and reference signals. Multiple TA in mTPR should be considered as separate objective

1. Specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation to enable simultaneous uplink transmission of physical channels and reference signal ~~, potentially including fast UL panel selection, separate UL timings/power controls for different panel/TRP and/or~~

~~simultaneous multi-panel UL transmission.~~ **Consider enhancements for eMBB and URLLC scenarios in both FR1 and FR2.**

2. Specify support of multiple TAs for the same carrier in multi-TRP scenario

Workload: We think the simultaneous multi-panel uplink transmission may require 0.25-0.5 TUs with RAN1 as leading WG

2 – TELECOM ITALIA S.p.A.

Support the justification indicated by Intel. Not sure if it is good to remove the examples in the moderator's proposal.

3 – LG Electronics Inc.

We support this topic with the highest priority for both FR2 and FR1(for vehicles). Simultaneous multi-panel transmission is very useful feature for UL throughput and/or reliability improvement. Panel-specific timing/power control is an essential part for mTRP operation in high frequency band. Fast UL panel selection has been discussed in Rel-17 but it is highly likely that there will be left-overs given the current progress. So, we support all three sub-topics.

4 – Nokia Corporation

This objective is complementatry to the "Asynchronous mTRP operation" in section 2.1.2, and hence we consider it high priority in this thread. This includes also simultaneous multi-panel UL transmission and further enhancements for MPE handling, if needed.

5 – InterDigital France R&D

Support this feature. Multi-panel uplink operation has been only partially discussed and supported in NR.

6 – ZTE Corporation

Support the enhancement for multi-panel uplink operation and/or enhanced multi-TRP uplink operation, which is a very interesting topic.

Scenarios:

- Handover devices as well as CPE/FWA/vehicle/Industrial devices (mainly for FR2)

Motivation/benefits:

- To further improve UL capacity (e.g., 15.7% mean UPT for STxMP) and reliability via spatial multiplexing/diversity
- BTW, some more detailed SLS results can be found in our contribution RP-212375.

Objective:

- We believe the above objective is clear enough. BTW, compared with modified objectives from Intel, we slightly prefer the original objectives, in our views.

Assessment of workload: We think the above enhancement may require 0.5 TUs on average with RAN1 leading WG

7 – Apple GmbH

We failed to see the necessity for simultaneous multi-panel transmission. Currently we do not have a clear framework even for UL panel selection. For the multi-panel UL operation, we suggest to focus on the UL panel selection.

Separate power control for multi-TRP/panel is already supported in Rel-17 due to Multi-TRP PUCCH/-PUSCH enhancement, we need further discussion to understand the scope

We are against separate UL timing for multi-TRP/panel

8 – Futurewei

We are supportive for enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, especially on the enhancement to support separate UL timings for different panel/TRP. In Rel-16/17 M-TRP, single UL timing (e.g., TA) is assumed, which generally will cause significant UL performance degradation or limit the use cases for M-TRP. Supporting separate UL timings for different panel/TRP will solve this issue.

9 – Samsung Research America

o For this item, we don't think the group should rush into specifying. We support studying and, if necessary, specifying this enhancement focusing more on the UL transmission aspects and UL timing (TA) and power controls conducive to UL mTRP/multi-panel. Beam indication support should already be included/-covered in Area 2 (extension of Rel-17 unified TCI framework)

o We don't support including fast "UE-initiated" UL panel selection in the scope. Either this is supported in Rel-17, or (otherwise) this is a highly/unusually controversial topic (how companies perceive the amount of control a UE can have on panel selection are irreconcilable) as evident in the past 2 releases.

10 – MediaTek Inc.

We do not see the commercial value of Simultaneous multi-panel Tx operation. This will cause high operational complexity for devices. On the performance side, there will be power restrictions per link, so it seems to us that the relevant usage scenarios will be extremely limited. We have also asked a number of times but there still seems very little consensus on what sort of device type this is targeting. This suggests that the commercial demand is unclear.

In our view **it would be better to focus on continuing to improve the specification of UL panel selection enhancements** instead, which seems to provide value in more operational scenarios, is operationally-friendly to more device types, and hence seems to have broader commercial value.

Regarding separate UL timings to different TRPs, if the need is only associated to asynchronous multi-TRP in DL, then unfortunately we fail to see the feasibility of the async mTRP feature (further comments will be provided in section 2.1.2). If it for some other operating scenario, then we would appreciate more clarity.

11 – vivo Communication Technology

Multi-panel in UL could be useful feature together with multi-TRP UL reception from throughput and reliability perspective. UL panel selection, intra- and inter-cell mTRP can be considered. The scope of the objective should considering overall TUs for MIMO.

12 – NTT DOCOMO INC.

- We support it, and we should clarify the relationship between "multi-panel" and "multi-TRP" in the main bullet. We suggest to update "multi-panel uplink operation" to "uplink operation for UE

equipped with multi-panel". For reception at gNB, single-TRP reception and/or multi-TRP reception can be assumed.

- For "multiple TAs for the same carrier in multi-TRP scenario" proposed by Intel, we suggest to clarify whether it is for intra-cell or inter-cell MTRP. For inter-cell MTRP, we believe it is necessary to consider multiple TAs for different cell/TRP. For intra-cell, we are open to discuss it. In FR2, it would be difficult to maintain the timing difference from two TRPs within one CP for large SCS. Also, we think the spec. impact is small.
- It can be WI led by RAN1. We think the necessary TU is 1TU or less.

13 – Spreadtrum Communications

Support in principle. Regarding the three examples listed in the bullet, we think fast UL panel selection should be the highest priority. For separate UL timings/power controls for different panel/TRP, we are OK if there's majority support. For simultaneous multi-panel UL transmission, we think it's for non-handheld devices only and should be low priority, we need to have a fast and robust UL panel selection first.

14 – Huawei Tech.(UK) Co.. Ltd

In this area, multiple things are mixed together and the scope is very broad. So, we need to figure out the high priority aspects for UL transmission. In our understanding, fast UL panel selection, and separate UL timing/power controls for panels/TRPs are high priority, while simultaneous transmission from multiple panels should be considered with lower priority.

From UE's complexity and the requirement on UE, fast UL panel selection is much easier than simultaneously multi-panel transmission. From commercial perspective, fast UL panel selection is also more mature. Before fast UL panel selection and separate UL timing/ power control for panels/TRPs are stabilized (not much progress in Rel-17 due to lack of time), simultaneous transmission could be considered for a later release if it is proved important in real deployment.

Proposals:

- Specify enhanced multi-panel uplink operation and~~/or~~ enhanced multi-TRP uplink operation, focusing on fast UL panel selection, and separate UL timings/power controls for different panel/TRP ~~and/or simultaneous multi-panel UL transmission~~ [RAN1]

15 – SHARP Corporation

We are supportive of enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation.

16 – Sequans Communications

In our understanding the complexity coordination and transmission from multipanel UEs doesn't justify the benefits in the short run. We believe this topic can be deprioritized and we can consider it for further enhancements in future releases.

17 – Sony Group Corporation

In our reading, some of these features are still under discussion in Rel.17 RAN1 AI 8.1.1 under Issue 4 and Issue 5. Given one meeting left, we are not sure whether all necessary progress will be completed in time. To be safe, we think the objective can be listed and can also be removed when completed in Rel.17.

18 – Guangdong OPPO Mobile Telecom.

Multi-panel UL operation is important for UL throughput enhancement. Thus, we support this direction. To be specifically,

- We support separate power controls for different panel/TRP, which can be further enhanced based on Rel-17, e.g. for multiple DCIs based M-TRP which is uncompleted in Rel-16/17.
- Separate UL timings for different panel: We suggest to firstly study in RAN4 whether UE can ensure the timing synchronization of multiple panels or not. If RAN4 identified the issue that single TA is not sufficient, then RAN1 can start to work on separate UL timing. Otherwise, no work on separate UL timings.
- We support simultaneous multi-panel UL transmission.
- We suggest to remove "fast UL panel selection" based on two reasons. 1. The same objective is in Rel-17 WID 2. It would be a special case of simultaneous multi-panel UL transmission.

19 – Asia Pacific Telecom co. Ltd

We support this area in general. However, we believe we should start from fast UL panel selection, which has been discussed but couldn't be fully developed due to limited time. Regarding separate UL timings/PC across panel/TRP, we are open to it. For STxMP, its target device seems to exclude handheld device, we see it as lower priority.

20 – DENSO CORPORATION

Supportive of this objective and O.K to focus on fast UL panel selection and separate UL timing/power control for panels/TRPs.

21 – NEC Corporation

We are interested in this objective and we suggest to make it clear that the enhancements are based on the unified TCI framework developed in Rel-17.

In addition, this objective should be targeting both intra- and inter-cell.

The estimated workload is 1 TU in RAN1.

22 – ZTE Corporation

Regarding simultaneous transmission cross multi-panel (STxMP) vs fast panel switching (a hot topic after reviewing companies' inputs), we would like to clarify our views herein.

- Fast panel switching has been captured in Rel-17 WID, and also studied in Rel-16. But, as Samsung mentioned, it is an unusually controversial topic. To be honest, we do NOT believe that no progress is due to lack of TU or offline discussion (we already have two WIDs before). If one topic failed twice after the corresponding item of WID was approved, why and how to convince companies that this issue can success in a new one?
- Technically speaking, the real controversial part is that many gNB and UE vendors believe that this feature has been supported in Rel-15 with spec transparent manner. If this situation can NOT be changed, we still need to face the same controversial situation again in Rel-18.
- If we have to choose one of them, we strongly suggest that STxMP is considered in this WID, and we may further review the fast UE panel switching can be well enhanced in this STxMP framework (like turn off some features).

23 – China Mobile Com. Corporation

We support this topic. Regarding the scope, we think separate power control can be realized by extension of Rel-17 unified TCI framework. Regarding fast UL panel selection, it can be studied in Rel-18 if this feature cannot be finished in Rel-17. Regarding simultaneous multi-panel transmission, we think it is beneficial for UL throughput enhancement and reliability improvement. Regarding separate UL timings for different panel/TRPs, we are open to discuss it.

Worload: We suggest 1 TU on this Area.

24 – CATT

We support enhancement for UL multi-panel and multi-TRP. We prefer simultaneous multiple-panel transmission for uplink to be with higher priority since it leads to better diversity and spatial multiplexing gain, both of which are inherent for improved uplink throughput, coverage, and reduced beam blockage.

Enhancements for simultaneous multi-panel transmission involve enhancements for single TRP scenarios and multi-TRP scenarios. For single TRP scenarios, potential enhancements include panel-specific beamforming, panel-specific power control, codebooks for simultaneous multi-panel transmission, higher-order UL MIMO and SRS. For multi-TRP scenarios, in addition to the potential enhancements that are listed for single TRP scenarios, PUSCH/PUCCH transmission schemes that allow simultaneous transmission from multiple panels towards multiple TRPs also can be considered.

25 – VODAFONE Group Plc

We support the objective although multi-TRP (rather than multi-panel) is our preferred priority.

26 – CEWiT

We are in support of this objective especially the simultaneous multi-panel transmission and also different UL timings.

27 – Fraunhofer IIS

Fast UL panel selection is currently discussed in Rel. 17. The purpose of discussing it again in Rel. 18 is unclear.

We prefer extending Rel. 17 features in Rel. 18, and hence we are supportive of simultaneous UL Tx from multiple panels and enhanced multi-TRP uplink operation with the unified TCI framework.

The estimated workload for Area 4 is 0.25 TU in RAN1.

28 – Lenovo (Beijing) Ltd

We support this topic. Simultaneous multi-panel UE transmission in UL for FR2, targeting throughput and/or reliability enhancements shall be a high priority. This shall be based on the R17 unified TCI framework. Scope of enhancement includes separate TA, power control, TPMI, and CW-to-layer mapping. It shall accommodate the enhancement of >4 Tx in 2.2.1. If N Tx is supported for single panel UE, for multi-panel UE each panel here can support N Tx as well.

We are open to asymmetric UE panels, but symmetric panel shall be the baseline.

29 – AT&T

We support specifying enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, mainly focusing on simultaneous multi-panel UL transmission, for applications not limited to hand-held devices, but also including vehicular and IAB use cases.

30 – Xiaomi Communications

We support the objective in general. For the simultaneous multi-panel/multi-TRP operation, we prefer it as high priority due to capacity and reliability enhancement as well as efficiency and delay improvements.

31 – Ericsson LM

We are mostly fine with the above objective except for two issues.

The first issue is that it is still unclear what enhancements are needed for fast UL panel selection, since the R17 framework facilitates switching based on DCI. Some of the comments are related to UE-initiated reporting, but that is hardly fast UL panel selection. Hence, we suggest to either replace 'fast UL panel selection' with 'UE initiated reporting', or require further clarification on what additional enhancements are needed for 'fast UL panel selection' on top of what is agreed in Rel-17.

Our second issue is that we think separate power control for different panels/TRPs can already be supported in Rel-17. In Rel-17 mTRP enhancements, up to two separate power controls can be configured, one per TRP. For the Rel-17 unified TCI state framework, it is possible to associate different power control parameters with different UL TCI states, which means that separate power control per TRP can be supported also for the Rel-17 unified TCI state framework. The only power control enhancement that we forsee for mTRP/multi-panel operation is how to handle simultaneous UL multi-panel transmission, is that what this proposal is aimed to solve?

There is also a clear overlap with the functionality in area 2. To us, it would make sense to introduce this enhanced UL operation in the Rel-17 TCI framework: for sure simultaneous multi-panel UL transmission would quite naturally require N>1. Support for simutaneous multi-panel UL transmission should,not be introduced in the Rel-16 TCI framework. Hence, we should consider to merge area 4 with area 2.

Overall, we would suggest the following:

- Specify enhanced multi-panel uplink operation for multi-TRP uplink operation, potentially including ~~fast UL panel selection~~, separate UL timings~~/power controls~~ for different panel/TRP and/or simultaneous multi-panel UL transmission [RAN1]
    - Simultaneous multi-panel/multi-TRP enhances both throughput and reliability for multiple TRPs
    - Different TA is supported for multi-TRP with multi-DCI operation

32 – Verizon UK Ltd

We support the objective. It is about time to have simultaneous multi-panel/multi-TRP operation, for not just hand-held devices, but also FWA, vehicular and IAB use cases.

33 – LG Uplus

We can support this in general.

34 – Qualcomm Incorporated

We suggest the following revision as a starting point, as separate UL timings are included in asynchronous mTRP, and separate power control is a natural outcome but not the only one.

- Specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, potentially including fast UL panel selection~~, separate UL timings/power controls for different panel/TRP~~ and~~/or including~~ simultaneous multi-panel UL transmission

Furthermore, we prefer to focus on the following sub-areas with higher priority:

- Multi-DCI based PUSCH enhancements including simultaneous PUSCH+PUSCH and PUSCH+PUCCH in one CC
- Single-DCI based multi-beam PUSCH including SDM scheme and FDM scheme

35 – KDDI Corporation

We support in general on this topic, and we support DOCOMO's update to clarify the relationship between "multi-panel" and "multi-TRP".

2.2.3 Area 6: Frequency-selective precoding

Based on summary RP-211652, further discussion could focus on

– Study and if necessary specify frequency-selective precoding, mainly targeting devices with >=4 Tx

Feedback Form 6: Comments on each objective with motivation/benefits/scenarios and assessment of workload in related working group(s)

1 – Intel Corporation (UK) Ltd

We are open for such enhancement in Rel-18. We agree that study phase is needed to better understand benefits of the proposed pre-coding considering that previous RAN1 analysis on this enhancement was not very conclusive.

2 – Spark NZ Ltd

comments from Spark NZ

In FR1 bands a rank of 4 is possible but in FR2 bands what is the justification to study >= 4 Tx? This will have consequences on UE batterylife and power consumption and additionally will place extrs burden on network energy efficiency to compensate for these losses.

3 – TELECOM ITALIA S.p.A.

comment to the one raised by Spark:

- not sure if your comment is related to Frequency-selective precoding
- on >=4 Tx in FR2, in case of industrial URLLC and CPEs there could be no major issues related to power consumption (the UE could be connected to external power, e.g. directly to the power grid)

4 – LG Electronics Inc.

Frequency-selective precoding was investigated in Rel-15 and the conclusion was that it's gain is not significant considering DCI overhead and UL channel estimation error. We think that this argument could still hold for >=4Tx. Due to above reason, this topic is a low priority item for us.

5 – Nokia Corporation

In our view this objective is complementary to UL enhancements for >4TX UEs in Section 2.2.1, and hence we support it as part of Rel-18. However, as observed during previous email discussions, a small study phase may be required in the beginning of the work to better characterize the gain potential for different scenarios.

6 – InterDigital France R&D

In general, we support frequency-selective precoding for uplink. However, from our perspective, the focus should be to support this feature by developing efficient CSI report to reduce feedback overhead for subband precoding using the existing codebook. We do not support introduction of new codebooks.

7 – ZTE Corporation

We are open to have some enhancement on frequency-selective precoding. As above companies mentioned, this enhancement can be assumed as a complementary to UL enhancement for >4 Tx UE besides for legacy 4Tx UE.

Scenarios:

- Handover devices and CPE/FWA/vehicle/Industrial devices (for both FR1 and FR2)

Motivation/benefits: To support high-performance transmission in larger UL BW.

- Significant gain for average & edge UPT (more efficient than WB high-res. only)
- In terms of granularity, 16-RB subband @100RB can almost reach upper bound.
- BTW, some more detailed SLS results can be found in our contribution RP-212375.

Objective:

- Flexible signaling design with tolerable increase of DCI overhead.
- Above applies to both CB and NCB PUSCH transmission Increase of #. of DMRS ports per UE.

Assessment of workload: The scope can be relevant to the enhancement on >4 Tx UL operation. In our initial views, 0.25 0.5 TU on average may be sufficient with RAN1 leading WG.

8 – Apple GmbH

We are open to study frequency-selective precoding. But we think this should be for CP-OFDM and coherent transmission only.

9 – Futurewei

We are open to study frequency-selective precoding to better understand the potential gain of this enhancement.

10 – MediaTek Inc.

We are open to study frequency-selective precoding enhancements to improve UL performance for CPEs with 4 or more Tx antennas. But we should also compare with using high resolution wideband precoding, as this may offer a simpler and more scalable solution in terms of overall system overhead.

11 – Samsung Research America

After the discussion in the previous round, it is evident that UL FS precoding can be beneficial for >4Tx scenario. However, a study phase is needed in order to quantify the performance benefits considering the DL control overhead. We observe some gain for 8Tx considering dual-stage (DL Type I) codebook, but the DL control overhead needs to be kept small, requiring a two-stage DCI design. In addition, whether this topic is urgent for improving NW performance is rather unclear. We view this topic as low priority given the urgency and market needs.

12 – vivo Communication Technology

We support to study frequency-selective precoding in UL, for UE with >=4Tx including necessary signaling enhancement.

13 – NTT DOCOMO INC.

We are fine to study it if work load is acceptable. But, we should clarify the schemes/scenarios, e.g., CB-based and/or non-CB based, FR1 and/or FR2, etc. We are fine to support both CB/NCB based, but if we need the down selection, we'd like to prioritize CB based, because CB based is used in real deployment and NCB is not, in our understanding.

It can be WI led by RAN1. We think the necessary TU is 0.5TU or less.

14 – Spreadtrum Communications

We are interested in UL frequency-selective precoding, and it's OK to focus on >=4Tx. Regarding the extension to enhanced uplink precoding, we think it should be deferred until we finalize UL frequency-selective precoding design.

15 – Huawei Tech.(UK) Co.. Ltd

Frequency selective precoding is beneficial for UL. It was already studied in Rel-15, and it was agreed for >2 antennas (in RAN1#89 meeting). But, due to the time limitation in Rel-15, the design of DCI for supporting UL frequency selective precoding could not be finished at the end of Rel-15. So, the feature was not completed. The benefits of frequency selective precoding is obvious, since the UL and DL channels are both frequency selective. For 4 or more UL Tx, frequency selective is beneficial. So, we prefer to support the feature. If there are still questions on the gain we are ok to have a study phase for this objective.

Proposals:

Study and if necessary specify frequency-selective precoding, mainly targeting devices with >=4 Tx [RAN1]

16 – SHARP Corporation

We are open to studying it for devices with >=4 Tx.

17 – Guangdong OPPO Mobile Telecom.

We support it in principle and prefer to only focus on the case with > 4 Tx. The 4Tx case was investigated in Rel-15. We don't think it is constructive to repeat the same study for 4Tx.

18 – NEC Corporation

We suggest to limit the scope to FR1 only.

The estimated workload is 0.25-0.5 TU in RAN1.

19 – KDDI Corporation

We support the discussion of frequency selective precoding, targeting uplink MIMO above 4 Tx. We believe that this is an important option for improving performance in high-order MIMO.

20 – China Mobile Com. Corporation

Since frequency selective precoding is more beneficial for >4Tx case, we think this item could be merged under the >4Tx operations.

21 – CATT

Current wideband precoder cannot sufficiently exploit the channel frequency-selectivity, UL frequency-selective precoding is preferred to be included in the objective for UL enhancements in Rel-18 to fully exploit the adaptive link adaptation gain. For frequency selective precoding, how to design the control signaling to reduce scheduling overhead can be considered.

22 – VODAFONE Group Plc

We support work on frequency-selective precoding and our preference is for FR1 and smartphones

23 – Fraunhofer IIS

In our view, frequency-selective precoding can be studied to clarify if there are potential gains. It should be clear in the objective if the intention is to apply it for codebook or non-codebook or both.

The estimated workload for Area 5 is 0.25 TU in RAN1.

24 – CEWiT

Since we are already considering >4Tx antenna for CPE like devices, it is evident that we need to study frequency selective precoding atleast in benefit of such devices. Though some companies refer to the Rel15 study showing no considerable gain, we believe frequency selective precoding will provide considerable gain especially for more Tx antenna and stationery UEs and hence we support the objective. We also propose to consider relevant issues like DCI compaction for indicating the TPMI.

25 – Lenovo (Beijing) Ltd

We support frequency-selective precoding for improved throughput. We are open to start with a study phase to identify the scope of enhancements in the following aspects:

- whether enhancements to transmit precoding matrix are considered, e.g., higher-resolution codebook
- whether frequency-domain compression is considered for UL codebook
- whether to support all number of Tx or only >4 Tx antennas

- enhancements to PUSCH-scheduling DCI, e.g., DCI formats 0*1, 0*2. The tradeoff between DCI overhead and throughput improvement shall be the focus.

26 – AT&T

As other companies have mentioned, this item is part of the UL enhancements for >4Tx UEs, and can be considered if workload permits, a study phase would be needed to assess the performance improvements

27 – Xiaomi Communications

we support this objective since it is complementary to >4Tx UL operation, and a study phase is preferred.

28 – Ericsson LM

We are OK with the study in principle. As in the >4 Tx case, identifying use cases / scenarios with realistic antenna configurations and proper channel models will be key to such a study. Also, as commented by many companies, overhead is a key concern with UL frequency selective precoding. Unless it can be demonstrated that it brings sufficient gain, DCI carrying FS precoding information should fit in Rel-15 PDCCH in order to maximize the scenarios where FS precoding can be used and to limit the specification effort needed in the work and study items. Therefore, if support for FS precoding with DCI payloads larger than those in Rel-15 is to be considered, it should be in a second stage after FS precoding performance evaluations.

Similar to the >4 Tx case, given the heavy load for Rel-18 MIMO work, it would be good to prioritize which of the many MIMO modes we will enhance. That is, we should downselect among e.g. {codebook, non-codebook}, {full-, partial-, and non-coherent}, {full power mode 1, 2}, etc.

29 – Qualcomm Incorporated

The objective of UL precoding enhancement is increasing UL capacity at the cost of additional DCI overhead. From this angle, the additional overhead can be used to enhance either the frequency resolution or the spatial resolution (but still with wideband precoding). Compared to frequency resolution, we think wideband spatial resolution enhancement has the following benefits

- The DCI payload is invariant with regard to the allocated PUSCH bandwidth
- Achieve better PA efficiency. As we commented before, frequency-selective precoding may increase MPR due to variable PSD. For instance, if the precoder is oscillating between [1,0]^T and [0,1]^T, the PSD on each single Tx has on/off pattern which would create inter-modulation and would require larger MPR to meet RAN4 requirements.

With this in mind, we make the following proposal:

Not pursue frequency selective UL precoding in Rel-18, or if it is pursued, the scope should include, as baseline, enhancements to wideband precoding.

30 – Spark NZ Ltd

spark nz

Devices targeting greater than or equal to 4 TX implies that at least 4 spatial streams are desired to be supported. From our knowledge of extensive 5G deployment field trials in New Zealand across different environments, the rank on offer by the propagation channel is much lower than 4, on average in the FR 2 bands. This would mean that *even if* at least 4 TX are available, on average, only a subset of them will be utilized, depending on the channel rank indication. The above comment also applies to the down link. Naturally, a rank 4 channel is also observable within FR 2 bands, yet only in a small percentage of time,

where its occurrence probability is less than 10% (very low). Since FR 2 bands need to support higher carrier frequencies and bandwidths, the device power consumption scales with the desire to support 4 or more spatial streams due to at least 4 set of mixed-signal circuits driving the antenna array architecture over such wide bandwidths and carrier frequencies. In such a scenario, with even with single carrier transmission, the power consumption would be high, with its effect being even more prominent with multicarrier transmission (via carrier aggregation). This is the reason why it would have a dominating effect on the UE battery life. Supporting frequency-selective precoding on top of this would not make things easier in any manner. On the other hand, in FR 1 bands, we do not believe the aforementioned issues will hold, since a rank of up to 8 can be successfully supported majority of the time, Here, frequency-selective precoding can potentially enhance performance, as pointed out also by many other companies.

Regarding your comment on UE power consumption for industrial uRLLC application, we can agree with your thoughts that the UE could be directly connected to mains power grid. However, this is only as long as there is no requirement on the UE to be mobile. For other scenarios, such as autonomous robots or automated guided vehicles (AGVs) performing programmed tasks on the factory floor, the UEs would then need to be battery driven and our considerations above would need to be taken into account.

2.3 Others

Not to intend to extend the discussion scope, this part will include the comments or proposals that you think can not be reflected in section 2.1 and 2.2.

Feedback Form 7: Other comments

1 – Intel Corporation (UK) Ltd

We think that some uplink enhancements are still missing. In particular it would be important to address UL coverage issues in FR2 by using more advanced deployment scenarios such as HetNet (TRPs with different Tx power) or Rx only capable TRPs. The corresponding enhancements can be used for further densification of the NW in cost efficient manner. The detailed objective for this enhancement is provided below.

- Identify and specify enhancements to support deployment scenarios such as TRPs with different Tx power / number of antennas or TRPs with Rx only capability

2 – TELECOM ITALIA S.p.A.

Support of simultaneous Tx and/or Tx switching between multiple bands also for smartphones is of high interest to improve UL performance for eMBB applications.

Proposal:

- **Specify simultaneous UE Tx and UE Tx switching up to [3] bands for smartphone-type UEs**

3 – Nokia Corporation

From previous email discussion round, “enhancement for DFT-S-OFDM” had good level of support and should be included in further discussion from our point of view. Two types of enhancements have been proposed here: support to more than one layer and faster-than-RRC switching between DFT-S-OFDM and

CP-OFDM. We understand this email thread should focus on support for more than one layer, as the other aspect can be considered under UL enhancements email thread.

In addition "enhancement for UL CW mapping" could be considered as well, as it allows for efficient handling of retransmissions for mTRP.

4 – ZTE Corporation

In RP-211652, the following item was identified as a possible enhancement item. Meanwhile, based on Mr. Chair's guidance, the CW mapping enhancement (i.e., to support >1 CWs for both >4 layers and ≤ 4 in UL) belong to the DL and UL MIMO.

- Potentially specify other UL enhancements e.g., enhancement for multi-carrier UL operation, enhancements for DFTS-OFDM, **enhancement for UL CW mapping** [leading WG: RAN1]

In detail, the motivation and necessity for UL CW mapping enhancement have been well justified in real tests (as shown in RP-212375), and this enhancement is supported by many operators and gNB/UE vendors (more than 10 companies based on August Rel-18 email discussion as in RP-211652). Also we share the same views with Nokia that this enhancement is beneficial for efficient handling of retransmissions for mTRP.

Therefore, we strongly suggest to capture the following bullet in Rel-18 MIMO enhancement. As least, it can be considered in Area 3: > 4 Tx UL operation in Section 2.2.1.

- **Study and if necessary specify enhancements to support >1 UL CW mapping for both ≤4 UL layer and >4 UL layer transmission**

5 – Apple GmbH

We propose we consider beam failure recover enhancement with regard to uplink beam status. We observed that currently beam failure recovery only monitors the beam quality for downlink beam, while due to asymmetric UL/DL link budget, it is observed in the field deployment that UL beam can fail while DL beam is still working. UL beam failure could significantly impact or handicap the UE performance due to unreliable PUCCH, especially, so that normal beam indication cannot help to recover from UL beam failure.

6 – Samsung Research America

Given that areas 1 to 5 have already imposed more work than what the projected/prospective TU allocation allows, we don't support adding "Others"

7 – MediaTek Inc.

We actually fail to see much gain in most/all of the proposals in the "Others" category from the August discussions.

- DFT-s-OFDM 2 layers: It was decided not to specify this all the way since Rel-15. Unclear to us what is the gain over using the configurations we already have specified for DFT-S-OFDM and CP-OFDM. Low priority.

- >1 UL CW mapping: In Rel-15, gains were only observed for >4 layers in our understanding. Not clear to us what has changed since to suggest that this is now useful for 4 layers and lower. Low priority.
- UL Rx-only TRP: Unclear to us what this is exactly, and the gains over normal TRP are unclear. Low priority.
- Multi-carrier UL switching: We question the incremental gain of enabling the UE to switch between 3 carriers vs 2 carriers, also when considering the extra SRS overhead and switching gaps needed for the UE.

8 – NTT DOCOMO INC.

We believe it is important to support more advanced deployment scenarios (e.g. UL dense deployment (Rx only capable TRPs)). It can improve UL performance significantly, from all of UE throughput, capacity and coverage perspective.

Also, following topics are beneficial for UL enhancement from our perspective:

- Dynamic UL waveform switching to avoid RRC-reconfiguration to switch the waveform
- UL CW mapping (e.g., 2 CWs for >= 2 layers)

It can be WI led by RAN1. We think the necessary TU is 0.5TU or less.

9 – vivo Communication Technology

Overall scope should not be very large, and UL enhancement should be prioritized over DL enhancement. Enhancement for DFT-s-OFDM was disucssed in UL enhancement in previous discussion, with UL and DL MIMO being merged into single item, it should be clarified which WI should handle ”enhancement for DFT-s-OFDM”.

10 – Huawei Tech.(UK) Co.. Ltd

We support the proposal from Telecom Italia, which is also being discussed under RAN94e-R18Prep-02. It may be good to clarify under which thread to discuss this potential WI objective. We have provided more detailed comments on UL Tx switching enhancements under RAN94e-R18Prep-02.

For MIMO enhancements, there is also a discussion under RAN94e-R18Prep-02 on uplink enhancements, which might be more relevant for handling under MIMO. We provide the same comment in RAN94e-R18Prep-02: If enhancements for DFTS-OFDM is about enabling up to rank 2 transmission for DFTS-OFDM, then this should be clarified, and it may be better considered under the scope of MIMO enhancements for DL and UL. Moreover, we should note that even though multi-layer DFT-s-OFDM is supported in LTE specifications, it has never been implemented in any UE nor in any network. It would be good to understand why the situation may be different with NR. If the gains are not expected to be larger than in LTE, then the probability that the feature be implemented for NR may not be higher than in LTE.

11 – DENSO CORPORATION

Agree that Dynamic waveform change and more than one layer for DFT-S-OFDM can be candidates for UL aspects.

12 – CATT

Multiple codewords for multiple UL layers allows separate MCS adaptation to the channel condition for different codewords and independent retransmission for different codewords, which are inherent for improved uplink throughput. Enhancement for UL CW mapping is preferred to be supported in Rel-18, targeting 2 codewords for >= 2 UL layers.

13 – ZTE Corporation

Regarding comments from MediaTek on CW mapping enhancement, sorry to say that we can not agree with you. We identify a clear necessary of >1 CW mapping for >2 layers. Some more detailed results from real field test and SLS/LLS results can be found in our contribution R1-2108886.

- Note: *The SINR gap between two UL MIMO layers is often large in our test results e.g. larger than 10dB. It is larger than what we observed in simulations possibly due to some practical differences e.g. inaccurate modeling of antenna placements in simulations, different blockage for different antennas, etc.*

14 – China Mobile Com. Corporation

We think the Enhancement for UL CW mapping e.g., 2 CWs for >= 2 layers can be also supported. One of reason to raise this issue is due to different antenna gains and insert losses between the two transmit chains and mainly dependent on the implementations. The mechanism could be one solution to balance the implementation of UE side and the performance of the network and uses.

15 – ZTE Corporation

repost with some revision...

Regarding comments from MediaTek on CW mapping enhancement, sorry to say that we can not agree with you. We identify a clear necessity of >1 CW mapping for ≥ 2 layers. Some more detailed results from real field test and SLS/LLS results can be found in our contribution R1-2108886.

- Note: *The SINR gap between two UL MIMO layers is often large in our test results e.g. larger than 10dB. It is larger than what we observed in simulations possibly due to some practical differences e.g. inaccurate modeling of antenna placements in simulations, different blockage for different antennas, etc.*

16 – VODAFONE Group Plc

We see that Dynamic UL waveform change and more than one layer for DFT-S-OFDM are important UL aspects.

17 – CEWiT

Since we are already considering >4Tx antenna for CPE like devices, it is evident that we need to study frequency selective precoding atleast in benefit of such devices. Though some companies refer to the Rel15 study showing no considerable gain, we believe frequency selective precoding will provide considerable gain especially for more Tx antenna and stationery UEs and hence we support the objective. We also propose to consider relevant issues like DCI compaction for indicating the TPMI.

18 – Lenovo (Beijing) Ltd

We support DFT-s-OFDM with rank>1. In R15/16/17, DFT-S-OFDM is designed as a robust, single layer transmission scheme for cell-edge UEs, and CP-OFDM is designed for rank 1-8 transmission for cell-center UEs. There is a gap between these two types of UEs, that is a UE near the cell edge can transmit with rank-1 DFT-S-OFDM without using its full power, but cannot transmit with rank-2 CP-OFDM because of the higher PAPR of the latter. DFT-s-OFDM transmission with rank>1 fills this gap and can help to improve the throughput for those UEs near, but not quite at the cell edge. This shall be studied under R18 UL MIMO.

19 – Ericsson LM

As also commented under multi-TRP (where this item was listed although it is not related to multi-TRP), Ericsson support increasing the number of UL DMRS ports without increasing the DMRS overhead as we see issues with shortage of orthogonal ports for UL MU-MIMO. We believe this is a rather small but product relevant enhancement, e.g. solution may be to increase the FD-OCC length from two to four. For symmetry reasons, we also support the same enhancement for DL DMRS as a separate capability.

Assuming it is not supported in Rel-17 or in an UL enhancements work item, we think that rank 2 and higher DFT-S-OFDM should be supported. It should have modest spec impact (DFT-S-OFDM is already supported for multilayer UL MIMO in LTE), but allows better PA efficiency and/or coverage, as discussed in RP-212344

20 – LG Uplus

We are interested in UL Tx switching to reduce device power consumption.

21 – Qualcomm Incorporated

We would like to point out that we see value in the following enhancements as well:

- SPS for mTRP: This is beneficial for IIoT (periodic and time-sensitive traffic) in the presence of high reliability requirements (e.g. 10^-6 BLER)
- Multi-TB scheduling with multi-TRP (single DCI to schedule multiple TBs each with e.g. TDM mTRP schemes): This is beneficial for higher bands where on the one hand PDCCH monitoring is sparser due to increase in SCS and on the other hand blockage becomes a more serious issue with narrower beams.
- Multi-layer (at least 2-layer) PUSCH in DFT-S-OFDM waveform: To bring NR uplink throughput/spectrum efficiency in par with LTE uplink for cell edge UEs in DFT-S-OFDM waveform, this feature should be introduced. Most of the LTE design can be reused to harvest this low-hanging fruit.

2.4 Summary of initial phase

2.4.1 Summary of Area 1(DL)

1. Views on Enhancement for high/medium mobility?

Support: Spark, IDC, Apple, Futurewei, vivo, Spreadtrum, Huawei/HiSilicon (both TDD and FDD), Continental Auto, Sharp, OPPO, Vodefone, Fraunhofer, Volkswagen, CeWiT, Ericsson (both TDD and FDD), Verizon (enhance on beams), Telstra

Study at first: Intel, Nokia/NSB, DCM (agree Intel)

Not support/low priority: LGE□concern on DL scope□, Samsung□low priority□

2. Views on Time-domain correlation/doppler-domain based CSI feedback or overhead reduction?

Support: Intel, Spark, Apple, DCM, Spreadtrum (preclude overhead), Huawei/HiSilicon(together with TDD), Sharp, OPPO, CATT, NEC, Vodefone, Fraunhofer, AT&T, Ericsson, Verizon, Lenovo/Motorola, Telstra

Study/clarify the scope: Futurewei, Continental Auto, CeWiT

Not support/low priority: CMCC, LGU+

3. Views on Enhancement of CSI acquisition for TDD via SRS enhancement?

Support: Intel, ZTE (together with CJT), Futurewei, vivo, Huawei/HiSilicon, Sharp, CMCC (capacity and interference), Vodefone, CeWiT, Ericsson, LGU+

Study/Clarify the scope: MTK, Spreadtrum, Xiaomi, OPPO, CATT, Fraunhofer, Lenovo/Motorola

Not support/low priority: Apple

4. Views on Enhancement for M-TRP URLLC:

Support: Intel, Spark, ZTE, Apple (open), DCM, CATT, CeWiT, Ericsson

Clarify the scope: Xiaomi

Not support/low priority: LGE, Nokia, Futurewei (more important on interference reporting), MTK, Samsung, vivo, Huawei/HiSilicon, Sharp, OPPO, Fraunhofer, LGU+, Lenovo/Motorala

Moderator: Based on these response from companies, Moderator woud like to suggest to discuss on how to refine/describe the objectives to support enhancement for UE in high/medium mobility in the second round,

- **Study and specify (if sufficient gains are identified) CSI and SRS enhancement for UE in high/medium mobility, including potential enhancement to both codebook based and reciprocity-based mechanisms**

2.4.2 Summary of Area 2(DL)

1. Views on Extend Rel-17 Unified TCI framework, e.g.,

Support: Intel, LGE, ZTE, Apple, Futurewei, Samsung, vivo, DCM, Spreadtrum, Xiaomi, Sharp, CATT, Vodafone, Faunhofer, Ericsson

Study/Clarify the scope: Nokia/NSB

for specific objective

- **for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and [inter-band])**

Support: Intel, ZTE, Apple, Futurewei, Samsung, vivo, DCM, Spreadtrum, Xiaomi, APT, Sony, CMCC, CeWiT, MTK, AT&T, Ericsson, Verizon, Lenovo/Moto, QC

Need clarification: OPPO, Huawei/HiSilicon (move to overhead reduction)

For specific objective

- **Combined MTRP schemes, more generic**

Support: Ericsson

Study/Clarification: Spreadtrum (clarify), Xiaomi, Lenovo/Moto

Not Support/low priority: Intel, ZTE, Futurewei, Samsung, DCM, CMCC, Fraunhofer, CeWiT, MTK, Verizon

Moderator: Based on this observation, Moderator would like to suggest focusing on what to do for extending Rel-17 unified TCI framework in the second round discussion with following draft objective as starting point

- ***Extend 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)***

2. Views on increasing the number of orthogonal DMRS ports both for S-TRP and M-TRP

Support: Intel, Spark, ZTE (could be included in CJT), Apple (Open), Futurewei, Samsung, Spreadtrum, Sharp, CMCC, Huawei/HiSilicon, Vodafone, CeWiT, Ericsson, Verizon, Lenovo/Moto

Study/Clarify the scope: Nokia/NSB, OPPO, CATT, Fraunhofer, QC

Not support/low priority: MTK(low priority)

3. Views on Enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance

Support the proposal: Intel, Spark, LGE, ZTE, Futurewei, Samsung, Sony, CATT, CMCC(focus SRS and DMRS), Huawei/HiSilicon (including SRS and DMRS), Vodafone(Codebook and CSI reproting), CeWiT, AT&T, Futurewei, Verizon, LGU+

Study/Clarification on Scope: DCM, QC

Not support/Low priority: Nokia/NSB(not support), Apple, Spreadtrum, Xiaomi, OPPO, Faunhofer, MTK, Ericsson, Lenovo/Moto(could study first)

Moderator: Based on the feedback, in the discussion on 2 most companies are positive on increasing the number of orthogonal DMRS ports, while some companies think it is better to have a study before normative work. in the dicussion on 3, there are relatively more companies supporting CJT/D-MIMO than companies who explicitly express not support, and some companies think it low priority mainly considering historic delployment, e.g., LTE CoMP and backhaul. In addtion, it is observed that some companies think 2 is something dependent on 3, and 6 involved operators either show explicit support or flexible to study first.

With these observations, moderator proposes to merge 2 and 3 into single objective and have a study phase, then to decide how/whether to proceed with it. The following draft objective is proposed as the starting point for next round discussion.

- ***Study and specify, if justified, enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports***

4. Views on Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic

Support: Intel, Furturewei, ZTE(UE-initiated), Apple (UE-initiated), DCM, APT, Sony (UE-initiated), NEC (UE-initiated), Huawei/HiSilicon(for large antenna array, and UE-initiated), Verizon, QC

Study/Clarify the scope: Nokia/NSB, Samsung, CMCC(UE-initiated, group based), MTK(UE-initiated), AT&T

Not support/Low priority: Spreadtrum, OPPO, CATT

Moderator: Based on the feedback, it seems most companies are flexible to do something new in Rel-17, however, some companies think it should be more focus rather than too many candidates, so Moderator would like to propose to discuss how to describe and limit the candidate based on following draft objective in next round.

- ***Study and specify, if justified,*** **overhead and/or Latency reduction for** ***beam management/beam accquisition procedues***

5. Views on Asynchronous M-TRP/Multiple TA for M-TRP

Support: Intel, LGE, Nokia/NSB, ZTE(Open), Futurewei, Sharp, Lenovo/Moto

Study/Clarification: Samsung, DCM, AT&T, QC

Not support/low priority: Apple (against), Spreadtrum (low priority), OPPO, [Sony], CATT, Huawei/HiSilicon, Fraunhofer, CeWiT, MTK(do not support), Ericsson, Verizon (low priority)

Moderator: ***From these feedback, considering majority of companies prefer taking it low priority, Moderator proposes to take this objective as low priority especially considering the workload related to DL area.***

2.4.3 Summary of Area 3(DL)

Most companies proposed low priority or no support of enhancements for DL on CPE.

4096 QAM: Cablelabs/Cocast support 4096QAM, and AT&T/Intel/Lenovo/Moto: study 4096QAM

DMRS overhead reduction: Huawei/HiSilicon/Lenovo/Moto

Moderator: ***From these feedback, considering majority of companies prefer taking it low priority, Moderator proposes to take this objective as low priority jointly considering the workload related to DL area.***

2.4.4 Summary of Area 4(UL)

For the initial objective,

- **Study and if necessary specify >4 Tx UL operation, e.g., for CPE/ FWA/vehicle/Industrial devices**

Support: Softbank, Telecom Italia, LGE, Nokia/NSB, ZTE, MTK, Samsung, NTT DOCOMO, SpreadTrum, Huawei,Hisilicon, Sharp, OPPO, KDDI, DENSO, NEC(limited to FR1), CATT, Vodafone, CEWiT, Lenovo/Moto, Telia,AT&T, Xiaomi, Verizon,QC

Study: Ericsson, IDC

Low priority: LGU+, Verizon, CMCC, vivo, Futurewei, Intel

Moderator: Based on this observation, it is proposed to continue the discusison with below objective as starting point, which should be further refined to make it more focus.

- ***Study and if necessary specify >4 Tx UL operation, e.g., to support more than 4 layers per UE in the UL for CPE/ FWA/vehicle/Industrial devices***

2.4.5 Summary of Area 5(UL)

For the initial objective

- **Specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, potentially including fast UL panel selection, separate UL timings/power controls for different panel/TRP and/or simultaneous multi-panel UL transmission**

To general objective, it is observed that

Support: IDC, ZTE, DCM, Sharp, APC, NEC, CMCC, VODAFONE, Ericsson, LGU+, KDDI

Study at first: Samsung

Not support: Sequans

at the same time, to each specific candidate, it is observed that

1. For multiple panels UL simultaneous transmissions:

Support: Intel, Telecom Italia, Nokia/NSB, OPPO, ZTE, CMCC, CATT, CeWiT, Faunhofer, Lenovo/Moto, AT&T, Xiaomi, Ericsson, Verizon, QC

Not support: Apple, MTK, Spreadtrum, Huawei/HiSilicon, APC

2. For UL panel selection transmission:

Support: Apple, MTK, vivo, Spreadtrum, APC, Huawei/HiSilicon, DENSO, CMCC, QC

Not support: Samsung, OPPO, Ericsson

3. For multi-PC in MTRP

Support: OPPO, APC(open), DENSO, CMCC(open)

Not support: MTK, Ericsson

4. For multi-TA in MTRP

Support: Intel, Telecom Italia, APC(open), DENSO, CMCC(open), CeWiT, Ericsson

Not support: Apple, MTK, OPPO

Moderator: Since each company has different preference to different schemes under the same umbrella, it is proposed to make the candidate more focus in the second round, e.g., mainly focus on 1 or 2, or any other way forward, e.g., no support **enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation in this WI**

- ***Study, if necessary specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, including e.g., fast UL panel selection, or simultaneous multi-panel UL transmission***

2.4.6 Summary of Area 6(UL)

For the objective,

- **Study and if necessary specify frequency-selective precoding, mainly targeting devices with >=4 Tx**

it is observed that

Support: Intel, Telecom Italia, Nokia/NSB, IDC, ZTE(Open), Apple(Open), Futurewei (Open), MTK(Open), vivo, DCM, Spreadtrum, Huawei/HiSilicon, Sharp(Open), KDDI, CATT, Fraunhofer, CeWiT, AT&T, Xiaomi, Ericsson

Not support/low priority: Spark, LGE, Samsung, QC

Moderator: From moderator's point of view, it is proposed to refine the objective with this draft objective as starting point,

- ***Study, and if necessary specify frequency-selective precoding, mainly targeting devices with >=4 Tx***

2.4.7 Summary of others

It is observed that the views here are still diverse on which should be included. There are at least 3 companies (MTK, Samsung and vivo) mentioned no more features to be added in the discussion

1. Support more than 1 layer for DFT-S-OFDM?

Supported by: DENSO, Vodafone, Ericsson, Lenovo, QC;

2. Support Tx switching for more than 2 bands?

Supported by: Telecom Italia, Huawei/HiSilicon, LGU+

3. Support 2 CW for >=2layers?

Supported by: ZTE, CATT, CMCC

Additional information is that after communicating with Hiroki-san, DFT-S-OFDM related enhancement and Tx switching will be handled in the thread of ”UL enhancement” , so in the next round, we only need to consider if it is possible to support 3 in MIMO WI.

3. Support 2 CW for >=2layers?

3 Intermediate Phase

In this round, Moderator would like to invite companies to provide your views on how to make the objectives more focus rather than too generic, and how to stablize the objectives.

3.1 Proposal for Area 1

Proposed objective:

- **Study and specify (if sufficient gains are identified) CSI and SRS enhancement for UE in high/medium mobility, including potential enhancement to both codebook based and reciprocity-based mechanisms**

Feedback Form 8: Comments on proposed objective 1

1 – LG Electronics Inc.

It seems that our position is missed in some items in the round-1 summary. We are not supportive of all DL CSI related topics in Rel-18. In legacy system, we already have many specification based tools for high/medium mobility UE, e.g. open-loop CSI mode with no PMI feedback, hybrid CSI mode (W1 only feedback), reciprocity based CSI estimation(e.g. FDD reciprocity based CSI to be introduced in Rel-17, SRS for DL CSI estimation), etc. In addition, L1/L2 based mobility enhancement will be discussed in different agenda for high/medium mobility UEs and CSI feedback enhancement for high/medium mobility UE will be discussed as one of the major topics of Rel-18 AI/ML item as commented by many other companies. Due to above reasons, we still prefer to deprioritize CSI enhancements from MIMO in Rel-18. For SRS enhancement, Rel-17 FeMIMO already include this topic, so the motivation of further enhancing SRS compared to Rel-17 is unclear to us. SRS transmission periodicity is already well controlled by gNB so gNB can configure short periodicity for high mobility UE with current specification.

2 – Intel Corporation (UK) Ltd

Intel is OK with this objective in principle, but the RS enhancement should not be limited to SRS. For example, CSI-RS may require similar enhancement as SRS to support codebook-based precoding. Suggest using more general wording.

- Study and specify (if sufficient gains are identified) CSI and ~~SRS~~ RS enhancements ~~for UE~~ in high-/medium UE mobility, including potential enhancement to both codebook based and reciprocity-based DL precoding ~~mechanisms~~

3 – ZTE Corporation

Firstly, we fully agree with the moderator that the objectives should be more focus rather than too generic, and some more detailed objectives are absolutely needed for above proposal.

Then, we still have not identify a clear motivation on CSI enhancement for UE in high/medium mobility, i.e., time-domain correlation/Doppler-domain based CSI feedback' as proposed by other companies.

- Generally speaking, for CSI codebook enhancement, we should hold on a bit to see the market's response for the previous three releases (TypeII CSI, eTypeII CSI, FR1 FDD reciprocity based CSI).
- The proposed compression in Doppler domain can be seen as forward-looking investigation without urgent need. Compared with issues identified from real deployment, this type of forward-looking investigation should have lower priority.
- Also, a potential AI/ML based study item for air interface also discusses CSI compression feedback. We can do forward-looking study there.

After that, for the remaining part, i.e., 'SRS enhancement for UE in high/medium mobility', we think that it can be merged with C-JT related enhancement, since both of them are mostly relevant to 'SRS capacity enhancement' in technical. In other words, we do NOT need to mention SRS enhancement twice in different areas in Rel-18 DL and UL MIMO.

Based on above, we suggest to consider this objective with low priority.

4 – vivo Communication Technology

In order to enhance DL MIMO in medium/high speed scenario, potential SRS is motivated from the overhead when configured with very short periodicity. And, configuration of SRS for antenna switching is restricted, such that it is not possible configure SRS in burst pattern, e,g, 4 consecutive slots with one symbol each and burst periodicity. It allows gNB to estimate Doppler over SRS.

5 – Futurewei

We are in general ok with the proposed objective. We suggest some wording changes as follows to make it clearer and consistent with the wording used for WID in previous release:

Study and, if needed, specify ~~(if sufficient gains are identified)~~ CSI and SRS enhancement for UE in high/medium mobility, including potential enhancement to both codebook based and reciprocity-based CSI acquisition mechanisms.

6 – Spark NZ Ltd

Spark NZ

We believe that improving the uplink/downlink signaling overheads for CSI estimation based on SRSs is critical here when UEs moves with medium to high mobility. Since the coherence time of the channel reduces with higher UE velocities (typical highway speed mobility offering millisecond-level coherence time), the uplink/downlink signaling needs to be lean enough to be able to cope with such reduced channel coherence times. This is a major challenge, and candidate techniques for estimating CSI with high resolution, which have the potential of bringing improvements in this direction, should be investigated

7 – AT&T

We are ok with this proposal, and are supportive of Intel's wording to not limit the enhancements to SRS

8 – Apple GmbH

We prefer the scope to be clarified, especially the purpose and scope of SRS enhancement.

For DL:

· NR only has transmission scheme 1, i.e., DMRS based MIMO transmission scheme

· However NR supports many different types of MIMO codebook including (1) non PMI (2) Rel-15 Type I SP (3) Rel-15 Type II MP (4) Rel-15 Type II (5) Rel-15 Type II PS (6) Rel-16 Type II (7) Rel-16 Type II PS (8) Rel-17 PS

· NR also supports SRS antenna switching for reciprocity-based DL MIMO

For UL

· NR supports both the codebook and non-codebook based PUSCH/SRS operation

The CSI enhancement part is clear. However, the SRS enhancement is not clear, is it for the reciprocity-based DL MIMO operation or it is for UL codebook/non-codebook based PUSCH operation. In the current NR, SRS has four possible usage (1) "codebook", (2) "non-codebook" (3) Antenna Switching (4) "Beam Management". More clarification is needed for the targeted usage case of SRS for enhancement

Therefore, we are fine with the CSI enhancement. Without clarification, we do not support SRS enhancement.

9 – Samsung Research America

Given the outcome of the initial round discussion, the need for 'Area 1' is unclear for Rel-18. Summarizing our arguments in the initial round:

· While NW performance enhancement at high/medium speed is important, CSI is hardly the limiting factor in current deployments. As also mentioned by several companies, implementation-based solutions utilizing the existing specification are possible to enhance NW performance at high/median speed.

· What can be improved on M-TRP URLLC is unclear.

Therefore, to manage the WI scope, we recommend that **Area 1 be assigned low priority or, justifiably, opted out from Rel-18 MIMO** (considered for future releases when CSI starts becoming a limiting factor for high-speed and the need for enhancing CSI for M-TRP URLLC becomes clear).

10 – Continental Automotive GmbH

We are supportive of this proposal; although we would have preferred also having the first sub-bullet of the first round.

11 – InterDigital France R&D

From our perspective, some enhancements for RS and CSI feedback may be needed to sufficiently support high mobility UEs. However we don't believe that any enhancement to existing codebooks would be necessary. The enhancements for RS may include aspects such as: more flexible and low overhead configuration, adaptive or event-based RS transmission.

In brief, we see three different components to this topic: RS aspect, CSI content, Codebook where from which we only support potential enhancements for RS aspects and possible new CSI content to support high mobility UEs.

12 – Spreadtrum Communications

Support. A study phase is needed at least for SRS enhancement for mobility to identify the potential enhancements.

13 – Guangdong OPPO Mobile Telecom.

We prefer the focused objective, rather than the general objective. For example, "Time-domain correlation/doppler-domain based CSI feedback or overhead reduction" is better than "CSI enhancement for high/medium mobility"

Following the same principle, we would encourage the proponents of SRS enhancements to clarify the specific objective. From our side, the scope and benefits of SRS enhancement are still not clear so far.

14 – MediaTek Inc.

We support in general the direction of the objective. But we think that the SRS proposal could still be clarified further, as we need to take into account battery consumption with the design aspect. We also think the term "codebook-based" here is slightly confusing. So we propose the following:

For DL MIMO operation, evaluate and specify CSI acquisition enhancement for UE in high/medium mobility by exploiting time-domain correlation/doppler domain, enhancing both CSI-RS-based CSI acquisition and (if justified) SRS for reciprocity-based CSI acquisition

15 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

- We support the "study and specify" of CSI enhancement for UE in high/medium mobility, including enhancement to codebook based mechanisms.

- Regarding SRS enhancement, the motivation is not clear. SRS has been enhanced in Rel-17 to increase the capacity, coverage and triggering flexibility, So, it needs to be clarified in the objective what specific SRS enhancements needs to be studied.

Also, for reciprocity-based enhancements, further clarification is needed on the scope of the enhancements - e.g., whether SRS configuration, or a reciprocity-based codebook (similar to Rel. 17 codebook) enhancements are to be considered, and whether UL overhead/complexity would also be included in the study.

16 – Beijing Xiaomi Mobile Software

We are OK with this objective in principle. And we prefer to add "time-domain correlation/doppler-domain based CSI feedback" back to make it more focus.

17 – Nokia Corporation

As indicated earlier we are not against further study in this area, but the overall priorities for further DL enhancements need to be considered carefully. At least we are assuming very limited amount of TUs will be available for DL MIMO enhancements in Rel-18. In any case we do not support limiting the scope artificially, e.g. as proposed by Xiaomi above. CSI is a complex area, and any subsequent study needs to focus on understanding the problem to be solved and identifying a proper solution, and not start the work from the point of view of defining a specific solution. Hence, if we decide to prioritize work on CSI in Rel-18, then it needs to have the necessary amount of time allocated to it so that we can do meaningful work.

Another relatively minor aspect is that we should avoid using the word ”mobility” when defining this objective. ”Speed” or ”velocity” are more appropriate, and it avoids confusion when considering the RAN2 aspects of the work, if any.

18 – Qualcomm Incorporated

For the CSI enhancement for UE in high/medium mobility, since the majority of companies support it, we could be open to study this topic. But to avoid a scope that is too broad, we think more explicit objective should be defined. In our understanding, there are two different directions in CSI enhancement to explore the time/Doppler domain correlation. One direction is utilizing time/Doppler domain correlation to compress CSI to achieve lower overhead. Second direction is to utilizing time/Doppler domain correlation to predict future CSI. We think it should be clarified the objective is for CSI compression, or prediction, or both.

19 – Huawei Tech.(UK) Co.. Ltd

We are fine for the proposal at this stage.

The following comment is for further clarification and doesn’t require an update of the moderator’s proposal. There are CSI acquisition requirement for TDD and FDD. Most mobility scenarios for NR now are based on TDD systems, so we believe it is important to enhance SRS based CSI acquisition for mobility. Regarding the questions on potential enhancements of reciprocity based mechanism (SRS enhancements for mobility), in our understanding, at least the following potential enhancements could be considered. One is SRS overhead reduction to support frequent SRS transmission for each UE for high speed cases, the other is SRS pattern enhancements for supporting prediction (Doppler estimation) for high speed channel. These details could be discussed in the study phase. For Apple’s comments, here the SRS enhancement is mainly for DL CSI acquisition for mobility scenarios.

20 – CATT

We support to study and specify CSI enhancement for high/medium mobility scenarios. However, we would like to point out that enhancement for SRS doesn’t necessarily need to be considered together with CSI enhancement. Furthermore, the motivations, objectives as well as benefits of SRS enhancement are still not clear to us. So, we prefer to discuss CSI and SRS separately.

21 – NEC Corporation

We don’t think both of them (CSI and SRS) are needed to be enhanced simultaneously in Rel-18 considering the working load, and we suggest to focus on CSI and CSI-RS enhancement.

22 – Ericsson LM

Ericsson support the objective. Limit to FR1. The definition of High/medium mobility needs to be clarified, for example, target use case is up to 120 km/h UE speed.

CSI-RS enhancement may also be needed for Doppler estimation purpose, hence we suggest updating the proposal as:

- Study and specify (if sufficient gains are identified) CSI ~~and SRS~~ enhancement for UE in high/medium mobility, including potential enhancement to both codebook based and reciprocity-based mechanisms, and possibly CSI-RS and SRS enhancements.

23 – VODAFONE Group Plc

We support this objective. We also agree with Intel's comment about scope not being limited to SRS. In response to QC, we think both compression and prediction should be considered.

24 – China Mobile Com. Corporation

We think SRS enhancement should be studied in Rel-18 to exploit the doppler information for TDD system. To make the motivation more clear, we can clarify it as SRS enhancement for reciprocity-based CSI acquisition.

25 – Sony Group Corporation

We are supportive to this objective.

If due to lack of time, we have to down-select between CSI enhancement and SRS enhancement (reciprocity-based channel acquisition). Our suggestion is to keep SRS enhancement on the table for UE in medium/high mobility. One reason lies in the fact that all bands in FR2 are TDD-based bands. Another reason is that SRS-based channel acquisition (only measured by NW) may consume less time when compared with CSI-RS based CSI reporting (measured and reported by UE). Of course, this doesn't imply we are not okay with CSI enhancement.

26 – NTT DOCOMO INC.

We are generally okay with the proposal. But, the SRS enhancement is not clear and should have lower priority. We also note that we already enhanced SRS in Rel.17 feMIMO. As we commented in the first round, codebook based tx. is more useful and important in our NW, even for TDD bands.

27 – Fraunhofer IIS

We support the general direction of Area 1.

Given comments from round 1, quite a good number of operators supports CSI enhancements for UEs in high/medium mobility.

Similar to Intel, we think that RS enhancements shall not be limited to SRS only, since CSI-RS enhancements are needed as well to support codebook-based precoding. Moreover, to have a clear scope we think words like "potential" or "e.g." shall be avoided in the proposal.

Also, we prefer to bring back "time-domain correlation/Doppler-domain based CSI feedback" to the proposal to have a clear focus.

So, we have the following proposal:

- ~~Study~~Evaluate and specify, if justified, ~~(if sufficient gains are identified)~~ CSI and ~~SRS~~ RS enhancements ~~for UE~~ in high/medium UE mobility by exploiting time-domain correlation/Doppler domain feedback, including ~~potential~~ enhancement to both codebook based and reciprocity-based DL precoding ~~mechanisms.~~

28 – LG Uplus

Area 1 is not a high priority to us.

29 – KDDI Corporation

We prefer to keep SRS enhancement on the table because TDD mode is mainly used for NR with wide bandwidth and specific enhancement against medium/high mobility is not fully discussed in Rel-17 SRS enhancements.

30 – CEWiT

We are supportive of Moderator's Proposal

31 – Volkswagen AG

Volkswagen is fine with the proposed objective of area 1. However, CSI enhancement for UE in high-/medium mobility is important for automotive environments. This may include potential enhancements to codebook based mechanisms by exploiting time-domain correlation/Doppler domain feedback. There these changes are proposed:

~~Study~~ Evaluate and specify (if sufficient gains are identified) CSI ~~and SRS~~ enhancement for UE in high/medium mobility by exploiting time-domain correlation/Doppler domain feedback, including potential enhancement to ~~both~~ codebook based ~~and reciprocity-based~~ mechanisms.

32 – Telekom Deutschland GmbH

We agree with the proposed objective of area 1. We see especially the need for the CSI enhancement for UE in high/medium mobility, including potential enhancement to codebook based mechanisms

33 – SHARP Corporation

We agree with the proposed objective of area 1.

3.2 Proposal for Area 2

Proposed objectives:

- **Extend 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)**
- **Study and specify, if justified, enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports**
- **Study and specify, if justified, overhead and/or Latency reduction for beam management/beam accquisition procedues**

Feedback Form 9: Comments on proposed objectives

1 – LG Electronics Inc.

- Extend Rel-17 Unified TCI framework: Fine in general but extending TCI framework itself is not an objective but a tool for supporting flexible beam indication in multi-TRP scenario and for multi-panel UE. Suggest the following revision:

Extend Rel-17 Unified TCI framework to be applicable for multi-TRP/panel/beam scenarios~~, e.g., for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and inter-band)~~

- Coherent JT: Fine in general but the examples touch too diverged technical areas based on different approaches. As this proposes 'study' first, these exemplary approaches can be discussed during WI. In addition, we don't have clear definition of D-MIMO. Suggest the following revision:

Study and specify, if justified, enhancement for Coherent-joint transmission from multiple TRPs.~~JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports~~

- Overhead/latency reduction: BM overhead/latency reduction features have been introduced in Rel-16 and Rel-17. We don't see urgent need for this topic again in Rel-18. Suggest to deprioritize this topic in Rel-18.

2 – ZTE Corporation

Regarding 'extend Rel-17 unified TCI framework', we can support this bullet basically. Some refinement may be needed for making this bullet much clearer (as follows).

Regarding C-JT/D-MIMO, we think that TDD-related enhancement should be considered with high priority due to the fact that most of commercial NR bands are TDD. In such case, we need to consider how to enhance CSI codebook for TDD, e.g., UE-assisting phase calibration among >= 2 TRPs. Besides for the increase of DMRS ports, we think that the improvement on SRS capability, e.g., TD-OCC, is essential herein. Finally, 'spatial domain interference avoidance' is a little bit controversial, and we think that some justification is needed before explicitly capturing this item.

Regarding beam management, it seems that most of proponents highlight the potential enhancement for UE initialized beam activation/indication that can significantly save the latency of beam activation as in current NR FR2 UE. Also we believe that the corresponding part has been well analyzed in Rel-17. So we can try to consider this enhancement as a starting point for discussion.

Proposed objectives:

- **Extend Rel-17 Unified TCI framework for indication of M>1 DL and/or N>1 UL TCI states by a single command at least for multi-TRP and inter-band~~, e.g.,~~**
  - ~~**for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and inter-band)**~~
- **Study and specify, if justified, enhancement for Coherent-JT/D-MIMO (at least for TDD), including ~~e.g.,~~ CSI codebook, CSI reporting, SRS capacity (e.g., by TD-OCC)~~, spatial domain interference avoidance~~, and larger number of orthogonal DL DMRS ports**

- **Study and specify, if justified, UE-initialized beam activation/indication for latency reduction for beam management/beam acquisition procedures**

3 – Intel Corporation (UK) Ltd

Objective in the 1st bullet. Further clarification to the first objective is required. Current formulation of the examples is not clear (esp for companies who doesn't follow BM discussion in Rel-17 and may not understand meaning of M, N > 1 and inter-band). Moreover the following question should be clarified as part of objective description:

- whether extension of Rel-17 includes support of all or subset of Rel-15/Rel-16 multi-TRP transmission schemes using new TCI framework?

- whether additional transmission schemes / beam indication are being also considered as part of this objective?

Due to limited TUs (commented by many companies in the 1st round of discussion), we prefer to limit the scope to Rel-15/Rel-16 transmission schemes only without introduction of the additional schemes.

Extend Rel-17 Unified TCI framework to support multi-TRP transmission schemes specified in Rel-15/Rel-16~~, e.g.,~~

- ~~**for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and inter-band)**~~

Objective in the 2nd bullet. The wording of the second objective is not fully clear. We propose the following clarifications.

Study and specify, if justified, enhancement for coherent-JT/~~D-MIMO~~, including e.g., codebook and CSI reporting enhancements to support~~,~~ spatial domain interference avoidance, larger number of orthogonal DMRS ports, etc.

Objective in the 3rd bullet. Intel supports the third objective as continuation of Rel-17 work that was not commenced due to limited TUs. Since beam indication latency was already addressed in Rel-17, we prefer to have more clearer Rel-18 objective focusing only on the latency reduction for the "beam acquisition" in the beam management procedures. The proposed modifications are provided below along with a few correction of typos:

Study and specify, if justified, overhead and/or ~~L~~latency reduction for ~~beam management/~~beam acequisition procedures

New objective. Intel strongly supports new objective on asynchronous mTRP enhancement in Rel-18 at least for UL and FR2 (where CP duration is relatively short comparing to propagation delay difference). RAN1 shall ensure robust NW/UE performance in mTRP scenarios in FR2.

Specify TA enhancement to support asynchronous M-TRP scenario in the UL; study and specify if needed DL enhancements to support the same scenario

4 – vivo Communication Technology

We are supportive of extension Rel-17 TCI framework to supporting multi-TRP schemes, current wording is good, which limits the scope of the work needed. M, N can be clarified in justification part.

The topic for beam management/beam acquisition enhancement needs to be clarified. When discussing the issue of advanced beam refinement/tracing enhancement in Rel-17, there is not much progress due to lack of clear discussion scope. We should avoid such situation in Rel-18. If the target scenario is for latency reduction, the following aspects can be considered in Rel-18: **latency reduction for MAC CE based TCI state activation, or frequency/time/beam tracking**

5 – Futurewei

We are in general ok with the proposed objectives.

We saw a comment saying that " 'spatial domain interference avoidance' is a little bit controversial, and we think that some justification is needed before explicitly capturing this item" ", we would like to provide some response on this comment. As we commented in the initial round, to resolve the issue of handling inter-cell interference and obtain the promised gain from the massive number of antennas, we have proposed a spatial-domain interference avoidance approach via Bi-directional Training (BiT), where DL interference probing and mitigation based on semi-statically coordinated SRS resources among gNBs is employed in TDD, which provides significant performance gain (e.g., please see RP-212456). Please note that compared to the conventional Coherent-JT, BiT requires no or little information exchange between the cooperating gNBs and the DL transmission is from one single transmission point, therefore the synchronization requirement among transmission points can be relaxed.

The standard impact of BiT are mainly SRS enhancements with dynamically indicated parameters associated with corresponding DL transmissions. Further study can be done for various flavors of cooperative MIMO technologies with different assumptions on backhaul, coordination, and transmission schemes among TRPs, etc.

Therefore, we are strongly supportive of including "spatial domain interference avoidance" as in the moderator's proposed objectives. We suggest some wording changes as follows to make it consistent with the wording used for WID in previous release:

Proposed objectives:

- Extend 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)**

- Study and, if needed, specify~~, if justified,~~ enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports

- Study and, if needed, specify~~, if justified,~~ overhead and/or Latency reduction for beam management/beam acequisition procedures

6 – AT&T

We are generally supportive of the proposed enhancements in area 2. We have the following comments/-suggestions.

1. For extending Rel. 17 unified TCI framework, it would be good to specify what are the targets for enhancements.

− Extend 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 e.g. multi-TRP and multi-panel UEs

2. For codebook enhancements for C-JT/D-MIMO, we believe this is needed in particular for improving the performance in low FR1 bands deployments, and should be given high priority. We support specifying codebook enhancements for C-JT. We are supportive of studying other performance enhancements.

3. We are supportive of the third bullet, in particular we do not believe the scope should only be limited to the enhancements that were identified in Rel. 17 and not treated due to lack of time.

7 – Apple GmbH

1. For the first bullet on Rel-17 unified TCI framework extension

We think the higher priority is to extend the unified TCI framework to support Multi-TRP, instead of indication of multiple DL and UL TCI states. Or, at least, we should clarify that the indication of multiple DL and UL TCI states is primarily used for Multi-TRP support.

2. For the second bullet on CJT MIMO and increased number of DMRS ports

We are fine

3. For the last bullet on overhead and latency reduction

We are supportive

8 – Samsung Research America

We are **generally supportive of Area 2** with a few comments below:

· Sub-objective 1: We suggest rewording to make the objective clearer "Specify extension of ~~Extend~~ Rel-17 Unified TCI framework ..."

· Sub-objective 2: Given comments from a good number of operators concerning the need for both FDD and TDD targeting FR1 (to make the scope clear), we suggest the following rewording "~~Study and s~~Specify~~, if justified,~~ enhancement for Coherent-JT/D-MIMO for both FDD and TDD targeting FR1, including ...". We are open to making the scope clearer (more limited/well-defined) for Rel-18

· Sub-objective 3: While the current wording is good (albeit a minor typo: "accquisition procedues"), it may be beneficial to further discuss the scope of this sub-topic in the next iteration(s). As of now the scope is too vague and broad.

9 – InterDigital France R&D

We believe that there is a significant body of work related to Rel-17 Unified TCI framework that has been left and needs to be completed and extended to other MIMO operation. Also, we think that the first and third bullets are very related, and they should be done in step with each other.

On the other hand, we don't support the work related to Coherent JT for two reasons. Firstly, there is no urgency and clear justification for this feature; and secondly, the work related to the extension of unified TCI framework and latency reduction for BM will be already very heavy to handle.

10 – Spreadtrum Communications

We support the proposal from moderator. For coherent-JT, a study phase would help people to have better understanding on network deployment for NR coherent-JT and its related potential enhancements. In addition, it would be better to clarify that coherent-JT should only be focused on FR1 deployment.

11 – CAICT

We support moderator's proposal.

12 – Guangdong OPPO Mobile Telecom.

The scope is too large and the workload will be too heavy for the group. Thus, we suggest to down-scope Area2

- As we commented before, we don't support rel-17 unified TCI framework for inter-band since the use case and benefit are unclear.
- For coherent JT/D-MIMO, we share the similar views as many other companies: it should be low priority compared to other important features
- The description of the 3rd bullet object is very vague and we don't know what will be done. Moreover, the similar objective was also included in R16 and R17 WID. What's the new thing? Thus, the detailed scope should be clarified before we can decide whether or not to agree it.

In summary, we support the following objective

- Extend Rel-17 Unified TCI framework, e.g.,

o for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and ~~**inter-band**~~ **intra-band**)

~~· **Study and specify, if justified, enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS Ports**~~

~~· **Study and specify, if justified, beam manamegement/beam accquisition procedues**~~

13 – SK Telecom

We support the proposal for area 2. Additionally, enhancement for Coherent-JT/D-MIMO needs to be specified for both FDD and TDD FR1 band.

14 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

- Our understanding is that the unified TCI framework objective is applicable to both S-TRP and M-TRP (Rel-16/17 multi-TRP schemes). With this understanding, we are supportive of the objective on extension of unified TCI framework and the listed examples. To avoid any potential misunderstanding, the transmission schemes can be included in the objective as,

- **Extend Rel-17 Unified TCI framework e.g., for indication of multiplex DL and UL TCI states (e.g., M>1 and/or N>1, and inter-band) <u>for single-TRP and multi-TRP schemes</u>**

- Regarding the potential objective on Coherent-JT/D-MIMO enhancement, further clarifications on the supported use cases and scope (e.g., limited to <1 GHz carrier, UL enhancements included?) are needed.

This objective should be considered low priority as significant gains are not expected over Rel-17 NCJT CSI enhancements.

- Regarding beam management/beam acquisition enhancements, the scope needs to be narrowed with at least some direction/examples, as with Unified TCI framework objective, included. Thus, we propose to list at least the following examples as sub-bullets for this objective:

- **UE-initiated and/or event-triggered beam update and/or reporting**
- **Grouping/sharing based beam measurements and/or reporting**

15 – Beijing Xiaomi Mobile Software

- For the first bullet, we support this objective. For more focus, topics such as TCI state activation, Support cross-TRP based unified TCI state indication or not, unified TCI state mapping for simultaneous PDCCH repetition and PDSCH repetition should be included.
- For the second bullet, we are general OK with this objective.
- For the third bullet, we support this objective. In order to make it more focus, it is better to list some possible directions including beam measurement/reporting via RACH for initial access, UE initiated beam switching, and event-triggered beam reporting.

16 – Nokia Corporation

This area sounds like a full-blown SID/WID by itself, it is hard to see how it could fit in the current form into a Rel-18 MIMO WI, where many companies have already indicated priority should be on UL enhancements. In particular the proposed objective on Coherent-JT/D-MIMO would require a separate SID, given its large scope.

Also we support Intel's view that Asynchronous M-TRP/Multiple TA for M-TRP is a critical aspect to be considered in Rel-18, especially for FR2 because of the very small CP duration, which makes it impractical to consider synchronized M-TRP deployments in FR2.

Hence, we do not support the list of objectives stated by the moderator in their current form. To be more specific:

- 1st bullet: we can consider a focused objective on the evolution of TCI framework
- 2nd bullet: do not support. Too large scope, requires longer evaluation phase, including impairments from practical deployments.
- 3rd bullet: we can consider a focused objective, not just a collection of left-overs from Rel-17. For example, UE-initiated beam selection.

17 – Huawei Tech.(UK) Co.. Ltd

We are generally supportive for the proposals.

For Coherent joint Transmission:

The enhancement for coherent joint transmission are high priority in Rel-18, so **we are supportive to specify the enhancements for CJT for both TDD and FDD**, and supportive to adding SRS enhancement in the example. The scenarios and benefits are clear. For the scenarios: in the current NR network, there are inter-site indoor/outdoor CJT cases (C-RAN structure), and intra-site outdoor CJT cases, for both TDD and FDD. For the benefits, with CJT, more antennas from multi-TRPs provide beamforming gain and

scheduling flexibility, and more UEs are available for MU pairing for high spectrum efficiency. We have shown performance gain in our Tdoc (RP-212150) as well.

The comments from companies who think CJT is low priority in the initial round is mainly due to the claim that CoMP in LTE is not successful in deployment. We clarify the difference here:

1. In LTE, CRS is always transmitted from each cell, then there is severe interference and overhead in the cooperated areas for CJT. The gain for CJT is limited when the interference and overhead from CRS existed for LTE system. However, in NR, there is no such always-on cell-specific signals like CRS, so there is no severe interference and overhead for CJT deployment in NR.

2. Furthermore, in current NR deployment, more C-RAN structure based network deployed compared to LTE, where the C-RAN structure is much easier to enable CJT operation.

For unified TCI extension:

We are generally fine for the proposals for overhead reduction and unified TCI state extension. However, the scenarios and benefits for extension of unified TCI state need some clarification. For scenarios, we prefer to include "**for large antenna array**" for supporting Macro deployment for FR2 in the enhancements. For benefits clarification, unified TCI is mainly for overhead/latency reduction, so better **to merge unified TCI state to overhead/latency reduction**. The first bullet on overhead and/or latency reduction is too generic and doesn't provide any focus for the work. In our view, the overhead/latency reduction will be achieved by the unified TCI framework. For reduced latency, UE-initiated beam triggering should be specified.

18 – Qualcomm Incorporated

For the first bullet, we suggest to clarify that extending Rel-17 unified TCI framework is applicable to both sTRP and mTRP by considering schemes supported in Rel-16 and Rel-17. We suggest the following corresponding additions:

- Extend 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)

- This includes both sTRP and mTRP

- For mTRP, it includes mTRP schemes supported in Rel-16/Rel-17

On the second bullet, the scope is not acceptable to us, which includes multiple objectives most of which are very vague leading to unnecessary discussion. In particular, we have the following comments:

- The relationship of "larger number of orthogonal DMRS ports" to CJT is unclear. In the previous round, multiple companies mentioned that "larger number of orthogonal DMRS ports" has lower priority. If any enhancement is needed, it would be actually for sTRP and not specific to mTRP / CJT.
- "Spatial domain interference avoidance" is unclear. Does it refer to inter-cell interference, or MU-MIMO interference? How is this related to CJT?
- As multiple companies mentioned, CJT can be done transparently. In terms of CSI codebooks, Type1 multiPanel CSI codebook can be used which has been available since Rel-15. Is the enhancement here to specify a "Type2 multiPanel CSI codebook"? If so, this should be mentioned explicitly and moved to area 1 as it is not necessarily related to multi-TRP.
- Overall, we think if the scope/objective of this enhancement is not clarified, it would be better to remove it at this stage since the urgency / practically of it have been questioned by multiple companies.

19 – NEC Corporation

We prefer enhancement to support async. MTRP more than enhancement to support CJT.

For BM enhancement, we support to have more detailed objectives. By reading first round discussions, it can be reasonable to include at least UE-initiated/assisted BM.

20 – CATT

As noticed by some other companies, the objective of Area 2 is still too inclusive. For example, we don't understand why C-JT and beam management related issues are included in the same area. We prefer to treat these uncorrelated issues in different areas.

21 – Ericsson LM

Ericsson does not support such a long list of objectives for Area 2 as this would generate a huge workload for RAN1. These Area 2 objectives alone would consume the projected 2-4 TU which was intended for the entire DL and UL MIMO WI.

In particular, the second sub-bullet on C-JT/D-MIMO enhancement proposal is not based on an urgent market request and it is also noted that the pre-cursor NC-JT have not yet emerged in deployments, let alone specified LTE CoMP features. Hence, this feature should be excluded to allow for more urgent CSI enhancements (e.g. Area 1 based CSI enhancements) for which there is an identified problem to solve and a direct benefit to operators and their installed base. In addition, there is a large number of companies not supporting C-JT/D-MIMO, and it should therefore not be included to be consistent with the similar situation and subsequent removal of Item 4 in Area 1.

The increase of number of DMRS ports is a relatively small enhancement but with direct impact to current massive MIMO products and current limitations in MU-MIMO operation. Note that DMRS port increase is unrelated to C-JT/DMIMO and should therefore be a stand-alone objective. The main use case for more DMRS ports is uplink MU-MIMO, hence the number of DMRS ports for PUSCH should be included and not conditioned on support for PDSCH C-JT.

Striving for general overhead/latency reduction in Rel-18 does not seem motivated to us, and it seems vague. One interesting proposal, which is also somewhat specific, is UE-initiated reporting. However, that would be more relevant in the inter-cell scenario. Therefore, we propose to remove general objectives on latency reduction, and work on UE-initiated reporting in the mobility WI.

To summarize, the objective for multi-TRP operation can be condensed to the following relevant enhancements which also better reflect the amount of available share of DL and UL MIMO time units:

- Extend Rel-17 Unified TCI framework to support Rel-16/17 multi-TRP operation, e.g. for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and inter-band)
- Extend the number of orthogonal DMRS ports for PUSCH and PDSCH without increasing the DMRS overhead

22 – CATT

Among the three issues listed in the proposal for Area 2, we only support C-JT.

23 – China Unicom

We support to enhance CJT in Rel-18 as this feature has significant benefits for 5G network evolution, the benefits include beamforming gain, interference mitigation, and gain in network capacity in MU scenario. With all listed benefits for network performance improvement, we prioritize CJT as one of the most important features for MIMO enhancement. We propose to go directly to the Work Item phase for specifying the CJT feature, because the benefits are already very clear in Rel-17.

24 – China Mobile Com. Corporation

Regarding the extension of Unified TCI framework, we think the higher priority is to support multi-TRP. We support enhancement for TDD C-JT since it is promising for cell edge and cell average performance improvement. For UE initialized beam activation/indication we think one or two specific directions should be included in the scope. We suggest to focus on

1 UE-initiated beam update and/or reporting

2 UE-group based beam measurements and/or reporting

25 – China Telecommunications

We support this proposal. For CJT, we think enhancement for both TDD and FDD should be specified.

26 – NTT DOCOMO INC.

We are generally fine with the 1st bullet.

For the 2nd bullet, we think it should lower priority than other objectives. The main concern is the potential large spec. impact and the occupied TU for DL enhancement.

For the 3rd bullet, it is too general, and it should clarify the detailed enhanced directions. At least UE-initiated/event-triggered TCI state activation/indication can be included.

- **Study and specify, if justified, UE-initiated/event-triggered TCI state activation/indication for beam management/beam acquisition procedures**

27 – Sony Group Corporation

On multi-TA for M-TRP, sorry that we didn't make ourselves clear in initial round. Our preference is to study and specify such feature when considering the fact that the distance from UE to different TRPs could be significantly different. If UE supports different TAs based multiple UL panels, multiple TA will alleviate UL inter-symbol interference, especially for higher SCS. If possible, we suggest reconsidering to add it back

Multiple TA for M-TRP

As for the item of overhead and latency reduction of beam management, we are supportive in principle. But without next level details, the corresponding WG (high likely RAN1) cannot be guided well, therefore triggering more discussion on the meaning of the scope. Hence, like many others, we would like to suggest adding back

"UE-initiated" beam management procedure.

28 – Fraunhofer IIS

Some comments for the proposals under Area 2:

- For the first bullet, we prefer to remove "Inter-band" from the proposal.

- We think that the workload and specification impact for C-JT/D-MIMO is very large. For performance evaluations of C-JT/D-MIMO, real-world hardware limitations (e.g., distributed sync, etc.), deployment constraints, complexity and costs should be taken into account. As one of the main targets of R18 is UL-related enhancements, C-JT/D-MIMO should be of low priority for R18.

- The scope is still very broad. More discussions are needed here.

29 – MediaTek Inc.

- **Extension of Rel-17 TCI framework:** We do not see the rationale for covering sTRP here. **Proposal: Extend the Rel-17 Unified TCI framework to enable indication of multiple DL and UL TCI states (~~e.g.,~~ M>1 and/or N>1, and inter-band) for the M-TRP scenario**
- **Coherent JT:** We still see this as a LOW priority and the work looks quite huge, which seems unbalanced considering that it seems that even NC-JT hasn't taken off commercially yet. It is not clear to us what "**spatial domain interference avoidance**" refers to here and why it is listed as a specific feature. Also the "**D-MIMO**" term seems to open the door to anything. If this work goes ahead the terms above in **bold** should be removed. Also we think that the following would need to be added: **the maximum number of TRPs assumed should be the same as the maximum for Rel-17**.
- **Beam management:** Propose to modify to the following, as it seems the majority of companies all had the same view that UE initiated beam mgmt was the key proposal: **Study and specify~~, if justified,~~ UE initiated beam management to enable overhead and/or Latency reduction for beam management~~/beam acquisition~~ procedures**

30 – LG Uplus

We support moderator's view in general.

Regarding C-JT, we would like to add "SRS capacity enhancement" for example study areas. And, regarding opposition about codebook design, current codebook design have limitation on various combination of TRPs. It causes hard operation management due to port reorganization. Transparent on device as possible is good but more enhancement schemes to achieve best performance should be studied such as codebook design, phase compensation over multi-TRPs, SRS capacity enhancement, etc.

31 – CEWiT

We agree with Moderator's proposal.

32 – SHARP Corporation

We are fine with the proposal.

3.3 Proposal for Area 3

Proposal: Take this objective as low priority.

Feedback Form 10: Comments on this proposal

1 – LG Electronics Inc.

OK not having this in Rel-18. We can also be flexible if the scope of this topic is limited to 4096 QAM

only.

2 – ZTE Corporation

Support the moderator's proposal

3 – Futurewei

We support this proposal.

4 – CableLabs

The scope of 4096QAM is related to Fixed Wireless Access. This development could be referenced to the similar 802.11be discussions/specification

5 – Apple GmbH

We support the proposal

6 – Samsung Research America

We **support the proposal from the moderator** or, justifiably, **opting Area 3 out from Rel-18 MIMO** (considered for future releases when the need becomes clear).

7 – InterDigital France R&D

Agree with moderator's assessment.

8 – Spreadtrum Communications

Support

9 – Guangdong OPPO Mobile Telecom.

We are fine with proposal

10 – MediaTek Inc.

Fine with the proposal in general, but might be clearer to say "low priority, so no Area 3 objective included".

11 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

We are ok with the low priority proposal from the moderator.

12 – Beijing Xiaomi Mobile Software

We support this proposal.

13 – Nokia Corporation

Assuming this refers to DL CPE proposals only, we agree with the moderator proposal.

14 – CATT Support this proposal.
15 – Huawei Tech.(UK) Co.. Ltd We are fine with the moderator's proposal.
16 – NEC Corporation Support the proposal.
17 – Ericsson LM Ericsson agrees.
18 – VODAFONE Group Plc We support the proposal.
19 – China Mobile Com. Corporation Support the proposal.
20 – NTT DOCOMO INC. We support the moderator's proposal.
21 – Fraunhofer IIS We are fine with the moderator's proposal.
22 – LG Uplus We agree with moderator's suggestion.
23 – CEWiT We agree with Moderator's proposal.

3.4 Proposal for Area 4

Proposed objective:

- **Study, and if necessary specify >4 Tx UL operation, e.g., to support more than 4 layers per UE in the UL for CPE/ FWA/vehicle/Industrial devices**

Feedback Form 11: Comments on proposed objective, including e.g., how to refine the objective

1 – LG Electronics Inc.

Support. It may be better to remove 'e.g.' as below. In addition, it may also be considered to specifically mention the max rank, e.g. up to rank 8.

Study, and if necessary specify >4 Tx UL operation~~, e.g.,~~ to support more than 4 layers per UE in the UL for CPE/ FWA/vehicle/Industrial devices

2 – ZTE Corporation

Support the moderator's proposal.

Based on our analysis and simulation results in RP-212375, 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 up to 12 layers or more for MU-MIMO and UE-aggregation.

Then, we have the following sub-bullets for identifying the potential enhancements on this objective.

Study and if necessary specify >4 Tx UL operation~~, e.g.,~~ to support more than 4 layers per UE in the UL for CPE/ FWA/vehicle/Industrial devices

- **Support >1 CWs for both >4 layers and 4 in UL**
- **For CB, Type-I like UL codebook as a starting point (for both >4 layers and 4).**
- **For NCB, re-design of DCI SRI codepoint (for both >4 layers and 4).**
- **Increase of #. of UL DMRS ports per UE.**
- **SRS design for supporting 6 or 8 Tx (e.g., for CB, NCB, and antenna switching (e.g., 6T6R, 6T8R, 8T8R)).**

3 – vivo Communication Technology

Since target device types are CPE/FWA/vehicle/industrial devices, a sub-bullet should be added in order to restrict the scope that cross-pole lineare antenna structure with coherent capabiliy is assumed.

4 – TELECOM ITALIA S.p.A.

support.

Not clear the comment from Vivo. We do not think it is necessary to limit the antenna structure, expecially considering that this kind of devices have more freedom of implementation.

5 – Futurewei

We are in general ok with the proposed objective.

6 – AT&T

We are supportive of the moderator's proposal. We support specifying enhancements for >4Tx UL operation to support more than 4 layers per UE in the UL. We see a need for such UL enhancements especially for CPE/FWA applications.

7 – Apple GmbH

We have concern on this proposal. The scope of the work can be quite large depending on whether we need to support >4 Tx UL operation for (1) coherent UE (2) partial-coherent UE or (3) non-coherent UE. The standardization work can be quite significant to support >4 Tx UL operation at least for coherent and partial-coherent UE. We prefer further clarification on the scope of this area

8 – Samsung Research America

We are generally supportive of Area 4 although the current wording implies that the scope is too vague and broad (hence at the risk of unsuccessful completion). It should be understood that this type of enhancement is a 'marathon' not a 'sprint' (i.e. >1 releases may be necessary). Therefore, we suggest to further discuss features to be prioritized in Rel-18 MIMO (and leave the rest for future releases). For instance (as mentioned in our previous comments):

- Limit the maximum number of layers to 4 for 6TX and 8TX
- Focus on codebook-based UL transmission.

Therefore, we suggest the following rewording to give this area more focus (**with this rewording we are supportive of Area 4**):

- Study, and if necessary, specify ~~>4~~ 6 and 8 Tx UL operation, focusing on codebook-based UL transmission with up to 4 layers ~~e.g., to support more than 4 layers per UE in the UL for~~ targeting CPE/ FWA/vehicle/Industrial devices

9 – Continental Automotive GmbH

We are supportive with including this in the scope.

10 – InterDigital France R&D

We could support this proposal, however as we indicated in the first phase, we need to further clarify the exact scope of this item and its necessity. For example, is the support of more than 4 layers the only objective of this proposal? Is the proposed scope by ZTE, e.g., increasing the number of CWs, RS ports, SRS AS enhancements, etc., a common understanding by other companies?

11 – Lenovo (Beijing) Ltd

We support this proposal. The maximal number of Tx antennas shall be 8. The maximal number of layers canbe determined by the study. Both SU and MU shall be considered. Other related topics include SRS, DMRS, TPMI and codeword-to-layer mapping.

12 – Guangdong OPPO Mobile Telecom.

Support the proposal

13 – MediaTek Inc.

Fine, but want to make it clear it is not for handheld devices. Suggest the following:

For non-handheld devices (e.g. CPE/ FWA/vehicle/Industrial devices) study and ,if necessary, specify >4 Tx UL operation, e.g. to support more than 4 layers per UE.

14 – Xiaomi Communications

We support the proposal in general. whether the supported layers is >4 layers or <=4 layers can be determined after further study.

15 – Nokia Corporation

We support the moderator proposal.

16 – CATT

Support the objective. We support studying up to 8 UL layers for both codebook and non-codebook based PUSCH. Other enhancements such as the number of codewords, enhancements of DMRS, SRS for UL and DL CSI acquisition may be also involved.

17 – Huawei Tech.(UK) Co.. Ltd

We are fine with the current proposal. Both CB and NCB should be included.

18 – Qualcomm Incorporated

We are supportive of >4 Tx UL operation for CPE/FWA devices. However, we don't support more than 4 layers. In our view, >4 Tx and >4 layer are two different aspects of UL enhancements. For stationary CPE/FWA devices, their UL channels are not rich enough to support >4 layers. However, it is still beneficial to support >4 Tx antennas to allow sharper beam with larger beamforming gain and less interference to signals from other UEs.

Therefore, we would be supportive of the proposed objective with the following update:

- **Study, and if necessary specify >4 Tx UL operation, e.g., to support more than 4 Tx (with up to 4 layers) ~~layers~~ per UE in the UL for CPE/ FWA/vehicle/Industrial devices**

19 – NEC Corporation

Support the proposed objective for FR1 only.

20 – Intel Corporation (UK) Ltd

We still don't think it is urgent aspect to address in Rel-18 and the scope should be substantially reduced focusing on codebook based operation with non coherent codebook subset and full power transmission. Suggested wording of the objective is provided below:

Study, and if necessary, specify >4 6 and 8 Tx UL operation, focusing only on non-coherent codebook-based UL transmission (including full power modes) with up to 4 MIMO layers

21 – Ericsson LM

A number of companies have commented that the priority is low and/or that the use case is unclear, while others see >4 Tx as highly desirable. These differences in our view may come down to the use case(s) and scenario(s), since the performance benefit as well as the business cases vary accordingly. They are also crucial to the exact solutions we may specify. For example, as mentioned by vivo, if deployments will use panel antennas similar to gNB, Tx chains and codebooks similar to the downlink could be assumed. On the other hand, if more general designs targeting antenna configurations more similar to current UEs are assumed, then quite different designs may be in order, such as those currently used for UL MIMO. The

question of the maximum rank also depends on the scenario and UE antenna configuration: if antennas are assumed to be mounted outdoor with line of sight to a serving gNB, the number of layers supported by the channel could be different than an indoor gNB antenna configuration in a factory scenario. One way forward therefore could be to consider these use case related aspects as part of the study, e.g.:

- Study, and if necessary specify >4 Tx UL operation, e.g., ~~to support more than 4 layers per UE in the UL~~ for ~~CPE/ FWA/vehicle/Industrial devices~~ CPE, FWA, vehicle, and/or Industrial devices
  - Identify a limited number of targeted use cases and scenarios, including UE antenna related assumptions for the study
  - Accordingly, evaluate performance of UL enhancements, including those using more than 4 layers
  - Specify any needed enhancements based on the outcome of the evaluations, where the need also takes into account UE and gNB complexity

22 – VODAFONE Group Plc

We support the proposal. Our view is any limitation on rank/layers due to UL channel richness should be investigated as part of the study, rather than decided now.

23 – China Mobile Com. Corporation

We think further clarification is neeed to restrict the scope for this area, e.g., the maximum number of layers, transmission scheme (codebook only or codebook& non-codebook).

24 – ROBERT BOSCH GmbH

We support > 4 TX UL operation; however, we also have concern on the number of layers as Qualcomm mentioned. A limitation to 4 layer could be studied. We are also fine to limit it to certain UE form factors other than hand-held devices, i.e., remove ”e.g.” and state clearly: **for certain UE form factors other than hand-held devices, e.g., CPE/ FWA/vehicle/Industrial devices.**

25 – NTT DOCOMO INC.

We support the moderator’s proposal.

26 – KDDI Corporation

We support moderator’s objective. It would also be desirable to study the enhancements related to >4 Tx UL operations as well.

27 – LG Uplus

We support the moderator’s proposal.

28 – CEWiT

We agree with Moderator’s proposal.

29 – SHARP Corporation

We support Moderator’s proposal.

3.5 Proposal for Area 5

Proposed objective or other way forward

- **Study, if necessary specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, including e.g., fast UL panel selection, or simultaneous multi-panel UL transmission**
- **Other way forward: e.g., not support enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation**

Feedback Form 12: Comments on proposed objective or other way forward

1 – LG Electronics Inc.

We believe that this feature is important for UL throughput and reliability improvement in Rel-18 for various UE types. Regarding the scope, we sympathize with ZTE's comment that simultaneous multi-panel transmission is a key feature to improve UL throughput and reliability that has not been discussed in 3GPP yet, so this must be included in-scope. Otherwise, we may face the same situation as Rel-16/17. We think that panel-specific timing control is also important for multi-TRP scenario. In our evaluation provided in RWS-210240, it was observed that a large portion of UEs experience the delay difference exceeding CP length in outdoor at both 30GHz and 60GHz and even in indoor at 60GHz. In some scenarios, more than half of UEs experience such case (e.g. **51.0 % UEs** at UMi, SCS=120kHz) so we believe that it is not a corner case, but a typical case in FR2 which would prohibit to apply mTRP features in FR2 real deployments. Thus, we suggest to add the removed item back (i.e. separate UL timings/power controls for different panel/TRP) or it is also considerable to split into two sub-items.

- **Support for simultaneous multi-panel UL transmission for higher UL throughput/reliability**

- **Study, and if necessary, specify features to support panel-specific UL transmission, e.g. panel-specific timing/power control for multi-TRP scenario.**

2 – ZTE Corporation

We believe that the enhancement for multi-panel uplink operation and/or multi-TRP uplink operation is very essential, and some warm-up discussion has been well done since Rel-15.

Regarding simultaneous multi-panel UL transmission vs fast panel switching (as a hot topic in first round), we would like to clarify our views herein.

- Technically speaking, for fast panel switching, the real controversial part since Rel-16 is that many gNB and UE vendors believe that this feature has been supported in Rel-15 with spec transparent manner. If this situation can NOT be changed, we still need to face the same controversial situation again in Rel-18.
- If we have to choose one of them, we strongly suggest that simultaneous multi-panel UL transmission is considered in this WID, and we may further review how the fast UE panel switching can be well supported in this simultaneous multi-panel UL transmission framework (like turn off some features). Furthermore, in our contribution RP-212375, it can be observed that UL capacity can be well improved by introducing simultaneous multi-panel UL transmission, e.g., 15.7% mean UPT.

Study, if necessary specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, including

- **Simultaneous multi-panel UL transmission, and**
- **Fast panel switching (after the above enhancement is stable)**

3 – vivo Communication Technology

From practical implementation point of view, simultaneous multi-panel UL transmission is not feasible for handheld device. If included in WID, it should be clarified that simultaneous multi-panel UL transmssion is targeted for CPE type of device. We support to include fast panel switching in the objective.

4 – TELECOM ITALIA S.p.A.

Study, if necessary specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, including e.g., fast UL panel selection, or simultaneous multi-panel UL transmission

5 – Intel Corporation (UK) Ltd

We support objective related to enhancements to multi-panel/multi-TRP operation in uplink.

1. Rel-18 should specify support of simultaneous transmission from the UE in multi-panel/multi-TPR scenarios to improve peak data rate (eMBB) and reliability of the transmission (URLLC). The enhancement should consider both FR1 and FR2 and PUSCH/PUCCH/SRS physical channels and reference signals. We don't think study phase is needed as the benefits for peak throughput and reliability improvement should be clear. This enhancement should be defined as separate objective in multi-panel/multi-TRP enhancement in uplink.

2. Many companies expressed positive views on multi-TRP enhancements (and UL in particular) in async scenarios in phase 1 discussion. Focusing on UL only, we share the same view with these companies that TA enhancements should be considered. We believe RAN1 should ensure robust UL performance of the NW/UE for multi-TRP solution in different cases including scenarios with Rx timing from TRPs exceeding CP duration. From this perspective objective on multiple TAs for the same carrier in multi-TRP scenario should be also included in the Rel-18 scope as part of multi-panel/multi-TRP enhancement in uplink.

- **Specify enhanced multi-TRP uplink operation to enable simultaneous uplink transmission of physical channels and reference signals. Consider enhancements for eMBB and URLLC scenarios in both FR1 and FR2.**
- **Specify support of multiple TAs for the same carrier in inter-cell multi-TRP scenario**

6 – Futurewei

As we commented in the initial round, we believe supporting separate UL timings for different panel/TRP is important to improve UL performance and/or enlarge the use cases for M-TRP. And based on companies' feedback in initial round, majority of the companies are supportive of this objective. It seems the list of supporting companies for this objective under "Summary of initial phase" (e.g., Section 2.4.5) is not comprehensive. Based on our own counting, the supporting companies are listed below. Company can correct our counting if we mis-interpret your position.

Support: Intel, Telecom Italia, LG, Nokia (overall topic), IDC (overall topic), ZTE (overall topic), Futurewei, NTT Docomo, Spreadtrum (ok), Huawei/HiSilicon, Sharp (overall topic), APC(open), DENSO, NEC (overall topic), CMCC(open), Vodafone (overall topic), CeWiT, Lenovo, ATT (over all topic), Xiaomi (overall topic), Ericsson, Verizon (overall topic), LG Uplus (overall topic), KDDI (overall topic)

Therefore, we would like to modify the objective as follows:

Study, if necessary specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, including e.g., fast UL panel selection, separate UL timings for different panel/TRP, or simultaneous multi-panel UL transmission

7 – AT&T

We think this is a very important area of enhancements and should be given high priority. We are supportive of specifying enhancements for multi-panel/multi-TRP uplink operation, especially including simultaneous multi-panel UL transmission, with no need for a study phase. We thus propose the following modification to the moderator's proposal.

- Specify enhanced multi-panel/multi-TRP uplink operation including simultaneous multi-panel UL transmission

8 – Apple GmbH

We are against simultaneous multi-panel UL transmission

We can support the following two alternatives

· First choice by removing simultaneous multi-panel UL

o i.e., Study, if necessary specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation with fast UL panel selection

· Second choice,

o i.e., not support enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation

9 – Samsung Research America

We are generally supportive of Area 5 although the current wording implies that the scope is too vague and broad (hence at the risk of unsuccessful completion). From the discussion in the initial phase, we suggest that fast UL panel selection be left to Rel-17 (targeting successful completion of this objective rather than hedging our bet with overloading Rel-18). STxMP remains relevant (especially from the perspective of UL transmission scheme). UL dense NW has also been mentioned multiple times as a relevant deployment scenario that can serve as a context for enhancements in this area.

Therefore, we suggest the following rewording to give this area more focus (**with this rewording we are supportive of Area 5**):

· Study, and if necessary, specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, including ~~e.g., fast UL panel selection, or~~ simultaneous multi-panel UL transmission and asymmetric DL-UL deployments (e.g. UL dense network)

10 – InterDigital France R&D

We strongly support enhancements for multi-panel uplink operation that includes fast UL panel selection and simultaneous UL transmission. This topic has been proposed and partially discussed since Rel-15, however it has been deprioritized due to slow progress of other topics.

We believe that this topic is very relevant for enhanced reliability and performance of FR2 operation and it should not be delayed any further from Rel-18.

11 – Lenovo (Beijing) Ltd

We support study simultaneous multi-panel UL transmission for enhanced throughput/reliability. Multi-PC and multi-TA are important for realizing the full potential for multi-TRP UL transmission in the inter-cell case and shall be included in the study. UL panel selection has been studied as part of R17 feMIMO and can be given lower priority.

12 – Spreadtrum Communications

We think simultaneous multi-panel UL transmission is not for handheld devices and it's a little early to discuss it since we doesn't even support fast UL panel selection yet.

If there's no consensus, we can accept the 'Other way forward□not support enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation '.

13 – Guangdong OPPO Mobile Telecom.

We suggest to remove "fast UL panel selection" since the same objective was discussed in R16 and R17, but no much progress was made. We dont need to duplicate the same study/work in R18.

In summary, we prefer to delete "fast UL panel selection" and only keep the use case of "simultaneous multi-panel UL transmission":

- Specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, potentially including, **~~fast UL panel selection, or~~** simultaneous multi-panel UL transmission

14 – Nokia Corporation

We support the study on multi-panel uplink and/or enhanced multi-TRP uplink operation, including e.g., fast UL panel selection, or simultaneous multi-panel UL transmission. As noted by Futurewei above, we do think it is critical to include at least **separate UL timings for different panel/TRP.**

15 – CATT

Support the objective. We support studying up to 8 UL layers for both codebook and non-codebook based PUSCH. Other enhancements such as the number of codewords, enhancements of DMRS, SRS for UL and DL CSI acquisition may be also involved.

16 – Huawei Tech.(UK) Co.. Ltd

For simultaneous multi-panel UL transmission is high complexity from UE side, and the commercial deployment for such UEs are not very clear. So, in our understanding, fast UL panel selection is higher priority than simultaneous transmission. The first bullet is acceptable if down-selection is not possible at this time between fast UL panel selection or simultaneous multi-panel UL transmission.

17 – MediaTek Inc.

We would propose ONLY to focus on "fast panel selection". We do NOT support working on simultaneous multi-panel Tx. Regarding different UL timings, it is unclear what the device operating scenario is assumed to be here.

Based on the above, we propose to modify the moderator proposed objective to:

Study and if necessary specify fast UL panel selection for enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation.

18 – Qualcomm Incorporated

The use cases for simultaneous multi-panel transmissions are very clear: a) Latency reduction by parallel transmission for eMBB/URLLC w/o the need for cancelation (PUSCH+PUSCH and PUSCH+PUCCH); b) Flexible per-TRP UL transmission for multi-DCI based mTRP especially with non-ideal backhaul (more efficient resource utilization instead of ensuring strict TDMing); c) Reliability for one PUSCH transmission with reduced latency as compared to TDMed PUSCH repetition in Rel-17; d) Increasing the peak UL data rate in FR2 (2 layers per panel resulting in 4 layers).

Hence, we suggest to keep the "**simultaneous multi-panel UL transmission**" part. Also, we think "**fast UL panel selection**" can be considered as a separate potential enhancement, which has been discussed in Rel-16 and Rel-17 and does not need a study phase if it is to be specified.

19 – NEC Corporation

Support the proposed objective.

20 – Ericsson LM

The support of asynchronous operation is an important enabler for increased adoption of mTRP technologies. Asynchronous mTRP operation would require multiple TA. Therefore we strongly support multiple TAs for multi-TRP, with focus on multi-DCI based operation. Multiple TAs could be part of area 2 as well – there is not any relation to multi-panel UL transmission.

We are supportive of studying simultaneous multi-panel UL transmission assuming it is intended for enhanced multi-TRP uplink operation (i.e., each of the multiple panels transmits towards one of the TRPs in uplink). Note that simultaneous multi-panel UL multi-TRP transmission should be applicable for both throughput and reliability improvement in multi-TRP UL operation.

As commented in the previous round, it is still unclear to us on the need for enhancements in the area of fast UL panel selection. Given Rel-17 allows TCI state switching via DCI, it is our understanding that fast UL panel selection is already possible implicitly in Rel-17. Note that what has been proposed by some proponents is related to UE- initiated reporting which is different from fast UL panel selection. Hence, we suggested to either replace 'fast UL panel selection' with 'UE initiated reporting', or remove 'fast UL panel selection' altogether.

Our suggested revision for area 5 is as follows:

- **Study, if necessary specify enhanced multi-panel uplink operation for ~~and/or enhanced~~ multi-TRP uplink ~~operation~~, including ~~e.g., fast UL panel selection, or~~ simultaneous multi-panel UL transmission**
- **Support multiple TAs for multi-DCI based multi-TRP operation**
- ~~**Other way forward: e.g., not support enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation**~~

21 – Xiaomi Communications

We support the proposed objective and a study phase is not needed. Our first priority is simultaneous multi-panel transmission which targets all UE types and should be included. Thus ,we suggest the following,

Specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, including e.g., fast UL panel selection, or simultaneous multi-panel UL transmission

22 – VODAFONE Group Plc

We support the proposed objective.

23 – China Mobile Com. Corporation

We think simultaneous multi-panel UL transmission is beneficial for both capacity and reliability. We are supportive of simultaneous multi-panel UL transmission with no need for a study phase. We hope fast UL panel selection can be finished in Rel-17 and focus on simultaneous multi-panel UL transmission in Rel-18.

24 – ROBERT BOSCH GmbH

We strongly support **simultaneous** multi-panel uplink operation. We believe it is very useful for enhancing rate/reliability.

25 – MediaTek Inc.

Regarding the Ericsson request for info, for fast UL panel selection there were a number of use cases agreed to be covered in rel-17, but which were not addressed due to lack of time. we would like to address those use cases in rel-18.

26 – NTT DOCOMO INC.

We believe enhanced UL operation for UE equipped with multi-panel is an important feature for UL enhancement for Rel-18. Both fast panel selection and simultaneous multi-panel UL transmission should be considered.

27 – Fraunhofer IIS

We support to study simultaneous multi-panel UL transmissions.

28 – Sony Group Corporation

We are fine to study and specify the UL enhancement for multi-panel UE and multi-TRP operation, rather than ”other way forward”.

However, in the example part, we tend to believe the fast panel selection is more mature than the simultaneous multi-panel transmission. Since the simultaneous multi-panel Tx was heavily discussed in RAN1 in Rel.16, but unfortunately our observation was that such fancy feature may beyond the capability of UE vendor(s)’ implementation and the performance gain was also not yet justified (due to power split among panels). Hence, we suggest focusing on panel selection/switch which would be easier to be completed in time.

29 – KDDI Corporation

We support the proposed obejective because this is important feature to enhance UL data rate and reliability.

30 – Sequans Communications

We are ok to compromise with study of multi-panel UL solutions

31 – LG Uplus

We support moderator’s proposal.

32 – CEWiT

We support the proposed objective. And between fast panel switching and simultaneous panel transmission, as a part of UL MTRP enhancements we believe simultaneous panel transmission is more beneficial over fast panel switching.

33 – SHARP Corporation

We are fine with the study of multi-panel UL transmission

3.6 Proposal for Area 6

Proposed objective:

- **Study, and if necessary specify frequency-selective precoding, mainly targeting devices with >=4 Tx**

Feedback Form 13: Comments on proposed objective

1 – ZTE Corporation

Support the above objective.

In our views, the increase of DCI overhead by introducing frequency-selective precoding should be limited (e.g, 10 bits as a starting point), and corresponding flexible signaling design (e.g., DCI or MAC-CE+DCI) should be well considered. Also, we think that by default, this enhancement should involve both CB and NCB PUSCH transmission. BTW, some more detailed SLS results can be found in our contribution RP-212375.

So, we have the following proposal for detailed objectives.

Study and if necessary specify frequency-selective precoding, mainly targeting devices with >=4 Tx

- **Flexible signaling design with tolerable increase of DCI overhead.**
- **Above applies to both CB and NCB PUSCH transmission**

2 – vivo Communication Technology

We are supportive of this objective, similar to comment above, at least for >4Tx antenna, cross-pole linear coherent antenna structure is assumed.

3 – Futurewei

We are in general ok with the proposed objective.

4 – Spark NZ Ltd

Spark NZ

_Devices targeting greater than or equal to 4 TX implies that at least 4 spatial streams are desired to be supported. From our knowledge of extensive 5G deployment field trials in New Zealand across different environments, the rank on offer by the propagation channel is much lower than 4, on average in the FR 2 bands. This comment also applies to DL. This would mean that *even if* at least 4 TX are available, on average, only a subset of them will be utilized, depending on the channel rank indication. Naturally, a rank 4 channel is also observable within FR 2 bands, yet only in a small percentage of time, where its occurrence probability is less than 10% (very low). Since FR 2 bands need to support higher carrier frequencies and bandwidths, the device power consumption scales with the desire to support 4 or more spatial streams due to at least 4 set of mixed-signal circuits driving the antenna array architecture over such wide bandwidths and carrier frequencies. In such a scenario, with even with single carrier transmission, the power consumption would be high, with its effect being even more prominent with multicarrier transmission (via carrier aggregation). This is the reason why it would have a dominating effect on the UE battery life. Supporting frequency-selective precoding on top of this would not make things easier in any manner. On the other hand, in FR 1 bands, we do not believe the aforementioned issues will hold, since a rank of up to 8 can be successfully supported majority of the time, Here, frequency-selective precoding can potentially enhance performance, as pointed out also by many other companies.

Regarding your comment on UE power consumption for industrial uRLLC application, we can agree with your thoughts that the UE could be directly connected to mains power grid. However, this is only as long as there is no requirement on the UE to be mobile. For other scenarios, such as autonomous robots or automated guided vehicles (AGVs) performing programmed tasks on the factory floor, the UEs would then need to be battery driven and our considerations above would need to be taken into account.

5 – AT&T

We are ok with this proposed objective from the moderator. We propose only including it with consideration of work load of other high priority items for MIMO enhancements

6 – Apple GmbH

We are open to study frequency-selective precoding. But we think this should be for coherent PUSCH transmission only. Furthermore, it is clearly only for CP-OFDM. Therefore, some clarification is preferred, i.e., limit the work of frequency-selective precoding to coherent PUSCH operation only.

7 – Samsung Research America

As commented earlier (also by other companies), albeit the potential gain in UL throughput, the benefit depends heavily of DL control signal design and overhead. Since there is lack of urgency and there are a host of other enhancement areas that can offer more promising gain (e.g. Area 5 and perhaps some in Area 4), we recommend that **Area 6 be assigned low priority or, justifiably, opted out from Rel-18 MIMO** (considered for future releases when the need becomes clear).

8 – InterDigital France R&D

We support this proposal, however we would like to emphasize that the scope of the proposal should be limited to efficient support of sub-band precoding using the existing codebook, and no enhancement on UL codebook would be included in the this sub-agenda.

9 – Lenovo (Beijing) Ltd

We support the proposal. The study shall be focused on the tradeoff between UL gain and DL overhead. However, we believe this depends on the Area 4 Proposal regarding support for >4Tx. We prefer to made clear that support for frequency selective precoding for >4Tx shall be conducted after the study phase for >4Tx support concludes, and that any supporting/non-supporting results for >4Tx should be conducted in Area 4 to avoid ambiguity.

We agree with Apple that this shall be limited to coherent transmission.

10 – Spreadtrum Communications

We support moderator's proposal.

11 – Guangdong OPPO Mobile Telecom.

We are fine the proposal in principle. We prefer to focus on > 4Tx since 4Tx was studied in R15

12 – MediaTek Inc.

The proposal is fine in general for us. We think it would also be good to consider high resolution precoding though.

Study, and if necessary specify frequency-selective precoding and wideband high resolution precoding, ~~mainly~~ targeting devices with >=4 Tx

13 – Nokia Corporation

We support the moderator proposal, and we are fine to focus the study on >4Tx.

14 – CATT

We support the objective. We think both codebook and non-codebook based PUSCH are targeted by the objective. How much of an increase in DCI overhead can be tolerated can be determined after further study.

15 – Huawei Tech.(UK) Co.. Ltd

We are fine with the proposal.

16 – NEC Corporation

Support the proposed objective for FR1 only. We are also OK to merge this objective into Area 4 as a sub-bullet.

17 – Qualcomm Incorporated

We have expressed concerns on the downside (varying DCI payload and less PA efficiency) of frequency-selective precoding in the 1st round. With that in mind, we think it is necessary to include high (spatial) resolution wideband precoding in the scope. Otherwise, we would not agree with this objective.

18 – Intel Corporation (UK) Ltd

We see some overlap of the scope of Area 6 and Area 5. In particular, It is not clear how to compare WB vs FS precoding in proposed objective for 6Tx and 8Tx UE due to lack of the baseline?

We, therefore, suggest to focus study (and possible normative work) only on 4Tx case, since the baseline for comparison in this case is clearly defined. We should also consider only CB operation for UEs with partial and full coherent capability.

- **Study, and if ~~necessary,~~ sufficient gain as shown, specify frequency-selective precoding~~, mainly targeting devices with >=4 Tx~~ for codebook based PUSCH transmission with 4Tx partial and full coherent UEs.**

19 – Ericsson LM

Similar to >4 Tx, companies' views seem to be a function of the use cases, scenarios, and UE antenna related assumptions that are varying among companies. Additionally, in our view there are valid concerns expressed on PA efficiency and MPR losses that can come with frequency selective precoding, which should be taken into account. The amount of overhead, and therefore its impact on PDCCH, is well understood to be a fundamental tradeoff as well.

Therefore, we would propose the following additional detail for the objective:

- Study, and if necessary specify frequency-selective precoding, mainly targeting devices with >=4 Tx
  - Identify a limited number of targeted use cases and scenarios, including UE antenna related assumptions for the study
  - Accordingly, evaluate performance of frequency-selective precoding enhancements, including DCI overhead vs. performance tradeoffs
  - Specify any needed enhancements based on the outcome of the evaluations, where the need also takes into account UE and gNB complexity, UE Tx chain implications such as MPR, and impacts on PDCCH

20 – China Mobile Com. Corporation

Since frequency selective precoding is more beneficial for >4Tx case, we think this item could be a subbullet under Area 4.

21 – NTT DOCOMO INC.

We support the moderator's proposal.

22 – Fraunhofer IIS

We are fine with the direction of the moderator's proposal. It should be clear in the objective if the intention is to apply it for codebook or non-codebook or both.

23 – KDDI Corporation

We support moderator's objective, and can discuss together how to deal with DCI overhead.

24 – LG Uplus

This is not urgent to us.

25 – Xiaomi Communications

We are fine with the proposal in general. Considering the signaling overhead impact, we think it is valid to also include the wideband high resolution precoding into the scope.

26 – SHARP Corporation

We are OK with the proposals.

3.7 Proposal for Others

please provide your comments on the newly added proposal, especially whether it could be part of the WI?

3. Support 2 CW for >=2layers?

Feedback Form 14: Your views on the additional candidate? whether it could be a part of the WI?

1 – LG Electronics Inc.

We are supportive on 2 CW for >=2 layers especially for mTRP joint transmission scenarios for DL and simultaneous multi-panel UL transmission for UL. This will enable more flexible MCS control for each TRP/panel.

2 – China Telecommunications

We support 2 CW for >=2layers to be part of the WI.

3 – ZTE Corporation

Support.

In detail, the motivation and necessity for UL CW mapping enhancement have been well justified in real-field tests (as shown in RP-212375), and this enhancement is supported by many operators and gNB/UE vendors in both Rel-17 TEI and Rel-18 August NWM discussion. Therefore, we strongly suggest to capture this bullet in Rel-18 MIMO enhancement.

4 – vivo Communication Technology

we can be supportive of this objective given the overall scope of this WI is well managed.

5 – Intel Corporation (UK) Ltd

We don't see need of this objective in Rel-18:

- The issue in the context of mTRP is already addressed by multi-DCI solution allowing two CWs with flexible MCS assignment to TRPs
- For all other cases, Rel-15 study shows worse performance of MCW to SCW. Further justification is needed, why such observation becomes not true

6 – Futurewei

Given the already very heavy load of the Rel-18 MIMO WID, our view is that this additional candidate should be low priority.

7 – Samsung Research America

This issue has been extensively discussed in Rel-15 for DL (with mTRP taken into account). Since the situation has not changed, we don't support this enhancement for DL.

On the other hand, some justification exists for UL especially when mTRP is involved (e.g. UL dense NW).

Yet given the prospectively limited TU allocation for Rel-18 MIMO, we are open to considering *study and, if needed, specify the support for 2 CWs for UL transmission with >=2 layers*", **only if** some existing areas are opted out from Rel-18 MIMO (such as Area 1, 3, and 6) and, better yet, more well-defined scopes are assigned to Areas 4 and 5.

8 – InterDigital France R&D

In our view, this is a low priority item.

9 – Lenovo (Beijing) Ltd

We support study 2 CW for >4 layers as part of >4Tx layers (Area 4). There is no need to support 2 CW for <=4 layers, as this was studied previously and no gain was evident.

10 – Spreadtrum Communications

Not prefer to include more topics. Instead, we need to down select some objectives from the 6 Areas above.

11 – Guangdong OPPO Mobile Telecom.

In general, we support the above three proposals as it would be beneficial for UL enhancement.

12 – CATT

We support 2 CW for >=2layers to be part of the WI to allow separate MCS adaptation to the channel condition and independent retransmission for different layers, which are inherent for improved uplink throughput.

13 – Nokia Corporation

We support the objective on Support 2 CW for >=2layers, with a focused scope.

14 – Qualcomm Incorporated

We do not support this. CW-layer mapping has been discussed practically in all releases so far. In Rel-15, it was studied extensively and based on the study it was decided to have one CW for up to 4 layers. In Rel-16, it was discussed again in the context of mTRP which resulted in the same outcome. In Rel-17, it was proposed in TEI and not agreed.

Given the above and the fact that the same can be already achieved with multi-DCI mTRP framework (with even better flexibility at the cost of DCI overhead) for DL (and also for UL depending on the outcome of Area 5), we think this should not be pursued.

15 – Ericsson LM

Thanks to the moderator for clarifying where the DFT-S-OFDM enhancements for UL-MIMO and fast CP-OFDM/DFT-S-OFDM switching will be considered in this round. It is our understanding that if 2+ layer DFT-S-OFDM UL MIMO is found agreeable in the UL enhancements discussion, then whether the work/study will be done in the MIMO WI or the UL Enhancements work item can be further discussed. Can the moderator confirm?

In our understanding, the most obvious use case for multi-codeword UL transmission is for UL M-TRP, since in that case the imbalance in the codewords is not only due to UE implementation, but due to imbalance in the radio links to the different TRPs. Given the overload in this WI, we suggest if any potential enhancements to codeword to layer mapping are to be identified for Rel-18 UL MIMO, they be studied for UL M-TRP in area 5, if UL M-TRP is indeed included. If UL M-TRP is not included in the MIMO work item, then the need for 2 codewords for >= 2 layers is less obvious to us, while it may be hard to fit the study & work needed to specify this and the other objectives in the 1 TU likely to be available for UL enhancements.

16 – China Mobile Com. Corporation

We support 2 CW for >=2layers to be part of the WI.

17 – ZTE Corporation

Please review our further comments based on the companies' inputs.

- Generally speaking, handling the essential issue proved by real-field tests in the NR network is very worthwhile with a high priority in Rel-18. It seems that majority companies can support this enhancement (although some of them may worry about the current workload of R18 MIMO).
- Regarding Intel's comments, to be honest, even in Rel-15, different companies may have different observation/preference about Rel-15 simulation results. Quite different from Rel-15 discussion in 2017, we now can have real-field tests for >=2 layer UL transmission. As we mentioned before in the initial round, the SINR gap between two UL MIMO layers is often large in our test results e.g. larger than 10dB. It is larger than what we observed in simulations possibly due to some practical differences e.g. inaccurate modeling of antenna placements in simulations, different blockage for different antennas, etc.
- Regarding some companies' comments about TU/workload of R18 MIMO, we firstly think that, considering that we have a clearly complete feature in LTE, the TU for this enhancement can be well controllable, e.g., 0.25 TU or less. Then, we are open to consider this enhancement with other Areas (e.g., Area 4 and Area 5) as Samsung and Ericsson suggested, and fully agree that this enhancement can also support some other UL enhancements as a relevant sub-feature.

Study and, if needed, specify the support for 2 CWs for UL transmission with >=2 layers, possibly while applying to >4 Tx UL operation (Area 4) and/or enhanced multi-TRP/panel uplink operation (Area 5) as a complementary feature.

18 – NTT DOCOMO INC.

We support 2 CW for >= 2 layers included in the WI.

19 – MediaTek Inc.

We actually think that none of the 3 proposals are well justified, with very little evidence demonstrating the benefits, and at least for 2 of the features ((1) DFT-s-OFDM 2 layer (2) 2 CWs) there were already considered in Rel-15 and decided not to be supported, with no overwhelming evidence that things have changed since. Therefore we would not e supportive of adding these features and consider them low priority.

20 – LG Uplus

This is not urgent to us.

21 – CEWiT

Regarding the objective , we support only for a study , before moving towards a WI. Though the contributors in R1-2108886 extensively showcase simulation results, we still need to clarify a lot of simulation assumptions like receiving power gap and other SLS,LLS details. Even in the contribution the gain reduces considerably when the receiving power gap is reduced to 6dB. So a direct WI is not possible without proper study. Also as multiple companies mentioned this may not be beneficial in DL as we already allow 2CWs for multi-DCI MTRP transmissions. Even in UL, we believe this may be acceptable only for >=4layers. So we propose the following text *study and, if needed, specify the support for 2 CWs for UL transmission with >=4 layers*

22 – Xiaomi Communications

We think it is hard to consider this at this stage, we are fine to study the 2 CW for >4 layers under the objective of >4Tx.

3.8 Summary of intermediate phase

3.8.1 Summary of discussion on proposal for Area 1

For objective

- **Study, and specify (if sufficient gains are identified) CSI and SRS enhancement for UE in high/medium mobility, including potential enhancement to both codebook based and reciprocity-based mechanisms**

Below is an overview about the support level based on companies' comments:

Support: Intel, vivo (Support SRS), Futurewei, Spark(Support SRS), AT&T, Apple, Continental Auto, IDC (no Codebook enh.), Spreadtrum, MTK, Lenovo/Motorala(support CSI part), Xiaomi, CATT (Separate SRS and CSI), NEC(prefer CSI and CSI-RS only, not SRS), Ericsson, Vodafone, CMCC (support SRS), Sony, DCM, KDDI, Huawei/HiSi(support SRS), Faunhofer, CEWiT, Volkswagen, Telecom Deutschland

Scope Clarification: OPPO, QC

Not support/Low priority: LGE, ZTE, Samsung, LGU+

Some specific comments are raised in the discussion, e.g., ask for clarification of SRS enhancement, scope should not be too open, **Moderator would like to propose the objective as below to make the objectives a**

bit more specific, which may not reflect all or some too specific comments as below

- **Study, and if justified, specify CSI enhancement, and possibly, CSI-RS and SRS enhancement,in high/medium velocities for exploiting time-domain correlation/Doppler-domain information, including potential enhancement to both codebook based and reciprocity-based CSI acquisition mechanisms**

3.8.2 Summary of discussion on proposal for Area 2

1. For objective

- **Extend 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)**

Below is an overview about the support level based on companies' comments.

Support: LGE, ZTE, vivo, Futurewei, Apple, Samsung (Specify), IDC, CAICT, SK Telecom, Lenovo/Motolora, Xiaomi, Ericsson, CMCC, China Telecom, DCM

Study/Clarify the scope: Intel, AT&T, QC, Huawei/HiSilicon, OPPO (not support inter-band), Fraunhofer (remove inter-band), MTK, Nokia/NSB(focused objective on evolution)

Not support/Low priority: CATT

Some specific comments are raised by companies to re-formulate the objective. Trying to reflect some common comments, **Moderator would like to propose the objective as below**

- **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 single-TRP and multi-TRP schemes**

2. For objective

- **Study and specify, if justified, enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports**

Below is an overview about the support level based on companies' comments.

Support: AT&T(To specify), China Unicom(To specify), SK Telecom, CMCC, China Telecom(To specify for TDD and FDD), LGU+, LGE, ZTE, Intel, Futurewei, Apple, Samsung(To specify for TDD and FDD), Spreadtrum, CAICT, Xiaomi, Huawei/HiSilicon (To specify for TDD and FDD), CATT, CEWiT

Not support/Low priority: IDC, OPPO, Lenovo/Motorola, Nokia/NSB, QC, Ericsson, DCM, Fraunhofer, MTK

It is observed that a lot of companies support the enhancements for Coherent joint transmission, and some companies propose to specify directly, but some companies negate it due to concern on workload, long evaluation phase, no urgent market as well as practicality. However, 6 of 7 operators support it, they may have more sense to judge the practicality. From Moderator's point of view, a study phase before specify in the WI for Coherent joint transmission may be helpful.

Jointly considering the comments, **Moderator would like to update the proposal as below**

- **Study, and if justified, specify enhancement for Coherent-JT/D-MIMO for both FDD and TDD targeting FR1, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports**

3. For objective

- **Study and specify, if justified, overhead and/or Latency reduction with beam management/beam acquisition procedures**

Below is the overview about the support level based on companies' comments.

Support: ZTE(UE-Initiated), Intel, vivo, Futurewei, AT&T, Apple, IDC, CAICT, Xiaomi, China Telecom

Scope clarification: Samsung, Lenovo/Motorola, Huawei/HiSilicon, NEC, CMCC, DCM, Sony, MTK

Not support/Low priority: LGE, OPPO, Nokia/NSB (Scope), QC, Ercisson, CATT

Other proposal:

(Intel, Nokia/NSB, NEC, Sony): propose to include Multi-TA for Asynchronous MTRP;

From the discussion, it seems UE-initiated beam management receives more positive feedback, **Moderator would like to make it a bit specific and propose to narrow this objective down to**

- **Study, and if justified, specify overhead and/or Latency reduction with UE-initiated beam management/beam acquisition procedures**

Feedback Form 15: Comments on narrowing down "overhead and/or Latency reduction....."?

1 – Samsung Research America

First, we'd like to express our appreciation to the moderator for the good and accurate summary.

Re this topic, our proposal is to use the final outcome (based on majority view) of "issue 6" in Rel-17 MIMO (under multi-beam) whose scope is already wide enough:

- UE -initiated (DL-only or DL/UL) beam selection, including the following options

- Opt1. The selected beam is reported by an event-triggered UE beam reporting via, e.g. UCI, MAC CE, UL CG, or Type 1/Type 2 CBRA/CFRA
- Opt2. The selected beam is reported by a legacy UE beam report (NW-configured)

For the WID, the following wording can be used as a starting point: "**Study, and if justified, specify UE -initiated beam selection based on event-triggered and/or NW-configured reporting**"

2 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

For beam management objective on the overhead and/or latency reduction, we suggest to include all the scenarios in the SI portion for this objective, for example,

Study, and if justified, specify enhancements for overhead and/or latency reduction with:

- **UE-initiated beam management**
- **Event-trigged /beam acquisition procedure**
- **Grouping/sharing based beam measurements and reporting**

3 – Ericsson LM

We support the moderator's attempt to narrow down the scope of the last sub-bullet. During the Rel-17 discussion, it has become clear that 'UE-initiated' may mean different things. We propose to narrow it down and clarify the scope even further, to state that "UE-initiated" means "event-driven":

- **Study, and if justified, specify overhead and/or Latency reduction with event-driven beam reporting.**

3.8.3 Summary of discussion on proposal for Area 3

For proposal

- **Proposal: Take this objective (DL enhancements for CPE) as low priority.**

All companies except one are fine to take Area 3 (DL enhancements for CPE) as low priority, so it is proposed not to discussedi it in final round.

Feedback Form 16: Comments on removing Area 3 (if any)?

1 – Ericsson LM

OK to remove

3.8.4 Summary of discussion on proposal for Area 4

Below is an overview about the support level based on companies' comments.

Support: LGE, ZTE, Telecom Italia, Futurewei, AT&T, Samsung(up to 4 layers), Cotinental Auto, Lenovo/Motorola(up to 8 layers), OPPO, Xiaomi, MTK(restriction on use case), Nokia/NSB, Vodafone, DCM, KDDI, LGU+, CEWiT

Need Clarification: vivo, IDC, BOSCH, CMCC, Intel, Ericsson, QC

Not support/Low priority: Apple

From the discussion, this proposal receives wide support, and it is pointed that current scope is too general. Based on comments, **Moderator would like to propose:**

- **Study, and if justified, specify [CW mapping, UL DMRS, SRS and CSI acquisition,etc.,] to enable 6 and 8 Tx UL operation, to support more than 4 layers per UE in the UL targeting CPE/ FWA/vehicle/Industrial devices**

As to whether to limit it to 4 layers can be discussed further. **Above all, this objective seems too open, too huge to be done in single release if we do not define clear components, e.g, in the [] in the WID.**

3.8.5 Summary of discussion on proposal for Area 5

For proposal

Proposed objective or other way forward

- **Study, if necessary specify enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation, including e.g., fast UL panel selection, or simultaneous multi-panel UL transmission**
- **Other way forward: e.g., not support enhanced multi-panel uplink operation and/or enhanced multi-TRP uplink operation**

Below is an overview about the support level based on companies' comments.

Support: LGE (specify STxMP), ZTE, Telecom Italia, Intel(STxMP), Futurewei, AT&T, Samsung(remove UL panel selection), IDC, Lenovo(Study STxMP), CATT, Nokia/NSB, NEC, Xiaomi, Vodafone, CMCC, BOSCH, MTK, DCM, Fraunhofer, Sony, KDDI, Sequans, LGU+, CEWiT

Study/Clarification: QC (keep STxMP), Ericsson,

Not support/low priority: vivo(not feasible for STxMP), Apple(Against STxMP), Spreadtrum (not OK for STxMP), OPPO(remove Panel selection), MTK (Not for STxMP)

From the discussion, majority of companies are willing to do at least something for area 5, but it is observed that some companies prefer simultaneous transmission to panel selection, some companies think panel selection has higher priority over simultaneous transmission while some companies point out the history of panel selection in the past, and some other companies think that both of them are feasible to be specified instead of studying first. At the same time, some companies are more favor of multiple TA or multiple PC. **So Moderator would like to propose a compromise way forward for area 5**

- **Support for simultaneous multi-panel UL transmission for higher UL throughput/reliability**
- **Study, and if justified, specify features to support panel-specific UL transmission, e.g. panel-specific timing/power control for multi-TRP scenario.**

3.8.6 Summary of discussion on proposal for Area 6

For objective

- **Study, and if necessary specify frequency-selective precoding, mainly targeting devices with >=4 Tx**

Below is an overview about the support level based on companies' comments.

Support: ZTE, vivo, Futurewei, Spark, AT&T, Apple(Open), IDC, Lenovo/Motorola, Spreadtrum, OPPO, MTK, Nokia/NSB, CATT, Huawei/HiSilicon, CMCC, DCM, Fraunhofer, KDDI, Xiaomi

Scope Clarification: Ericsson

- **Not support/low priority:** Samsung, QC (need include high resolution wideband precoding), Intel (focus on only 4Tx), LGU+

It is observed that this proposal is almost agreeable if some clarification can reach common understanding, so the proposal revised as below

- **Study, and if justified, specify frequency-selective precoding and wideband high resolution precoding targeting devices with >=4 Tx**

3.8.7 Summary of discussion on proposal for Area Others

For objective

- **Support 2 CW for >=2layers?**

Below is an overview about the support level based on companies' comments.

Support: LGE (both TDD and FDD), China Telecom, ZTE, vivo, OPPO, CATT, Nokia/NSB, CMCC, DCM

Not Support/Low priority: Intel, Futurewei, Samsung, IDC, Lenovo/Motorola, Spreadtrum, QC, Ericsson, LGU+, MTK, Xiaomi

Based on this overview, it seems we can take it out of the scope, however, it seems companies mainly show concern on DL, for uplink, companies are a bit more open. Jointly considering the discussion and the expectation on UL enhancement, **Moderator would like to revise the proposal to make it focus on UL as one option**

- **Alt 1: Support 2 CW for >=2layers in uplink**
- **Alt 2: No Support 2 CW for >=2layers**

4 Final Phase

4.1 Proposal for Area 1 after intermediate round

- **Study, and if justified, specify CSI enhancement, and possibly, CSI-RS and SRS enhancement,in high/medium velocities for exploiting time-domain correlation/Doppler-domain information, including potential enhancement to both codebook based and reciprocity-based CSI acquisition mechanisms**

Feedback Form 17: Comments on Proposal for Area 1 after intermediate round?

1 – Samsung Research America

As mentioned in intermediate phase, while NW performance enhancement at high/medium speed is important, CSI is hardly the limiting factor in current deployments. As also mentioned by several companies, implementation-based solutions utilizing the existing specification are possible to enhance NW performance at high/medium speed.

Therefore, to manage the WI scope, we recommend that **Area 1 be assigned low priority or, justifiably, opted out from Rel-18 MIMO** (considered for future releases when CSI starts becoming a limiting factor for high-speed and the need for enhancing CSI for M-TRP URLLC becomes clear).

2 – China Telecommunications

We support 2 CW for >=2layers for both DL and UL. If companies have conerns on DL, we can compromise to only UL, i.e., Alt 1.

3 – Guangdong OPPO Mobile Telecom.

Support Moderator's proposal except the SRS part.

As many companies commented, the motivation/scope/benefit of SRS is not clear. By reading through companies' inputs, we noticed some aspect/motivations were mentioned for SRS enhancement

- Overhead reduction: In Rel-17, frequency-domain partial sounding is introduced. This new mechanism can reduce the SRS overhead.

- Doppler estimation for high speed channel: In Rel-17, it was agreed that "For Rel-17 TRP-based pre-compensation scheme, indication of carrier frequency for uplink transmission (Doppler frequency reporting) in TRP-based pre-compensation scheme is supported using implicit indication of the Doppler shift(s) using uplink signal(s)". Accordingly, there is an on-going discussion on the potential SRS enhancement in R17 now. Thus, what's the new thing for R18?

Thus, the scope of SRS part should be clarified with clear motivation and focused aspects for enhancement before we can agree it.

4 – Sony Group Corporation

Support the moderator proposal.

5 – VODAFONE Group Plc

We support the moderator's proposal.

6 – Intel Corporation (UK) Ltd

A few editorial corrections to make the wording clearer and to remove unnecessary details in the objectives.

In addition, since codebook is always considered as part of CSI, there is conflict between "specify CSI enhancement" and "specify potential enhancement to codebook".

It should be also clarified that the enhancement targets DL precoding (not UL reception).

Suggest revision is provided below:

Study, and if sufficient gains are shown ~~justified~~, specify ~~based~~ potential CSI enhancement (including codebook)~~, and possibly,~~ CSI-RS and SRS enhancement, in high/medium velocities ~~for exploiting time-domain correlation/Doppler-domain, including potential enhancement~~ to assist both codebook based and reciprocity-based ~~CSI acquisition mechanisms~~ DL precoding.

7 – vivo Communication Technology

Generally CSI (codebook) enhancement takes lots of effort and time, given UL MIMO enhancement in Rel-18 is important, we can be ok if overall scope is limited. Intel's edit looks better however further narrowing of scope is needed.

8 – Apple GmbH

We do not support CSI-RS and SRS related studies. CSI-RS enhancement has been discussed during Rel-17 and there is no convincing argument to support CSI-RS enhancement especially considering that we already support PDSCH rate matching CSI-RS. We already did SRS enhancement in Rel-17, the scope of further SRS enhancement is unclear.

9 – SHARP Corporation

We support the moderator's proposals.

10 – AT&T

We think exploiting time-domain correlation/doppler domain information have the potential of improving the performance, especially for high/medium velocity UEs. We also see however that the scope of enhancements in this area might be too large considering other areas of further enhancements of MIMO in Rel. 18. We are ok with the proposal by Intel, and we think even more reduction of scope might be needed.

11 – InterDigital France R&D

We are generally fine with the proposal, however we find the scope is still quite large for the expected allocated TUs.

As we mentioned in the previous round, we don't think any codebook enhancement is needed, and we only support potential enhancements related to RS aspects and possible new procedures to support high mobility UEs.

Also, we need to clarify what is meant by high velocity. 120Km/h, 250Km/h, 500Km/h? This needs to be clarified, as depending on the target velocity, one of CSI-RS or SRS enhancements could be prioritized. For

example, if the target speed is 250Km/h and above, then SRS enhancements may be prioritize over CSI-RS, as CB-based transmission may not be relevant. On the other hand, if we are targeting up to 120Km/h, then it may make sense to consider some enhancements for CSI-RS processes.

In brief, our recommendation is to clarify the max target velocity, and then narrow down the scope, i.e., to chose one of CSI-RS or SRS enhancements.

12 – Telstra Corporation Limited

Similar to Vodafone, AT&T and others, Telstra is very interested in pursuing this work. We do not agree to down prioritising or removing this area of work. We think it is important to look at how exploiting delay / Doppler channel feedback can improve spectral efficiency and performance for a number of use cases, including medium to high speed UEs. We would like to see this work prioritised and taken seriously.

13 – ZTE Corporation

As we mentioned before, there is no clear motivation on CSI enhancement for UE in high/medium mobility, i.e., 'Time-domain correlation/Doppler-domain based CSI feedback' as proposed by other companies.

- Generally speaking, for CSI codebook enhancement, we should hold on a bit to see the market's response for the previous three releases (TypeII CSI, eTypeII CSI, FR1 FDD reciprocity based CSI).
- The proposed compression in Doppler domain can be seen as forward-looking investigation without urgent need. Compared with issues identified from real deployment, this type of forward-looking investigation should have lower priority.
- Also, a potential AI/ML based study item for air interface also discusses CSI compression feedback. We can do forward-looking study there.

After that, for the remaining part, i.e., 'SRS enhancement for UE in high/medium mobility', we think that it can be merged with C-JT related enhancement, since both of them are mostly relevant to 'SRS capacity enhancement' in technical. In other words, we do NOT need to mention SRS enhancement twice in different areas in Rel-18 DL and UL MIMO.

Based on above, we suggest to consider this objective with low priority.

14 – NTT DOCOMO INC.

We are okay with the proposal, although we think SRS enhancement should have lower priority, even for study.

15 – Futurewei

We are in general ok with the proposed objective.

16 – Qualcomm Incorporated

The whole objective could be removed.

If kept, we suggest to narrow it down to CSI enhancement for codebook-based CSI acquisition.

17 – Nokia Corporation

We agree with the views expressed above that the objective is still too ambitious and too large for the foreseen time allocation. Qualcomm's suggestion is a reasonable way forward.

18 – MediaTek Inc.

We support the moderator objective, due to the codebook-based CSI acquisition having clear benefits in our view.

Regarding Intel's suggestion to improve the text, if there are such modifications, we believe that we should keep the text on time-domain/doppler domain correlation to ensure that we have a clear focus, i.e. the following:

Study, and if sufficient gains are shown ~~justified~~, specify ~~based~~ potential CSI enhancement (including codebook)~~, and possibly,~~ CSI-RS and SRS enhancement, in high/medium velocities by ~~for~~ exploiting time-domain correlation/Doppler-domain~~, including potential enhancement~~ to assist both codebook based and reciprocity-based ~~CSI acquisition mechanisms~~ DL precoding.

19 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

As we mentioned in the Intermediate Phase, the motivation for SRS and reciprocity-based CSI acquisition are still not clear. Regarding SRS-based Doppler measurement, UE power consumption is a concern for a burst SRS design. For a focused objective, we propose to prioritize CSI-RS based Doppler measurement/CSI reporting with the following suggested modification to the proposal:

Study, and if justified, specify ~~based~~ CSI enhancement, and ~~possibly,~~ CSI-RS ~~and SRS~~ enhancement, in high/medium velocities for exploiting time-domain correlation/Doppler-domain, including potential enhancement to ~~both~~ codebook based ~~and reciprocity-based~~ CSI acquisition mechanisms

20 – Telekom Deutschland GmbH

Deutsche Telekom supports moderator's proposal.

21 – CATT

As we mentioned in previous discussions, CSI enhancement for high/medium mobility is important for practical deployment. However, the motivation and benefit of introducing further enhancement for SRS is not clear to us. Actually, enhancement of SRS for overhead reduction and Doppler estimation can be achieved with current spec or implementation. Considering the limited time budget available for Area 1, we suggest to remove SRS enhancement from this area.

22 – Beijing Xiaomi Mobile Software

We are general OK with this objective and it is better to make the SRS part more focus.

23 – LG Electronics Inc.

We have similar view as Samsung, Qualcomm, Nokia, ZTE that Area1 should be a low priority. Regarding CSI-RS and SRS enhancements, we have same view as Apple. We should note that the scope grows compared to the endorsed version. The endorsed document only mentions CSI enhancement (as captured below) but now it includes CSI-RS and SRS enhancements.

- Further enhancements for CSI (e.g., mobility, overhead, etc.)
. Particularly for high/medium mobility

24 – Huawei Tech.(UK) Co.. Ltd

We could be fine with this area, although recognizing that there was already work on high speed train (HST) in R17, so the CSI enhancement for mobility should have lower priority compared to Area-2.

25 – NEC Corporation

We are fine with the proposal. But we don't have the intention to support another SRS enhancement in Rel-18 considering that there would be a lot of potential SRS related enhancement in other areas (e.g., in area 4, 5, 6).

26 – CEWiT

We are fine with the Moderator's proposal.

27 – China Mobile Com. Corporation

Our preference for DL MIMO enhancement is Area2>Area 1. We are ok to consider this Area with low priority.

28 – Spreadtrum Communications

We also prefer to remove SRS enhancement from Area1 since we don't see the necessity to further enhance SRS.

29 – Fraunhofer IIS

We support the moderator's proposal in general. As mentioned by many operators and verticals (AT&T, Vodafone, Telstra, Deutsche Telekom, VW, Continental, …) enhancements based on exploiting Doppler-domain information for UEs with medium/high speeds should be considered with high priority. Nevertheless , we do think that the scope is too broad. We agree with QC, Nokia, Motorola/Lenovo's, … suggestion to focus on CSI-RS based Doppler measurement/codebook-based CSI enhancements for UEs in medium/high speed scenarios.

Study, and if justified, specify ~~based~~ CSI based enhancement, and possibly, CSI-RS ~~and SRS~~ enhancement, in high/medium velocities for exploiting time-domain correlation/Doppler-domain, including ~~potential~~ enhancement to ~~both~~ codebook based ~~and reciprocity-based~~ CSI acquisition mechanisms.

30 – Ericsson LM

Support as priority 1 item.

The motivation is that it is observed in real deployments that DL MU-MIMO performance reduces significantly at medium and higher UE velocities. To increase the operator's return on investment of massive MIMO antenna technology, we believe that extending the downlink MU-MIMO feature to higher velocities is a high priority issue that needs to be solved for both reciprocity based operation and for CSI feedback based operation. Hence, we see an urgency and a market need for this proposal.

31 – Volkswagen AG

The proposed objective of area 1 sounds reasonable. However, if the scope is deemed to be too broad, then an alternative would be to focus first only on CSI-RS enhancements rather than both CSI-RS and SRS enhancements.

Study, and if justified, specify CSI enhancement, and possibly, CSI-RS ~~and SRS~~ enhancement, in high/medium velocities for exploiting time-domain correlation/Doppler-domain information, including potential enhancement to both codebook based ~~and reciprocity-based~~ CSI acquisition mechanisms.

32 – MediaTek Inc.

Just to add to our previous comment that we see this as a Priority 1 item.

33 – Continental Automotive GmbH

We are in principle in line with the proposed objective of area 1. For the automotive industry we see especially the need for the CSI enhancement for UE in high/medium mobility, including enhancement to codebook based mechanisms by exploiting time-domain correlation/Doppler domain feedback. Because of time constrains we would limit to CSI RS based enh. in Rel. 18 only. We see a clear need in the field for these improvements in mobility scenarios. Our proposal for the objective:

Study, and if justified, specify ~~based~~ CSI based enhancement, and possibly, CSI-RS ~~and SRS~~ enhancement, in high/medium velocities for exploiting time-domain correlation/Doppler-domain, including ~~potential~~ enhancement to ~~both~~ codebook based ~~and reciprocity-based~~ CSI acquisition mechanisms.

34 – KDDI Corporation

We are supportive to moderator's proposal.

35 – Fraunhofer HHI

We support the moderator's proposal in general. Nevertheless we would focus on CSI-RS based Doppler measurement/codebook-based CSI enhancements for UEs in medium/high speed scenarios.

Study, and if justified, specify ~~based~~ CSI based enhancement, and possibly, CSI-RS ~~and SRS~~ enhancement, in high/medium velocities for exploiting time-domain correlation/Doppler-domain, including ~~potential~~ enhancement to ~~both~~ codebook based ~~and reciprocity-based~~ CSI acquisition mechanisms.

4.2 Proposal for Area 2 after intermediate round

- **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 single-TRP and multi-TRP schemes**
- **Study, and if justified, specify enhancement for Coherent-JT/D-MIMO for both FDD and TDD targeting FR1, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports**
- **Study, and if justified, specify overhead and/or Latency reduction with UE-initiated beam management/beam acquisition procedures**

Feedback Form 18: Comments on Proposal for Area 2 after intermediate round, inlcuding your comments on narrowing down ”overhead reduction.....”?

1 – Samsung Research America

· Sub-objective 1: Support moderator’s proposal

· Sub-objective 2: Support moderator’s proposal (wording refinement on the objective can be done to ensure that the scope is clear)

· Sub-objective 3: Support moderator’s proposal with possible wording refinement (to limit the scope) based on our input in section 3.8.2 (based on the outcome of ”Issue 6” of Rel-17 multi-beam enhancement in FeMIMO): “***Study, and if justified, specify UE -initiated beam selection based on event-triggered and/or NW-configured reporting***”

2 – Samsung Research America

Correction on our input on sub-objective 2 (apology): Support moderator’s proposal (wording refinement on the objective can be done to ensure that the scope is clear) but with rewording ”Study and, if justified specify” to ”**Specify**” as explained in previous rounds.

3 – Guangdong OPPO Mobile Telecom.

The scope is still too large and will lead to unmanageable workload for the group. Thus, we suggest to down-scope Area2

For the 1st bullet

- We failed to see the motivation to support common TCI pools for inter-band CA. Thus, we suggest to remove it
- R17 unified TCI framework focused on sTRP. Thus, what does it mean to extend the framework for sTRP? What is the typical use cases and benefits for “further extension” to sTRP?

For the 2nd bullet:

- From our view, it is low priority compared to other objectives.
- D-MIMO and C-JT are two different things, although they have some overlapping. Thus, the scope is so large that the 2nd bullet is sufficient for a standalone WI/SI.

For the 3rd bullet

- The current objective is more concrete and clearer. Thus, we support it.

In summary, we support the following objective

- 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 ~~single-TRP and~~ multi-TRP schemes
- ~~**Study, and if justified, specify enhancement for Coherent-JT/D-MIMO for both FDD and TDD targeting FR1, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports**~~

- Study, and if justified, specify overhead and/or Latency reduction with UE-initiated beam management/beam acquisition procedures

4 – Sony Group Corporation

Support the moderator proposal.

5 – Intel Corporation (UK) Ltd

Our comments from the previous round of discussion were not addressed.

1. The description of the first objective is not clear, e.g., meaning of M, N, inter-band, D-MIMO, enhancement to spatial domain interference avoidance, etc. The actual transmission schemes for extension were not clarified. This opens the door for many proposals and that would require study not captured in the objective. With current formulation RAN1 will not be able to provide TU assessment for this work and may face the issue future scope clarification in RANP meetings similar to clarifications in Rel-17 MIMO WID.

We propose to make the following updates:

- **Extend Rel-17 Unified TCI framework to support multi-TRP transmission schemes specified in Rel-16/Rel-17~~, e.g.,~~**
  - **~~for indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1, and inter-band)~~**
- **Study, and if sufficient gains are shown ~~justified~~, specify enhancement for Coherent-JT/~~D-MIMO~~ for both FDD and TDD targeting FR1, including ~~e.g.,~~ codebook, CSI reporting~~, spatial domain interference avoidance,~~ and larger number of orthogonal DMRS ports**
- **Study, and if justified, specify overhead and/or ~~L~~latency reduction with UE-initiated beam management/beam acquisition procedures**

2. As commented in the previous rounds, the objective on asynchronous operation shall be kept to enable multi-TRP in FR2. If current RAN4 assumption of 2us for SCS = 15kHz is scaled to SCS =120kHz, mTRP area would be limited to 35m region relative to the center position between TRPs (assuming perfect NW timing sync). In this case there will be very small fraction of UEs that can benefit mTRO with current restrictions. We, therefore, propose to consider this scenario in Rel-18 .

Specify TA enhancement to support asynchronous M-TRP scenario in the UL; study and specify if needed DL enhancements to support the asynchronous M-TRP scenario

6 – vivo Communication Technology

Currently the scope of area 2 is too big, we are ok with first bullet where the intention is to extend Rel-17 TCI framework to MTRP. On third bullet, for latency reduction, one straight forward enhancement is to remove artificial latency on **MAC CE based TCI state activation**

7 – Apple GmbH

Overall, the scope of current Rel-18 MIMO is very large. We feel that downscope might be needed.

For us, our highest priority is

1. Third bullet, i.e., overhead and/or Latency reduction with UE-initiated beam management/beam acquisition procedures
2. First bullet, Extension of Rel-17 Unified TCI framework, but focusing on Multi-TRP

8 – Asia Pacific Telecom co. Ltd

We share other companies views that down-scope may be needed. Our first preferences are the first bullet and the third bullet. OPPO's revision is OK to us.

9 – SHARP Corporation

We support the 1st and the 3rd bullets.

If the down-scope is applied, the 2nd bullet is a low priority from our perspective.

10 – AT&T

Support the moderator proposal on the enhancements in this area.

11 – InterDigital France R&D

Unfortunately, we don't see much change in the new proposal for Area2. We would like to re-iterate our concern that Area2 is extremely heavy and time consuming. In fact, it is three different work topics packed under one item. Given the limited expected allocated TUs, we cannot support Area2 in its current form, and a real down-scoping should be done.

Some comments for each topic;

- For extension of TCI framework, as also mentioned by other companies, we are not sure about the benefit and usefulness of the extension of TCI framework to inter-band.
- For CJT, we still have concern about the workload and the scope. The current scope is vast and not clear on many fronts. Before proceeding, we need to clarify several aspects, for example, whether the enhancements are for synchronous/asynchronous networks, TDD or FDD, UL or DL, etc. On another point, interference avoidance has been always an objective in MIMO transmission, but it can be done in many forms, e.g., UE-based, NW-based, UL/DL, inter/intra, etc., however it is not clear to us which direction is intended here.
- For third topic, we are ok with the current formulation.

12 – Verizon UK Ltd

Support moderator's proposal.

13 – NTT DOCOMO INC.

We are fine with the 1st bullet.

For the 2nd bullet and 3rd bullet, we think the 3rd bullet should have higher priority than the 2nd bullet. And we're okay to say 'specify' for the 3rd bullet.

- ~~Study, and if justified,~~ Specify overhead and/or Latency reduction with UE-initiated beam management/beam acquisition procedures

14 – ZTE Corporation

Regarding 'extend Rel-17 unified TCI framework', we can support the current formulation.

Regarding C-JT/D-MIMO, we think we need to consider how to enhance CSI codebook for TDD, e.g., UE-assisting phase calibration among >= 2 TRPs. Besides for the increase of DMRS ports, we think that the improvement on SRS capability, e.g., TD-OCC, is essential herein (e.g., for CSI acquisition). Finally, thanks to some replies from the proponent company, we are open to 'spatial domain interference avoidance' for further study. Please review the following update

- **Study, and if justified, specify enhancement for Coherent-JT/D-MIMO for both FDD and TDD targeting FR1, including e.g., CSI codebook, CSI reporting, SRS capacity (e.g., by TD-OCC), spatial domain interference avoidance, and larger number of orthogonal DL DMRS ports**

Regarding beam management, we are fine with the current formulation from moderator. If we would like to go with Samsung's version, we think that beam activation should be considered as another popular solution in Rel-17, where gNB response can be achieved by DCI based TCI indication transparently.

"***Study, and if justified, specify UE -initiated beam selection/activation based on event-triggered and/or NW-configured reporting***"

15 – CAICT

We can support moderator's proposal.

16 – Futurewei

We are in general ok with moderator's proposal.

As we commented in the previous rounds, to resolve the issue of handling intercell interference and obtain the promised gain from the massive number of antennas, we have proposed a spatial-domain interference avoidance approach via Bi-directional Training (BiT), where DL interference probing and mitigation based on semi-statically coordinated SRS resources among gNBs is employed in TDD, which provides significant performance gain (e.g., please see RP-212456). Please note that compared to the conventional Coherent-JT, BiT requires no or little information exchange between the cooperating gNBs and the DL transmission is from one single transmission point, therefore the synchronization requirement among transmission points can be relaxed.

The standard impact of BiT are mainly SRS enhancements with dynamically indicated parameters associated with corresponding DL transmissions. Further study can be done for various flavors of cooperative MIMO technologies with different assumptions on backhaul, coordination, and transmission schemes among TRPs, etc.

Therefore, we are strongly supportive of including "spatial domain interference avoidance" as in the moderator's proposed objectives.

17 – Qualcomm Incorporated

We support the first bullet (extension of unified TCI).

We do not support the second bullet (coherent JT). The second bullet, as commented by others, would require a separate SID. We suggested before to limit the scope and include only clear objectives if companies are serious about this enhancement. However, it still seems that this second bullet will be a massive study item for a scheme that can be done transparently today. Hence, we propose to remove the second bullet, and instead, focus on more important areas. From the previous rounds of discussions, we actually see a large number of companies including some operators do not support this enhancement.

We support the third bullet (overhead and latency reduction), in particular, we are ok with reducing the scope to UE initiated BM, which is supported by the majority. Would like to note that our view on the latency/OH reduction in beam management was not captured correctly in the Moderator's summary for the intermediate round. We haven't expressed concern on the 3rd bullet (BM).

18 – Nokia Corporation

Unfortunately we are not OK with the proposal for this area. Adding "Study and if needed..." doesn't reduce the workload, in fact it might increase it, given that companies are then expected to spend more time with evaluations of possible directions instead of a more focused specification work.

We see potential for narrowing further the scope on 1st and 3rd bullets, as expressed by several companies above. As for the second bullet, if companies really want to discuss it further it should be done as a separate SI/WI from the main one addressed in this thread, as it is very large and encompassing many different aspects of MIMO operation. We can then decide if we do work on DL+UL MIMO or C-JT, as we don't see it possible to do both in Rel-18. We anticipate that our strong preference is to improve UL performance in Rel-18, as expressed by vast majority of companies during June workshop.

Finally, much more important is to address the objective mentioned by Intel above, and which we copy here:

Specify TA enhancement to support asynchronous M-TRP scenario in the UL; study and specify if needed DL enhancements to support the asynchronous M-TRP scenario

19 – Motorola Mobility UK Ltd.

Lenovo, Motorola Mobility :

For extension of Rel-17 unified TCI framework, we are generally ok but prefer to clearly state or have a note mentioning that "**multi-TRP scheme includes multi-TRP schemes supported in Rel-16/17**". We are supportive of including single-TRP schemes which can be beneficial specially for the scenario of multi-DSCH/PUSCH scheduling from single TRP.

For CJT/DMIMO, our preference is to down prioritize the proposal. The current scope of the proposal is very large, as it includes enhancements to codebook design, CSI reporting, spatial domain interference avoidance (SRS enhancements?), as well as DMRS enhancements. At least "spatial domain interference avoidance" which appears to be a specific solution proposed by one company, can be discussed in the study phase as part of CSI measurement/reporting and does not need to be explicitly included in the objective.

For beam management objective on the overhead and/or latency reduction, we propose to include all the scenarios for this objective, for example,

Study, and if justified, specify enhancements for overhead and/or latency reduction with:

- **UE-initiated beam management**
- **Event-trigged /beam acquisition procedure**
- **Grouping/sharing based beam measurements and reporting**

20 – Fraunhofer IIS

We support the first bullet with a focus on M-TRP. We prefer to remove "inter-band" from the proposal.

As commented in the previous rounds and by many others, the workload for C-JT/D-MIMO is very high and would require a separate SID. Moreover, it remains unclear which deployments are focused (indoor, outdoor or both) and whether the enhancements are for synchronous or asynchronous networks. As one of the main targets of R18 is UL-related enhancements, C-JT/D-MIMO should be of low priority for R18.

We support the moderator's proposal related to the third bullet.

21 – CATT

The scope for Area 2 is still too large. We are supportive to study and specify C-JT in this area only. The remaining two items (i.e., the first and third bullets), if needed, should be discussed separately.

22 – Beijing Xiaomi Mobile Software

- For the first sub-objective, we support it and suggest to update "single-TRP and Multi-TRP schemes" to "single-DCI and multi-DCI schemes"
- For the second sub-objective, we are generally OK with this one.
- For the third sub-objective, we support it. And in addition to UE-initiated beam management/ beam acquisition procedures, we also prefer to include beam measurement/reporting via RACH for initial access.

23 – LG Electronics Inc.

Like many other companies, we also feel that the scope of Area2 is too large. Some suggestions for each bullet as below:

• **Extended unified TCI**: we suggest to remove **e.g.** to preclude diverged proposals other than the extension to multiple TCI.

• **Coherent-JT**: as commented earlier, current wording would mean that we need to study all the exemplary solutions/areas which covers too large scope. What needs to be enhanced for coherent-JT can be discussed during the study phase, so we suggest to remove 'including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports'. Another comment is that the difference between Coherent-JT and D-MIMO is unclear to us. As Coherent-JT was well defined since LTE, we suggest to remove 'D-MIMO' to avoid confusion.

• **BM latency/overhead reduction**: as commented earlier, this item needs to be a low priority item.

24 – Huawei Tech.(UK) Co.. Ltd

We are generally supportive of the proposal. We propose that the second bullet be changed to "specify". We saw that several companies provided their priorities. If there is a need to down-scope we would support keeping the second bullet only.

25 – NEC Corporation

We still slightly prefer to remove or to limit CJT enhancement objectives.

We support remaining objectives in the proposal.

26 – MediaTek Inc.

Unified TCI framework extension: We support the work. We would like to constrain possible configurations if possible. We think one aspect is to limit the max values allowed for M and N (e.g. max 2). We also believe the main justification is for M-TRP. If we consider S-TRP we would not like that to add more complexity.

C-JT/D-MIMO: This proposal is still very vague in our view. There have been requests to refine scope, but it seems that supporters are not in agreement on whether the focus is C-JT or some form of point selection. It is not clear to us how the term ”D-MIMO” is constraining the work as it seems unclear what it is. Despite a lack of alignment on the scenarios, some basic scenario assumptions are unclear: number of TRPs assumed (these should be no more than defined for existing M-TRP), whether the TRPs are perfectly synchronized or not (we believe they should be). So we still see this overall work as low priority.

UE-initiated beam management: We support the moderator proposed objective as is.

P.S.: We would NOT support adding back the asynchronous M-TRP simultaneous DL reception for the reasons mentioned in previous rounds.

27 – CEWiT

We are fine with the Moderator’s proposal.

28 – Spreadtrum Communications

We are generally OK with moderator’s proposal. Agree with some other companies that further down scoping is needed.

29 – China Mobile Com. Corporation

First bullet: As mentioned by many companies, the extension of Rel-17 Unified TCI framework can focus on M-TRP with existing transmission schemes. Intel’s revision is fine to us.

Second bullet: We support to consider C-JT in Rel-18 for promising benefits. For “spatial domain interference avoidance”, we agree with Lenovo,Motorola that not to explicitly included it in the objective or replace it with ”SRS enhancement with spatial domain interference avoidance”.

Third bullet: We’re ok to say ‘specify’ for the 3rd bullet.

30 – Ericsson LM

Support area 2 as priority 2 item. We classify this area with Priority 2 since it contains useful and urgent feature components. However, the scope is currently too large and needs to be reduced.

We support to extend the unified TCI framework to M, N>1. Note that this would be required to support simultaneous UL multi-panel transmission.

C-JT/D-MIMO should have low priority, since the degraded DL MIMO performance due to mobility (addressed in Area 1) needs to be resolved first, before it make sense to introduce this feature. Even if several operators are positive to an evolution towards C-JT, we believe that an even larger number of operators, who have invested in massive MIMO products more urgently need enhancements that fix the UE speed

issue with MU-MIMO. Hence, Area 1 has clear priority and the C-JT enhancement should, if included, have limited and relevant scope such as only for intra-site C-JT.

The increase of number of DMRS ports is a relatively small enhancement but with direct impact to current massive MIMO products and current limitations in uplink MU-MIMO operation. Note that DMRS port increase for PUSCH is unrelated to C-JT/D-MIMO and does not fit under multi-TRP. A UE should not need to support C-JT to support additional PUSCH DMRS ports or PDSCH DMRS ports. It should therefore be a stand-alone objective or it can be moved to an objective that better suits the use case, such as unified TCI framework or Area 4.

We support the moderator's attempt to narrow down the scope of the last sub-bullet. During the Rel-17 discussion, it has become clear that 'UE-initiated' may mean different things. We propose to narrow it down and clarify the scope even further:

- **Study, and if justified, specify overhead and/or Latency reduction with event-driven beam reporting.**

31 – China Unicom

Specifying enhancements for CJT is high priority for us, which brings benefits to system performance and capacity for both indoor and outdoor scenarios. And TDD related enhancements (e.g. SRS enhancements) should also be considered in the scope.

32 – China Telecommunications

We support the moderators's proposal.

4.3 Proposal for Area 4 after intermediate round

– **Study, and if justified, specify [CW mapping, UL DMRS, SRS and CSI acquisition, etc.,] to enable 6 and 8 Tx UL operation, to support more than 4 layers per UE in the UL targeting CPE/ FWA/vehicle/Industrial devices**

Feedback Form 19: Comments on Proposal for Area 4 after intermediate round?

1 – Samsung Research America

Comment: Support moderator's proposal with the following wording change (since there is no consensus in supporting >4 layers, the maximum number of layers per UE should be kept open): "**Study, and if justified, specify [CW mapping, UL DMRS, SRS and CSI acquisition, etc.,] to enable 6 and 8 Tx UL operation, ~~to support more than 4 layers per UE in the UL~~ targeting CPE/ FWA/vehicle/Industrial devices**"

As for the text inside the brackets, it is understood that the scope (and the wording of the objective) for Area 4 still need to be worked on to ensure that the Rel-18 scope is reasonable.

2 – Guangdong OPPO Mobile Telecom.

Not sure why CSI acquisition is included here. CSI acquisition is usually related to DL MIMO, rather than UL MIMO. Thus, we suggest the following proposal

- Study, and if justified, specify [CW mapping, UL DMRS, SRS ~~and CSI acquisition~~, etc.,] to enable 6 and 8 Tx UL operation, to support more than 4 layers per UE in the UL targeting CPE/ FWA/vehicle/Industrial devices

3 – Xiaomi Communications

same view as Oppo's comment, CSI acquisition is not included here.

4 – VODAFONE Group Plc

Since there is no consensus on the number of layers, suggest splitting it as a separate bullet rather than removing it all together:

- **Study, and if justified, specify [CW mapping, UL DMRS, SRS and CSI acquisition, etc.,] to enable 6 and 8 Tx UL operation, targeting CPE/ FWA/vehicle/Industrial devices**
- **Study, and if deemed feasible, specify support for more than 4 layers per UE in the UL**

5 – Intel Corporation (UK) Ltd

As we commented in the previous round the currently proposed scope is very big.

1. We don't expect many devices to support > 4Tx, therefore, RAN1 should be more focused on aspects feasible/friendly for implementation, i.e., codebook-based operation with non-coherent (possible partial-coherent) codebook subset and full power transmission.

2. Given there is no 8 layers requirement for DL in RAN4, more than 4 MIMO layers is not urgent to address for UL in Rel-18 . RAN1 can come back to this issue in later releases, e.g., after RAN4 defines support of 8 MIMO layers in DL.

3. We don't see strong need / priority to define more than 1CW in UL.

- For sTRP, UE (e.g., non coherent and with Tx antenna power imbalance) can use fixed unitary virtualization, e.g. based on DFT or CDD to equalize the signal quality between Tx antennas. In this case there will be no puncturing issue
- For mTRP (if included in Rel-18 scope), NW would support mDCI offering required flexibility of using different MCS and Tx power for different TRPs. We don't think sDCI should be considered for optimization and likely to be worse due to common Tx power across all MIMO layers.

Updated wording of the objective is provided below:

Study, and if sufficient gains are shown ~~justified~~, specify ~~[CW mapping, UL DMRS, SRS and CSI acquisition, etc.,] to enable~~ 6 and 8 Tx UL operation focusing only on non-coherent codebook-based UL transmission (including full power modes), to support up to ~~more than~~ 4 layers per UE in the UL targeting CPE/FWA/vehicle/Industrial devices

6 – vivo Communication Technology

We are ok to limit the suported transmission layers to 4. To further restrict the scope of this area, assumption on antenna structure, coherence should be added.

7 – Apple GmbH

The scope of this bullet is too large for Rel-18 MIMO. We think this should be a low priority item. Furthermore, NR already supports up to 4 layers PUSCH operation, and it is transparent to the specification on how many Tx/PA that UE uses. If there is anything that needs to be specified or studied, it should be the support of > 4 layer PUSCH operation.

8 – SHARP Corporation

We are supportive of the moderator's proposal, and our preference is to include more than 4-layer PUSCH operation for CPE/FWA/vehicle/Industrial devices.

9 – AT&T

Support this proposal. Whether to specify more than 4 layers can be part of the study phase.

10 – InterDigital France R&D

The new proposal is polished and objective, however it remains heavy and its workload should be considered carefully. Given the clarity of the proposal, we can support it.

11 – Verizon UK Ltd

Support the proposal and open to consider limiting the layer to 4, no objection to >4.

12 – NTT DOCOMO INC.

We're generally fine with the proposal. For the content in the brackets, we think the scope for 'specifying' can be determined/revised after 'study'. With such understanding and the wording of 'etc.' in the brackets, we're okay to remove the brackets.

13 – ZTE Corporation

Support the moderator's proposal in principle, and this enhancement has our high priority.

First of all, we do think that to support more than 4 layers per UE is very essential if having >4 Tx; otherwise, the performance gain introducing by >4 Tx will be degraded severely. So, the restriction of 'up to 4 layers' proposed by some companies is unacceptable for us.

Then, regarding comments on 'CSI acquisition', if our understanding is correct, the motivation of this part is relevant to *UL* CSI acquisition.

After then, regarding restriction on 'non-coherent UE' only, it is quite confusing to us, due to the fact that how to achieve 4 or more UL layer transmission purely based on non-controllable precoding, and handle the inter-layer interference. It seems not to make sense.

Based on above, we can support the guidance from the moderator about the detailed objectives. Please review the following minor update:

- **Study, and if justified, specify ~~[~~enhancements on >1 CW mapping, larger number of orthogonal UL DMRS ports, SRS and UL CSI acquisition, UL codebook for CB, and SRS-resource-combination for NCB~~, etc.,]~~ to enable 6 and 8 Tx UL operation, to support more than 4 layers per UE in the UL targeting CPE/ FWA/vehicle/Industrial devices**

14 – Lenovo (Beijing) Ltd

To the moderator: our comments in the intermediate round was to support up to 8 TX antennas, not 8 layers. The maximal number of layers shall be determined by the study.

We agree with OPPO that CSI acquisition shall be removed. For UL, SRS serves the purpose of CSI acquisition and needs to be enhanced for >4 ports. The maximal number of layers supported shall be part of the study. Given CW mapping is now part of 4.6 "Area Others", we can leave it out of this proposal. We propose to amend the text to

· **Study, and if justified, specify [~~CW mapping~~, UL DMRS, SRS ~~and CSI acquisition,~~ etc.,] to enable 6 and 8 Tx UL operation, to support ~~more than 4~~ up to X layers per UE in the UL targeting CPE/ FWA/vehicle/Industrial devices.**

15 – Futurewei

We are in general ok with the direction of the proposal. However, regarding the 6 TX UL operation, it is unclear to us the motivation and the usage scenario for this case. Compared to 8 TX, the 6 TX case requires much more standardization effort, e.g., a new codebook design is necessary whereas for 8 TX case, the DL codebook design could be reused, We also suggest adding "enhancement to" after "specify" to make the proposal clearer.

Study, and if justified, specify enhancement to [CW mapping, UL DMRS, SRS and CSI acquisition, etc.,] to enable ~~6 and~~ 8 Tx UL operation, to support more than 4 layers per UE in the UL targeting CPE/FWA/vehicle/Industrial devices.

16 – Qualcomm Incorporated

We do not support the current version of the objective for the reasons mentioned in the previous rounds. The current wording of the objective seems defining the scope of this study only for ">4 layers". We would be supportive of the proposed objective with the following update:

- **Study, and if necessary, specify >4 Tx UL operation, e.g., to support more than 4 Tx (with up to 4 layers) ~~layers~~ per UE in the UL for CPE/ FWA/vehicle/Industrial devices**

Furthermore, we don't see the need to list examples such as "UL DMRS, SRS and CSI acquisition" for now. If we start to list examples, the most important one "precoder codebook" for >4 Tx seems missing in the list.

17 – Nokia Corporation

We are fine with the scope in general, but it needs to be revised to remove the CSI part as well as leave the number of layers for further study and decision in the WID.

18 – TELECOM ITALIA S.p.A.

We are fine with the moderator's proposal, and are ok to remove the square brackets, being the list an example.

If it helps the discussion, we are also ok with Vodafone to split the bullet in two sub-objectives

19 – Spreadtrum Communications

Support the proposal in principle. We think supporting more than 4 layers is the key motivation of this proposal. if it's only for up to 4 layers with 6/8Tx, non-codebook based UL Tx can be reused without RAN1 impact. Regarding the examples in bracket, they are only valid if 'more than 4 layers' is kept.

20 – CATT

Support the proposal in general. We think more than 4 layers is necessary in the scope.

Regarding comments on CSI acquisition, we also think it is not clear. If it is UL CSI acquisition, it can be removed or change "**SRS and CSI acquisition**" to "**SRS ~~and~~for UL CSI acquisition**" since the purpose of enhancements for SRS is for UL CSI acquisition. If it is for DL CSI acquisition, its purpose would not be "to enable 6 and 8 Tx UL operation, to support more than 4 layers per UE in the UL targeting CPE/ FWA/vehicle/Industrial devices", we can add a new bullet for enhancements of SRS for antenna switching with up to 8 Tx.

21 – LG Electronics Inc.

Support in principle, but agree with OPPO that CSI acquisition needs to be removed.

22 – Huawei Tech.(UK) Co.. Ltd

We are generally fine with the proposal. Enabling 6Tx and 8Tx UL operation is in itself sufficient without over-optimizing the feature, so RAN1 should be careful about the targeted enhancements given that there will likely not be many TU for each objective in this WI. For example, reusing DL CW-to-layer mapping should be sufficient.

23 – NEC Corporation

Support the proposal for FR1 only.

24 – CEWiT

We are fine with the Moderator's proposal.

25 – China Mobile Com. Corporation

We do not think much gain can be achieved if it's only for up to 4 layers.

Our preference for UL MIMO enhancement is Area5>Area 4>Area 6.

26 – Ericsson LM

Overall, we think area 4 has priority 3.

Similar to other companies' comments, we think it is sufficient to list SRS enhancement rather than SRS and CSI acquisition, since SRS for UL CSI (rather than SRS for DL CSI) should be prioritized for UL MIMO purposes.

Codebooks will also need to support 6 & 8 Tx.

Regarding the number of layers, we prefer to have more than 4 layers kept as in the current proposal. It is not obvious to us that a new codebook design will bring sufficient gain on its own.

As we commented earlier, it is important to have clear use cases, and so we should clearly define what CPE/ FWA/vehicle/Industrial devices are. So we suggest to put square brackets (i.e. [CPE/ FWA/vehicle/Industrial devices]) if more detailed formulations are not suitable at this stage. Overall, we suggest then:

- **Study, and if justified, specify [CW mapping, UL DMRS, SRS, and codebooks, ~~and CSI acquisition~~, etc.,] to enable 6 and 8 Tx UL operation, to support more than 4 layers per UE in the UL targeting [CPE/ FWA/vehicle/Industrial devices]**

We agree with moderator that this will require a lot of effort, and we should downscope where feasible. However, its benefits and commercial interest are more immediately clear to us as compared to proposals 5 & 6.

27 – MediaTek Inc.

We support the general direction, but we think the current version of the objectives is misleading with the specific components added. We also think 4 layers makes sense to consider. See update below:

- **Study, and if justified, specify ~~[CW mapping, UL DMRS, SRS and CSI acquisition, etc.,] to enable~~ 6 and 8 Tx UL operation with~~, to support more than~~ 4 or more UL layers per UE in the UL targeting CPE/ FWA/vehicle/Industrial devices**

4.4 Proposal for Area 5 after intermediate round

- **Support for simultaneous multi-panel UL transmission for higher UL throughput/reliability**
- **Study, and if justified, specify features to support panel-specific UL transmission, e.g. panel-specific timing/power control for multi-TRP scenario**

Feedback Form 20: Comments on Proposal for Area 5 after intermediate round?

1 – Samsung Research America

· Sub-objective 1: While we are supportive of this, some assessment on the benefit is needed (also including feasibility and scenarios). Therefore, we propose the following wording refinement: "**Study, and if justified, specify features to facilitate ~~Support for~~ simultaneous multi-panel UL transmission for higher UL throughput/reliability**"

· Sub-objective 2: It is now understood that the purpose of this rewording is to narrow down the scope to panel-specific TA/PC (of which we are supportive). Therefore, we propose the following wording refinement: "**Study, and if justified, specify ~~features to support panel-specific UL transmission, e.g.~~ panel-specific timing/power control for UL multi-TRP/panel scenario**"

2 – Guangdong OPPO Mobile Telecom.

We support the 1st bullet

Regarding the 2nd bullet, We support Samsung's version.

3 – VODAFONE Group Plc

Prefer Samsung's versions for both bullets.

4 – Intel Corporation (UK) Ltd

For the second bullet. Different TAs is due to transmission to different TRPs, i.e. is also essential for single panel UE for uplink transmissions targeting different TRPs in TDM. Suggest to add "beam-specific/panel-specific" or remove "panel-specific". Proposed wording is provided below:

Study, and if justified, specify features to support beam-specific/panel-specific UL transmission, e.g. beam specific/panel-specific timing/power control for multi-TRP scenario

5 – Intel Corporation (UK) Ltd

We would like to repeat our comment. There is overlap with Area 5. To avoid conflicting discussions, we propose to focus FS precoding on 4Tx and codebook based precoding in Rel-18. More than 4Tx can be addressed in later releases. There is also no need to consider FS precoding for non-coherent UEs.

- **Study, and if ~~necessary,~~ sufficient gain as shown, specify frequency-selective precoding~~, mainly targeting devices with >=4 Tx~~ for codebook based PUSCH transmission with 4Tx partial and full coherent UEs.**

6 – vivo Communication Technology

The first bullet should be "study, if needed", and it should be clarified whether simultaneous multi panel UL transmission means same channel or different channels (i.e. PUSCH+PUSCH or PUSCH+PUCCH), and it should also be clarified total number of simultaneous Tx antennas.

7 – Apple GmbH

We are against and cannot accept both bullets.

1. First bullet, currently, specification does not support UL panel switching in the explicit way. There is no reason we jump to the simultaneous multi-panel UL transmission

2. To certain extend, panel-specific power control is already supported in Rel-17. We do not support anything related to panel-specific TA since it is not useful in the deployment

8 – Asia Pacific Telecom co. Ltd

We support Moderator's proposal and Samsung's revision as well.

9 – SHARP Corporation

We support Samsung's revision.

10 – AT&T

Support the moderator's proposal.

11 – InterDigital France R&D

Despite our interest for the item related to fast UE panel selection, we support the compromised proposal by the Moderator.

As expressed in our earlier comment, the topic under Area5 is very relevant for enhanced reliability and performance of FR2 operation.

12 – Verizon UK Ltd

Support moderator's proposal and Samsung's rewording.

13 – NTT DOCOMO INC.

Although we think panel-specific UL transmission is also important, we can accept current version.

14 – ZTE Corporation

We support the moderator's compromise proposal that points to a good way-forward direction. In our views, simultaneous multi-panel UL transmission should be considered with high priority, and after it is stable, we can further review fast panel selection.

Then, Samsung's updated version seems good as clarification.

15 – Xiaomi Communications

we support moderator's proposal and Samsung's revision. Simultaneous multi-panel/multi-TRP transmission is high priority to us

16 – Lenovo (Beijing) Ltd

For the first bullet, we support the moderator's proposal, but we think it should be limited to simultaneous transmission of the same channel/signal.

For the second bullet, we support Samsung's amendment.

17 – Futurewei

We are in general ok with moderator's proposal. We are also ok with Samsung's revision.

18 – Qualcomm Incorporated

We support the two objectives in principle.

For the second bullet, as previously commented by some companies, panel-specific power control for multi-TRP scenario is already possible in Rel-17. For the panel-specific timing enhancement, for mTRP, we suggest limiting the scope to multi-DCI based multi-TRP as explained before. In addition to mTRP, we also prefer to include sTRP, since this can also be applicable to sTRP operation, e.g. inter-cell BM. Hence, we suggest:

- **Study, and if justified, specify features to support panel-specific UL transmission, e.g. panel-specific timing~~/power control~~ for multi-DCI based multi-TRP scenario, as well as for sTRP operation, e.g. for inter-cell BM**

19 – Nokia Corporation

We support this area in general, and we prefer Intel's formulation.

20 – TELECOM ITALIA S.p.A.

We are in general ok with moderator's proposal. We are also ok with Samsung's revision.

21 – CATT

We are supportive of simultaneous multi-panel UL transmission and we think panel-specific timing/power control for M-TRP scenarios is not necessary. In Rel-17, panel-specific power control for M-TRP scenario is implicitly supported since TRP-specific power control is supported and the repetitions for M-TRP are transmitted in different slots/sub-slots.

22 – LG Electronics Inc.

Support the moderator's proposal. We don't prefer to add 'beam-specific' as Intel suggested because it may unnecessarily allow too many different TA values, e.g. one TA per beam. To our understanding, whether/how to specify 'panel' in specification can be further discussed during the WI. Regarding QC's proposal to limit UL synch enhancement to multi-DCI mTRP, we don't see any relation between UL synchronization and specific mTRP mode of operation, e.g. multi-DCI or single DCI. So, we prefer not to limit to multi-DCI mTRP only.

23 – Fraunhofer IIS

We only support to study simultaneous multi-panel UL transmissions. In our view, panel-specific power control is already possible in R17.

24 – Huawei Tech.(UK) Co.. Ltd

As commented before, we can only agree to have simultaneous multi-panel UL transmission and UL panel selection considered at the same level, i.e. both with a study, or both to directly specify.

25 – NEC Corporation

Support the proposal.

26 – CEWiT

We are fine with the Moderator's proposal, with the second bullet as proposed by Samsung

27 – China Mobile Com. Corporation

We support the proposal and Samsung's revision as well

28 – Ericsson LM

We think area 5 has priority 5 with the current formulation.

We do not support the current proposal. The formulation needs to change to make this more useful. The first bullet needs to be studied first and should be moved to Area 2, since it is related to extending Unified TCI state framework to N>1. The second bullet is here limited to FR2 since it focuses on panels, however it should be applicable to FR1 as well.

- It is premature to state simultaneous multi-panel UL transmission should be specified. This needs to be studied first. In addition, there is a very strong connection to area 2 – simultaneous multi-panel UL transmission will rely on that the unified TCI framework is extended to N>1. Only after such extension has been completed, simultaneous multi-panel UL transmission can be specified.
- Extensions to power control and timing in an mTRP scenario need to be supported also for UEs without panels, e.g., in FR1. Making it dependent on UEs with multiple panels is too restrictive. Note that separate timing (power control) is needed also when the UE only transmits to one TRP at a time. As we commented in the intermediate round, this is better discussed in area 2

29 – MediaTek Inc.

Simultaneous UL transmission: We do NOT support for the reasons of operational complexity vs highly dubious realistic performance gain/applicability that we highlighted previously.

We believe that the fast panel selection leftovers from Rel-17 are more useful and widely applicable.

Panel-specific UL transmission: We do not see a strong motivation for the proposed components of this objective but, if agreed, would like clarification that the UL different TA/power control is 1) not for simultaneous UL transmission, and 2) not assuming asynchronous DL simultaneous reception by the UE, and 3) no more than 2 TA/power control instances enabled.

30 – KDDI Corporation

We suppo
rt the moderator's proposal.

4.5 Proposal for Area 6 after intermediate round

– **Study, and if justified, specify frequency-selective precoding and wideband high resolution precoding targeting devices with >=4 Tx**

Feedback Form 21: Comments on Proposal for Area 6 after intermediate round?

1 – Spark NZ Ltd

Spark NZ

It seems that no note thas been taken about our previous comments by the moderator as we said some channels in bands do not support a rank of 4 or larger.

2 – Samsung Research America

As commented earlier (also by other companies), albeit the potential gain in UL throughput, the benefit depends heavily of DL control signal design and overhead.

At least one other company commented on disassociating this with Area 4. While the comment is well intended, it is practically impossible to do so unless Area 4 and 6 are done in separate releases (in tandem). It is technically sound, for instance, to complete Area 4 first (under the assumption of frequency non-selective precoding) before Area 6 (now assuming 2, 4, 6, and 8Tx with the codebooks ready in addition to SRIs).

Since there is lack of urgency, we recommend that **Area 6 be assigned low priority or, justifiably, opted out from Rel-18 MIMO** (considered for future releases when the need becomes clear, and after Area 4 is completed).

3 – Guangdong OPPO Mobile Telecom.

Support the proposal in principle. It would be better to only consider >4Tx, rather than >=4 Tx

4 – Intel Corporation (UK) Ltd

We would like to repeat our comment. There is overlap with Area 5. To avoid conflicting discussions, we propose to focus FS precoding on 4Tx and codebook based precoding in Rel-18. More than 4Tx can be addressed in later releases. There is also no need to consider FS precoding for non-coherent UEs. Wideband high-resolution is not in the scope of this area and should be considered as separate proposal.

- **Study, and if ~~necessary,~~ sufficient gain as shown, specify frequency-selective precoding ~~or wideband high resolution precoding targeting devices with >=4 Tx~~ for codebook based PUSCH transmission with 4Tx partial and full coherent UEs.**

5 – vivo Communication Technology

We are fine with moderator's wording.

6 – Apple GmbH

The scope of Rel-18 MIMO proposal is way too large at this stage. Initially, the proposal only contains frequency selective precoding. Now we also add the high resolution TPMI. We think even if we include this bullet, the scope of the bullet has to be reduced, by picking either one of the two.

7 – AT&T

As commented earlier, while we see the potential benefits of frequency selective precoding for UL throughput, we do sympathize that this item can be given a lower priority considering the work load of other MIMO enhancement areas, and can be revisited after enhancements in area 4 are completed.

8 – InterDigital France R&D

We have a couple of comments for this item. First, the proposal should indicate that this feature is intended to support only CP-OFDM. Second, we do not agree with the addition of high-resolution WB precoding. Its inclusion in the work item description will increase the work load and divert the original motivation of the work that is support of frequency selective precoding. Furthermore, it is not clear to us whether high-resolution WB precoding can offer any again over frequency-selective precoding for >4TX.

We agree with other companies comment that a fixed DCI payload should be considered, and we suggest this to be captured in the proposal. We would like to emphasize that the scope of the proposal should be limited to efficient support of sub-band precoding using the existing codebook, and no enhancement on UL codebook would be included in the this sub-agenda.

9 – NTT DOCOMO INC.

The meaning of '**wideband high resolution precoding**' and its relationship with frequency-selective precoding is not clear, which should be clarified.

10 – ZTE Corporation

In general, it may be considered as a sub-bullet in Area 4, if agreed.

We are open to consider this proposal but which may not be urgent. If we have to narrow down the MIMO scope, we can live without this Area 6.

11 – Lenovo (Beijing) Ltd

We think the scope of this is too big. Wideband high resolution precoding should be deprioritized in R18. We would like to reiterate our comments in the previous round regarding studying the tradeoff between the UL throughput and the DL overhead. Additionally, we prefer it is made clear that the study for frequency selective precoding for >4Tx shall be conducted after the conclusion of the study phase for >4Tx support conducted in Area 4.

12 – Xiaomi Communications

We support moderator's proposal. We are also fine if this would be a sub-bullet for Area 4.

13 – Futurewei

We are in general ok with moderator's proposal.

14 – Qualcomm Incorporated

While we agree with the revision of the objective, we are also ok with removing it.

15 – Nokia Corporation

We are fine with this objective. As for some comments above that the WID is too large, we agree with that, but we also believe priority needs to be given to UL enhancements in Rel-18, instead of the large enhancements proposed in area 2, for example.

16 – Spreadtrum Communications

Wideband high resolution precoding is a separate topic and will bring lots of spec work. Therefore, we suggest to remove it. Comparing with Area 4, we think Area 6 should have lower priority, and we are OK to remove Area 6, if necessary.

17 – TELECOM ITALIA S.p.A.

In general ok with moderator's proposal.

Strongly support the comment that if the scope is too large, priority should be given to UL enhancements.

It was not clear, but much better to have two separate activities (one for DL and one for UL)

18 – CATT

We are supportive of frequency-selective precoding for >= 4Tx. Since the load of Rel-18 UL MIMO is already very large, we'd better not to expand the scope any more. Therefore we prefer to remove "wideband high resolution precoding" in the scope.

Regarding the relationship of Area 6 and Area 4, we think Area 6 should not be a sub-bullet for Area 4 since it involves enhancement for 4Tx.

19 – LG Electronics Inc.

Firstly, we don't prefer to add additional scope, i.e. wideband high resolution precoding which has not been included in the endorsed scope. Secondly, we share with Samsung and AT&T's comment that this can create some complicated interaction with Area4 discussion, and needs to be handled after completing Area4.

20 – Fraunhofer IIS

We support to study frequency selective precoding and do not see the need to include wideband precoding in the proposal. It should be clear in the objective if the intention is to apply it for codebook or non-codebook or both.

21 – CAICT

We support moderator's proposal.

22 – Huawei Tech.(UK) Co.. Ltd

Enhancements on frequency selective precoding and wideband high resolution precoding are opposite enhancement directions for UL precoding. It is not make sense to include the both in R18. We could be supportive for the frequency-selective precoding. Intel's formulation seems ok.

23 – NEC Corporation

Support the proposal for FR1 only.

24 – CEWiT

We are fine with the Moderator's proposal.

25 – China Mobile Com. Corporation

Given the heavy workload, we are okay to take Area 6 as low priority.

26 – Ericsson LM

We think area 6 has priority 4.

We suggest this be clarified with "frequency-selective precoding <u>and/or</u> wideband high resolution precoding", so that it is clear that both may not be specified.

Regarding the proposal to exclude non-coherent UL MIMO from frequency selective precoding, we disagree. Non-coherent UL MIMO is typically easier to specify, and is the most widely (if not solely) used NR UL MIMO in networks today.

As stated in area 4, the potential benefits of frequency selective precoding are less clear at this stage. Given the need to downscope, we prioritize this lower than the >4 Tx in area 4, and so rate frequency selective precoding as priority 4.

27 – MediaTek Inc.

We support the moderator proposal.

We do see Area 4 as the relative priority when taking Area 4 and 6 in isolation.

However, (to avoid misunderstanding) we would see Area 5 (assuming current status) as the lowest priority now.

4.6 Proposal for Area Others after intermediate round

- **Alt 1: Support 2 CW for >=2layers in uplink**
- **Alt 2: No Support 2 CW for >=2layers**

Feedback Form 22: Comments on Proposal for Area others after intermediate round? or your preference of the two alternatives?

1 – Samsung Research America

Note that Alt1 can be included in Area 5 since the sole use case is for multi-TRP (in our understanding). Else it can be included in Area 4 if the intention is for >4Tx.

2 – China Telecommunications

We support 2 CW for >=2layers for both DL and UL. If companies have conerns on DL, we can compromise to only UL, i.e., Alt 1.

3 – Guangdong OPPO Mobile Telecom.

We support Alt.1

4 – Xiaomi Communications

We can see the benefit of supporting this feature, the large SINR gap between layers (also identified from real tests) and the inflexibility of CW retransmissions would both degrade the system performance. For the uplink, the enhancements would be simpler than that for the downlink, so it would be good to solve this issue specified as an optional feature for UE implementation. Thus, we can support Alt.1.

5 – Sony Group Corporation

We tend to agree the technical analysis from Xiaomi on why 2 CWs are beneficial for >= 2 layers either in DL or UL.

We prefer to support 2 CWs for >= 2 layers in both DL and UL. But due to the existing concern, we can live with Alt.1 (only from UL).

In addition, if Alt.1 can be acceptable, we think this objective can be absorbed into Area 5, rather than a separated objective.

6 – Intel Corporation (UK) Ltd

We don’t see strong need / priority to define more than 1CW in UL (<= 4 layers).

- For sTRP, UE (e.g., non coherent and with Tx antenna power imbalance, issue mentioned in ZTE tdoc) can use fixed unitary virtualization, e.g. based on DFT or CDD, to equalize the signal quality between Tx antennas and address the issue.
- For mTRP (if included in Rel-18 scope), NW would support mDCI offering required flexibility of using different MCS and Tx power for different TRPs. We don't think sDCI should be considered for optimization since it is likely to provide worse performance due to the same Tx power across all MIMO layers.

Our preference is Alt 2.

7 – vivo Communication Technology

We are ok with alt1 given overall scope is managable.

8 – Asia Pacific Telecom co. Ltd

We can support Alt 1.

9 – InterDigital France R&D

Given the limited available TUs, we support Alt 2.

10 – NTT DOCOMO INC.

We support Alt1 to be included in the WI.

11 – CAICT

We support Alt1.

12 – Lenovo (Beijing) Ltd

Whether to support 2 CW depends on the scenario. For single panel transmission >4 TX antenna, if rank>4 is supported, sending 2 CW can better match with the transmission quality. For simultaneous multi-panel transmission, sending different CW to separate TRPs is also helpful, irrespective of the number of layers. Therefore, between these two alternatives our preference is Alt.1.

13 – ZTE Corporation

We support Alt-1 with our high priority.

Regarding Intel's comments, the type of non-coherent 2Tx UE is only in the market. For 2 layer transmission, only unitary matrix TPMI ([1, 0; 0, 1]) can be used in such case, and it means that UE should equalize power difference between Tx antenna by default. It is impossible to use DFT or CDD (as you suggested) from NW perspective. To be honest, technical speaking, we do not believe that the unitary virtualization can well handle it under this type of Tx imbalance, and we may experience the similar situation as NR design with channel coding + interleaving. Then, for mTRP in Rel-18, it may be up to Area-5 discussion, and after reviewing companies' views in Rel-18, sorry to say that it seems that majority companies point to opposite direction (from your assumption) that s-DCI for UL mTRP is popular. That is also the basic assumption for Rel-17 UL mTRP PUSCH/PUCCH evolution.

14 – Spreadtrum Communications

Support Alt2. We have concern on supporting 2 CWs for >=2layers. As commented by QC, this issue has been discussed in three releases and no consensus has been made. From techniqual perspective, since we have not specified 2 CWs for >4layers yet, the spec impact of supporting 2 CWs for >=2layers will be too large, such as the signaling and procedure design on gNB scheduling and UE processing, UE capability and so on. Also as we commented before, considering the workload, we need to down select some objectives rather than adding more topics.

15 – Qualcomm Incorporated

We support Alt 2 (No Support of 2 CW for >=2layers)

16 – Fraunhofer IIS

Support of Alt2.

17 – Nokia Corporation

We support Al1 as a compromise.

18 – CATT

We support Alt.1.

19 – LG Electronics Inc.

Our preference is to discuss 2CW enhancements for both DL and UL together. If this is for UL only, we could discuss 2CW option under both Area 4 (for >4Tx) and Area 5 (for simultaneous multi-panel Tx), so no separated item seems to be required. From technical perspective, we are supportive on Alt1.

20 – Huawei Tech.(UK) Co.. Ltd

We support Alt2

21 – NEC Corporation

We are open to have Alt1. However we don't see that much spec impact and it can be included in objectives for other uplink enhancement, for example, area 5.

22 – CEWiT

We support Alt1

23 – MediaTek Inc.

We support Alt-2 for the reasons mentioned before.

24 – MediaTek Inc.

Just to comment on the moderator rationale for proposing Alt-1. This feature was only ever proposed for UL in our understanding (in last email discussion it was under the UL enhancements discussion), so all of the comments we have made regarding this feature were only ever related to its application in UL.

25 – China Mobile Com. Corporation We support Alt1.
26 – Ericsson LM We prefer not to specify 2 CW for >=2 layers (i.e. Alt 2) unless it is studied as part of UL M-TRP. Given this, we think this area has the lowest priority overall, and rate it as priority 6.
27 – China Unicom We support Alt1 to support 2 CW for >=2layers in uplink, introduction of this feature is beneficial to UL network performance.

4.7 Draft Justifications for the WID

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, including the enhancements for single TRP and Multi-TRP.

In the evolution of NR, several areas are raised, which are necessary to be enhanced for supporting 5G-Advanced commercial deployment. First, UE's experience for high/medium speed scenarios is identified necessary to be enhanced, where the performance loss is mainly due to the outdated CSI. The enhancements on CSI acquisition including codebook based and reciprocity based are required. Second, Rel-17 unified TCI framework will be extended to indicate multiple DL/UL TCI states with less overhead. Third, enhancements on coherent joint transmission are triggered from different areas for the promising benefits of cell edge and cell average performance improvement. Fourth, UE equipped with 4 or more antennas is expected to be enhanced by supporting more layers or frequency-selective precoding for promising benefits on UL throughput improvement, as well as UE with multiple panels is also expected to be enhanced for improving the reliability and uplink througput.

Feedback Form 23: Modification or revision of the draft justifications?

1 – NTT DOCOMO INC. We're generally OK with this version. There is a typo in the last sentence 'throughput'.
2 – Qualcomm Incorporated We have suggested removing some objectives. If that is agreed, assumedly the justification would be updated accordingly.
3 – Nokia Corporation We have proposed the removal of some objectives, and our assumption is that the justification would be adjusted accordingly as well.
4 – Motorola Mobility UK Ltd. Lenovo, Motorola Mobility :

It seems the justification for beam management enhancements is missing.
5 – TELECOM ITALIA S.p.A. We suggest to split in two activities: one for DL and one for UL. As a consequence the proposal should be revised to accommodate the link specific topic. A part from that, the justification looks ok to us
6 – LG Electronics Inc. This needs to be updated depending on discussion outcome of Area1/2/4/5/6.
7 – Ericsson LM Typo: '~~are~~ several areas are raised'. General comment: if some topics are not specified/studied then the justification will need to be updated.
8 – ZTE Corporation In our views, some areas, e.g., Area 1, may be removed from the WID. We may further update the justification after the above areas are stable.
9 – Intel Corporation (UK) Ltd It is very early to discuss justification, since the objectives are not very stable wrt to detailed scope.

4.8 Summary of final phase

4.8.1 Summary of discussion on proposal for Area 1

For proposal of Area 1,

− Study, and if justified, specify CSI enhancement, and possibly, CSI-RS and SRS enhancement, in high/medium velocities for exploiting time-domain correlation/Doppler-domain information, including potential enhancement to both codebook based and reciprocity-based CSI acquisition mechanisms

Below is an overview about support level of the proposal for Area 1

Support: OPPO (SRS need clarification), Sony, Vodafone, Intel(reformulation, concern on some details) Sharp, AT&T (similar to Intel), InterDigital (No codebook enhancement, velocity scenarios?, select CSI or SRS?), Telstra, NTT DOCOMO(SRS low priority), MTK(reformulation), Moto(without SRS), DT, CATT(remove SRS), Xiaomi(SRS need more focus), LGE(no enhancement for CSI-RS and SRS), NEC(no SRS), CEWiT, Spreadtrum(without SRS), Fraunhofer(without SRS), Ericsson, Volkswagen(without SRS), Continental Automative(without SRS), KDDI

Not support: Apple, QC(at most CSI), Nokia(share QC's view)

Low priority: Samsung, ZTE, Huawei, CMCC

In the discussion, necessity of enhancement for SRS is challenged quite often, to make the scope more focus and specific, **Moderator would like to propose to refine the objective to**

- **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**

4.8.2 Summary of discussion on proposal for Area 2

For objective

- **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 single-TRP and multi-TRP schemes**

Below is an overview about the support level of this objective for Area 2

Support: Samsung, OPPO(motivation of inter-band?, Single-TRP?), Sony, Intel(refinement by deleting e.g., and restrict it to Rel-16/17 schemes), vivo, Apple (focus on mTRP), APT, Sharp, AT&T, InterDigital (motivation of inter-band?,), Verizon, NTT DOCOMO, ZTE, CAICT, QC, Nokia, Moto(refinement), Fraunhofer(without inter-band), Xiaomi(reformulation) , LGE(remove e.g,), NEC, MTK, CEWiT, CMCC(share intel's view)

Not support:

Low priority:

In the discussion, the motivation of inter-band single-TRP are challenged by several companies, but main reformulation is concentrating on how on make the scope a bit specific, jointly considering the views, **Moderator would like to propose to refine the objective to**

- **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**
    - **for multi-TRP, only includes multi-TRP schemes supported in Rel-16/Rel-17**

For objective

- **Study, and if justified, specify enhancement for Coherent-JT/D-MIMO for both FDD and TDD targeting FR1, including e.g., codebook, CSI reporting, spatial domain interference avoidance, and larger number of orthogonal DMRS ports**

Below is an overview about the support level of this objective for Area 2

Support: Samsung (specify), Sony, intel(refinement) AT&T, Verizon, ZTE(reformulation), CAICT, Futurewei, NEC (limited scope) , LGE(remove including part) , CEWiT, CMCC(no explicit "interference avoidance"), CATT, Xiaomi, Huawei/HiSilicon, Spreadtrum, China Unicom, China Telecom

Not support: QC, Nokia

Low priority: OPPO, Apple (not presented in priority list), NTT DOCOMO, Moto, MTK, Ericsson, Fraunhofer

Workload related concern: vivo (too big, not presented in priority list), InterDigital

In the discussion, the workload is still the main concern, jointly considering the views of intermediate round and final round, **moderator would like to propose to refine the objective to**

- **Specify larger number of orthogonal DMRS ports**
- **Study, and if justified, specify enhancements of CSI acquisition for Coherent-JT for both FDD and TDD targeting FR1**

For objective

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

Below is an overview about the support level of this objective for Area 2

Support: Samsung(reformulation), Sony, Intel(refinement), Apple, APT, Sharp, AT&T, InterDigital, verizon, NTT DOCOMO, ZTE(reformulation), CAICT, Nokia, Moto, Fraunhofer, Xiaomi, MTK, CEWiT, CMCC, Ericsson(further narrow down)

Not support: vivo (support other option)

Low priority: OPPO, LGE

Note: Intel and Nokia propose introducing additional objective for enhancement of TA and corresponding DL enhancement

To this objective, jointly considering the comments, it seems relatively less controversial, **Moderator would like propose the objective as**

- **Study, and if justified, specify overhead and/or latency reduction for UE-initiated beam management/beam acquisition procedures**

4.8.3 Summary of discussion on proposal for Area 4

For objective

- **Study, and if necessary, specify [CW mapping, UL DMRS, SRS and CSI acquisition, etc.,] to enable 6 and 8 Tx UL operation, to support more than 4 layers per UE in the UL targeting CPE/ FWA/vehicle/Industrial devices**

Below is an overview about the support level of this objective for Area 4

Support: Samsung(reformulation), OPPO(without CSI acquisition), Xiaomi(without CSI acquisition), Vodafone(similar as Samsung, additionally study for more than 4), vivo (up to 4 layers), Sharp, AT&T, InterDigital, Verizon, NTT DOCOMO, ZTE, Lenovo(refinement), Futurewei(refinement),QC(Refinement), Nokia(Remove CSI part), TI(share VDF's view), Spreadtrum, CATT(more than 4 layers, refine[]), LGE(without CSI acquisition), Huawei(reusing CW mapping), NEC(for FR1 only), CEWiT, Ericsson, CMCC, MTK(refinement)

Not support:

Low priority: Apple

To this objective, jointly considering the comments that this feature could be supported in more than one release, **it is proposed to refine the objective a bit slim as**

- **Study, and if justified, specify [at least] 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**

4.8.4 Summary of discussion on proposal for Area 5

For objectives

- **Support for simultaneous multi-panel UL transmission for higher UL throughput/reliability**
- **Study, and if justified, specify features to support panel-specific UL transmission, e.g. panel-specific timing/power control for multi-TRP scenario**

Below is an overview about the support level of these 2 objectives for Area 5

Support: Samsung(reformulation), OPPO(similar to Samsung's view), VDF(similar to Samsung's view), Intel(beam-specific), Asia Pacific, Sharp(similar to Samsung's view), AT&T, InterDigital, Verizon, NTT DOCOMO, ZTE(similar to Samsung's view), Xiaomi(similar to Samsung's view), Lenovo(similar to Samsung's view), Futurewei, QC(reformulation with more details), Nokia(Share Intel's view), TI, CATT(Simultaneous transmission only), LGE(no change), Fraunhofer(Simultaneous transmission only), NEC, CEWiT, CMCC, Ericsson, KDDI

Not support: Apple (against both), Huawei(joint decision on simultaneous and selection),MTK(not support simultaneous, need clarification for Panel specific UL transmission)

Low priority: Fraunhofer (panel specific timing/power control)

To this objective, jointly considering the comments from companies are relatively aligned, especially on how to reformulate the objectives, **it is proposed to refine the objectives as**

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

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

Note: To clarify MTK's question, since it will be studied first, from moderator's perspective, which scenarios are to be precluded or included could be further discussed

4.8.5 Summary of discussion on proposal for Area 6

For objective

- **Study, and if necessary, specify frequency-selective precoding and wideband high resolution precoding targeting devices with >=4 Tx**

Below is an overview about the support level of this objective for Area 6

Support: OPPO(remove =4Tx), intel(more refinement without wideband high resolution, limit to 4Tx), vivo, Apple(either frequency selective or wideband high resolution), InterDigial (need more clarification on wideband), NTT DOCOMO (need more clarification on wideband), Xiaomi, Futurewei, QC, Nokia, TI, CATT, LGE(concern on wideband),Fraunhofer(no wideband), CAICT, Huawei(concern on wideband), NEC(FR1 only), CEWiT, Ericsson(change and to and/or), MTK

Not support: QC

Low priority: Samsung, Spark, AT&T, ZTE, Levono(hold on after conclusion of study on >4), QC, Spreadtrum, CMCC,

To this objective, main concern focuses on wideband high resolution, **it is proposed to refine the objectives as**

- **Study, and if justified, specify frequency-selective precoding targeting devices with >=4 Tx**

4.8.6 Summary of discussion on proposal for Area Others

For the investigation of the altenatives

- **Alt 1: Support 2 CW for >=2layers in uplink**
- **Alt 2: No Support 2 CW for >=2layers**

Below is an overview about the support level of each alternative for Area Others

Alt 1: Samsung, CT, OPPO, Xiaomi, Sony, Xiaomi, Asia Pacific, NTT DOCOMO, CAICT, Lenovo, ZTE, Nokia, CATT, LGE, NEC, CEWiT, CMCC, CU, Ericsson(under multiple panel)

Alt 2: Intel, InterDigital, Spreadtrum, QC, Fraunhofer, Huawei, MTK, Ericsson

It is obvious that more companies are supportive to Alt 1 while several companies show negative toward it, and it is motivated from improvement of uplink transmission, Moderator would like to encourage companies to live with it and propose

- **Study, and if justified, specify 2 CW for >=2layers in uplink**

4.8.7 Summary for the draft justifications for the WID

Justifications should be revised based on final conclusion or objectives. Based on the progress for this moment, it is proposed as below:

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, including the enhancements for single TRP and Multi-TRP.

In the evolution of NR, several areas are raised, which are necessary to be enhanced for supporting 5G-Advanced commercial deployment. First, UE's experience for high/medium speed scenarios is identified necessary to be enhanced, where the performance loss is mainly due to the outdated CSI. The enhancements on DL CSI acquisition including codebook based and reciprocity basedwith feedback based are required. Second, DL overhead and latency reduction including extension of Rel-17 unified TCI framework will be extended to indicate multiple DL/UL TCI states and UE-initiated beam managementwith less overhead for multi-TRP scenarios with large antenna array is required for efficient beam management procedure. Third, enhancements on coherent joint transmission are triggered required from different areas for the promising benefits of cell edge and cell average performance improvement. Fourth, in single- and multi-TRP cases, large number of orthogonal layers for multi-UE scheduling is identified. More orthogonal DMRS ports are required. Fifth, UE equipped with 4 or more antennas is expected to be enhanced by supporting more layers or frequency-selective precoding for promising benefits on UL throughput improvement, as well asand UE with multiple panels is also expected to be enhanced for improving the reliability and uplink throughput. Sixth, for the case of equal or more than 2 UL layers, 2 codeword is required for performance improvement for the case of different links quality.

5 Conclusion

Justification:

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, including the enhancements for single TRP and Multi-TRP.

In the evolution of NR, several areas are raised, which are necessary to be enhanced for supporting 5G-Advanced commercial deployment. First, UE's experience for high/medium speed scenarios is identified necessary to be enhanced, where the performance loss is mainly due to the outdated CSI. The enhancements on DL CSI acquisition including codebook based and reciprocity basedwith feedback based are required. Second, DL overhead and latency reduction including extension of Rel-17 unified TCI framework will be extended to indicate multiple DL/UL TCI states and UE-initiated beam managementwith less overhead for multi-TRP scenarios with large antenna array is required for efficient beam management procedure. Third, enhancements on coherent joint transmission are triggered required from different areas for the promising benefits of cell edge and cell average performance improvement. Fourth, in single- and multi-TRP cases, large number of orthogonal layers for multi-UE scheduling is identified. More orthogonal DMRS ports are required.

Fifth, UE equipped with 4 or more antennas is expected to be enhanced by supporting more layers or frequency-selective precoding for promising benefits on UL throughput improvement, as well asand UE with multiple panels is also expected to be enhanced for improving the reliability and uplink throughput. Sixth, for the case of equal or more than 2 UL layers, 2 codeword is required for performance improvement for the case of different links quality.

Objectives for WID

- **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**
- **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**
- **Specify larger number of orthogonal DMRS ports**
- **Study, and if justified, specify enhancements of CSI acquistion for Coherent-JT for both FDD and TDD targeting FR1**
- **Study, and if justified, specify overhead and/or Latency reduction for UE-initiated beam management/beam acquisition procedures**
- **Study, and if justified, specify [at least] 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**
- **Study, and if needed, specify features to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability**
- **Study, and if justified, specify panel-specific timing/power control for UL multi-TRP/panel scenario**
- **Study, and if justified, specify frequency-selective precoding targeting devices with >=4 Tx**
- **Study, and if justified, specify 2 CW for >=2layers in uplink**

6 References

[1] RP-212657

[2] R1-211651

[3] R1-211652