[RAN93e-R18Prep-01] Evolution for downlink MIMO - Version 0.0.7
RAN

3GPP TSG RAN Meeting #93-e **RP-211651**

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Source: Moderator(CMCC)

Title: **Moderator's summary of discussion for [RAN93e-R18Prep-01] Evolution for downlink MIMO**

Agenda item: **9.0.1**

Document for: **Discussion and decision**

1 Introduction

Proposals on various Evolution for DL MIMO were provided to the 3GPP RAN Rel-18 workshop in June 2021. DL MIMO enhancements was identified as a topic for further email discussions as in RWS-210659:

- **Evolution for downlink MIMO**, with the following example areas:
  - Further enhancements for CSI (e.g., mobility, overhead, etc.)
  - Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam
  - CPE(customer premises equipment)-specific considerations

The email discussion aims at reaching common understanding on a set of areas with high-level description, which could help RAN to converge on a reasonable scope for DL MIMO enhancements in Rel-18. Please provide your proposals/comments with sufficient motivation assessment, and avoid inputs simply indicating "support/not support".

2 Initial Phase

The goal for initial round is to collect proposals from companies for each area, which can be used for potential areas convergence in the intermediate round.

2.1 General comments

Based on the RAN Rel-18 workshop (RWS), the following example areas are included for area of downlink MIMO. Companies are welcome to provide detailed proposals and comments in each of example areas. ***For any proposal and comment that does not fit into the example areas, please include them in the "other proposals" section. Please note that only the proposals submitted in RWS will be discussed in this email discussion.***

Feedback Form 1: General comments

1 – VODAFONE Group Plc

While uplink improvements should be a major area for Rel 18, there should still be opportunity for some study of downlink improvements. DL improvements for bands at 2.1 GHz and below would be especially useful. Particular areas include:

a) overhead reduction for FDD MIMO;

b) techniques enable by extra UE processing power (Rel 18 is three releases / 5 years after Release 15).

2 – Futurewei

Our view is that MIMO enhancements for FR1 are at least equally important as for FR2 in Rel. 18. For MIMO enhancements for sub 7 GHz band, the following areas should be included:

- Cooperative massive MIMO (e.g., spatial domain interference avoidance via Bi-directional Training (BiT)) which provides significant performance gain [1].
- CSI/SRS Enhancements for high mobility.

[1] RWS-210036, "Enhancements for support of eMBB+ services for Rel-18", Futurewei, RAN Rel-18 Workshop

3 – HuaWei Technologies Co.

Since multi-TRP and multi-beam are two separate areas, it may be better to separate the two areas for further discussion.

4 – HuaWei Technologies Co.

Since multi-TRP and multi-beam are two separate areas, we think it is better to separate the two areas for further discussion.

5 – Guangdong OPPO Mobile Telecom.

We are supportive of further MIMO enhancement in Rel-18. From Rel-15, 3GPP has introduced a toolbox of various advanced MIMO mechanism, some of that are widely used in practical deployment. Meanwhile, there is still some room for further enhancement and may provide benefits for customers. Rel-18 MIMO enhancement should focus on practical deployment requirement. Moreover, RAN should keep a manageable scope and clear objectives for MIMO enhancement.

6 – Qualcomm Incorporated

As in other cases, the DL MIMO evolution proposals should not be used to further optimize every single MIMO design aspect. The enhancement areas should be carefully chosen to include only essential improvements.

7 – NTT DOCOMO INC.

Both FR1 and FR2 enhancements can be considered for DL MIMO. But the work scope of DL MIMO should be much smaller than UL enhancement. We think UL enhancement is more important than DL enhancement in Rel.18.

8 – LG Electronics France

We think it may be considered to separate MTRP topic and multi-beam topic in the future discussion since scope of each of them can be quite large

9 – ZTE Corporation

There may be some overlaps among UL enhancements, DL-MIMO, and mobility as many companies raised during the June WS, since these above items are all relevant to legacy MIMO enh. in Rel-16/17. To enable the new marker of 5G-Advanced 'UL enhancement', as well as balance TU(s) & scopes across several WID(s), we support to split legacy MIMO related objectives as follows:

- Regarding UL enhancement, UL-MIMO (involving UL-only and DL and UL operation, e.g., >4 Tx operation, **UL CW mapping enhancement (for ≥ 2 layers)**) should be considered.
- Regarding DL MIMO, DL-MIMO related aspects should be involved.
- Regarding mobility, Layer 1/layer 2 based inter cell mobility (mainly for Scenario-2 but also include left-over issues for Scenario-1) should be involved.

10 – Nokia Corporation

Some general comments from our side below:

- From the Rel-18 workshop it is clear there is a strong request from operators to **focus on UL enhancements** in Rel-18, including capacity driven enhancements and multi-TRP/multi-panel aspects. This should be taken into account when considering the DL-centric enhancements.
- **Multi-TRP/multi-panel aspects** are split between DL and UL threads, with the main DL aspects considered here. For future discussions we should **consider merging this topic and UL enhancements**, e.g. "**Coverage and multi-antenna enhancements**" with focus on uplink multi-antenna aspects.

  At the very least, an eventual WID needs to combine DL and UL aspects of MIMO enhancements, where applicable. Coverage enhancements can be considered separately.
- Clear objectives needed for **RAN4** work on all topics, to be listed already when drafting the WID.

11 – China Mobile Com. Corporation

We think multi-TRP and multi-beam can be split to two separate areas. Multi-beam enhancement for latency and overhead reduction has been discussed in R17, and we found that the exact enhancements are quite various. We suggest to specify the working direction in R18 to avoid the discussion is too diverse.

12 – TELECOM ITALIA S.p.A.

3GPP spent a lot of resources on MIMO enhancements. Unless critical issues are required by the market DL enhancements should be lower priority. The main focus should be to complement the solutions to improve UL performance (throughput and coverage)

13 – CATT

Starting from Rel-15, DL MIMO has been studied extensively throughout all the subsequent releases of NR. For DL, based on current spec and the work items to be finalized in Rel-17, comprehensive functionalities such as single-TRP and multi-TRP transmissions as well as enhancements for URLLC and HST can/will be supported.

Therefore, in our view, only the items which can be identified as critical and commercially essential to the system are necessary to be studied and standardized in Rel-18 for DL. For example, CSI enhancement for medium to high mobility and C-JT can be considered.

14 – LG Uplus

Coherent Joint transmission and reception in multi-TRP deployment scenario should be studied to improve DL and UL throughput and reliability enhancement.

15 – MediaTek Inc.

We think that some selective enhancements would be useful for DL MIMO on **CSI reporting** particularly for UEs experiencing high mobility, and **multi-beam/TRP enhancement to improve FR2 intra-cell mobility (joint with UL)**. See respective sections for details.

16 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

Leftovers from Rel-17 primarily not completed due to time-constraints should be prioritized. For example, M/N>1 TCI-state signaling support, asynchronous mTRP (multiple TA)and advanced beam refinement/-tracking. We should prioritize among the number of enhancements to have the right proportion of leftovers/further enhancements of some of Rel-17 features and the new/advanced DL MIMO features for diverse use-cases/deployment scenarios.

17 – CEWiT

We believe DL MIMO enhancements should also be considered based on the scope of UL enhancements as Rel18 is expected to have more UL enhancements. Also we feel it is better to split Multi-TRP and Multi-Beam as separate topics.

18 – Samsung Electronics Co.

Our view is that at least evolved handling of mTRP and multi-beam should be considered which can wrap up what was started in previous releases as a scope of Rel-18 DL MIMO. Also, if needed, further enhancements for CSI (e.g., mobility, overhead, etc.) can be also considered.

19 – InterDigital France R&D

We generally agree with the proposed scope, and also the intention that there should be a focus on UL enhancements. Having said that we believe that UL MIMO topics related to UL enhancements should be captured under the general MIMO enhancements.

20 – Spark NZ Ltd

MIMO is a very mature technology. Enhancements to MIMO are only marginal. The channel rank is limited by the environment for example if there is a strong line of sight present the channel rank would be influenced by the LOS and not any MIMO enhancements. There maybe some gains to be had from better CSI acquisition.

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

Feedback Form 2: Detailed proposals or comments for this area

1 – VODAFONE Group Plc

- Different compression techniques when using DL CSI-RS feedback (aiming to provide sufficient accuracy whilst minimising feedback overheads)
- Different reference signal cadences for different mobility scenarios (to aid prediction and tracking techniques)
- Power boosting the CRS when using channel reciprocity

2 – Ericsson LM

Here we see the following objectives:

- Enhanced CSI accuracy to improve link adaptation for general use cases
  - Study, and if beneficial, specify post-PDSCH decoding based CSI reporting
- CSI enhancements for URLLC use cases
  - Specify CSI enhancements for already existing multi-TRP URLLC schemes.
  - Specify CSI enhancements to prioritize URLLC CSI during ongoing UE processing of a 'High Latency' CSI
- CSI enhancement for faster enabling of DL MIMO after initial access and handover
  - Specify triggering of early CSI reporting using the already existing CSI request bit in the RAR grant, both for CBRA and CFRA

3 – Futurewei

On further enhancements for CSI, the following area should be included:

- CSI/SRS Enhancements for high mobility. This is essential to support MU-MIMO with high mobility.

4 – vivo Communication Technology

Further CSI enhancement considering higher vehicular speed and overhead, should be considered for both TDD and FDD. CSI feedback based as well as non-PMI feedback based schemes (for TDD) should be considered, including SRS enhancement.

5 – Apple GmbH

We are interested in the following areas for CSI enhancement in Rel-18

- Enhancement on CSI reporting with multiple hypothesis to provide more scheduling suggestions
- Enhancement on CSI reporting to accommodate UE with dynamic CSI processing load/condition
  - At we explained in our contribution RWS-210499, current CPU/active RS related UE capability cannot handle dynamic CSI processing load/condition

6 – AT&T

On further enhancements for CSI, we think the following should be considered/included

1. CSI enhancement targeting DL, UL and MU-MIMO
2. Further CSI enhancements for overhead and latency reduction, including DMRS-based CSI estimation
3. CSI enhancements inc. Doppler domain exploitation/compensation to reduce the feedback overhead, especially applicable to moderate to high mobility UEs

7 – HuaWei Technologies Co.

For this area, if it is supported, our thinking is:

Scenarios: both FDD and TDD should be included.

CSI enhancements for supporting mobility: Doppler based Codebook/CSI feedback enhancements for FDD (including CSI-RS overhead reduction); and SRS enhancements for mobility for TDD (such as new SRS pattern in time domain and overhead reduction)

It is known that reduce the periodicity for the measurement can support mobility, but the overhead issue need to be handled. The detailed discussion of enhancements and performance evaluation results can be found in our Tdoc RWS-210437.

8 – Intel Corporation (UK) Ltd

We support objective for further CSI enhancement in Rel-18. In terms of detailed descriptions, the following enhancements should be considered:

Objective #1. Specify CSI enhancements for multi-TRP URLLC schemes

Comment: Rel-16 specifies several transmission schemes to support PDSCH transmission for URLLC. However, there is no CSI feedback mechanism that can be used to assist the corresponding transmission schemes. Some implementation approaches could be used to predict parameters (e.g. MCS) for such PDSCH transmission, however, efficiency and accuracy of such schemes were never proved under URLLC context. Considering the discussion above we propose to address the CSI issues fir multi-TRP URLLC transmission schemes and include the corresponding objective in Rel-18.

Objective #2. Study and specify (if sufficient gains are shown), CSI enhancements for high mobility scenarios.

Comment: We think that such CSI enhancement should be considered for Rel-18, but study phase is required to understand the benefits of the schemes in the scenarios with bursty traffic, where interference may change rapidly.

9 – Guangdong OPPO Mobile Telecom.

RAN1 has developed CSI compression via exploiting spatial-domain and frequency domain correlation in Rel-15/16/17. However, there is still obvious performance gap between the NR CSI feedback and the ideal channel state information. Exploiting of time-domain correlation can offer another dimension for further CSI compression. There were different potential mechanisms proposed for discussion, e.g., Doppler domain compression, burst CSI reporting, and so on. Among of the potential mechanisms, we think CSI enhancement based on Doppler domain compression is the most attracting one due to its performance gain.

10 – Qualcomm Incorporated

CSI enhancement exploiting time-domain correlation

Since Rel-16, feedback overhead has been reduced by exploiting frequency-domain correlation in addition to spatial-domain compression. However, the Type II and eType II CSI are not optimized for different mobility scenarios. For stationary or pedestrian UEs, the channel may be highly correlated across a long duration of time. Although less frequent CSI reporting may be configured to reduce the feedback overhead, the time-domain correlation could be further exploited to provide more accurate CSI. For mid- or high-mobility UEs, the CSI is aged due to inevitable latency due to CSI processing, which cannot be improved by more frequent CSI reporting. The system performance degrades significantly when such aged high-resolution CSI is applied. Given this, it is worth exploiting time-domain correlation in Rel-18 to further enhance CSI at least in the following two aspects. The first aspect is PMI overhead reduction. Instead of simply increase the CSI reporting periodicity, we could leverage the time-domain correlation to design CSI for a better accuracy-overhead tradeoff. The second aspect is to facilitate CSI extrapolation at the gNB, especially for mid-to-high speed UEs.

11 – NEC Corporation

We see the overhead issues with current CSI framework due to frequent measurements and reporting, especially considering UE movement in a high mobility scenario.

We support to identify and specify features to facilitate more efficient CSI measurements and reporting for fast moving UE.

12 – NTT DOCOMO INC.

We support CSI enhancement for high speed/mobility scenario.

13 – Spreadtrum Communications

CSI feedback can be further enhanced for some typical use cases to achieve better tradeoff between performance and overhead, for example:

- CSI enhancement for high mobility UE
- CSI enhancement for stationary UE

14 – Beijing Xiaomi Mobile Software

We support further CSI enhancement for latency and overhead reduction for high mobility UE, such as CSI feedback considering time domain correlation.

15 – ZTE Corporation

Overall views:

- Flexibility of URLLC CSI triggering is an interesting topic. When another CSI is being processed, the current spec cannot allow fast CSI to be triggered in such case, which restricts the flexibility for gNB to trigger CSI for low-latency applications. Also, DMRS-based CSI reporting, at least for CQI, can be considered. Enhancement may also depend on the progress of Rel-17 CSI in URLLC.

- Then, 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). Also, more effort should be put on the study on AI/ML based CSI enhancement instead.

- Finally, some companies highlighted coherent JT. But, in our views, coherent JT has been specified in LTE, but there are few corresponding deployments (unfortunately). Furthermore, for many cases, coherent JT can be implemented in a spec-transparent manner. So, some justification is needed.

Objective:

- High priority: CSI enhancement for URLLC, including applications on mTRP schemes, CSI triggering flexibility considering CPU occupation restriction and DMRS based CSI reporting

- Low priority: CSI for mobility (Doppler-domain correlation), coherent JT or distributed MIMO

16 – SHARP Corporation

We support the objective of CSI enhancement.

- CSI enhancement for high mobility UEs
- CSI enhancement for low overhead, e.g. time-domain compression by exploiting correlation.

17 – Nokia Corporation

We support CSI enhancements in Rel-18, in particular:

- CSI acquisition enhancements for higher mobility UEs / High Speed Trains
- Lower the latency of initial acquisition and improve the CSI processing timeline

18 – China Mobile Com. Corporation

We suggest study the following areas:

a) CSI enhancement for high mobility UEs: for high-speed UEs, the CSI accuracy is unsatisfactory due to fast channel variations. More efficient and higher accuracy CSI feedback is needed.

b) CSI enhancement for M-TRP URLLC schemes: CSI enhancement in Rel-17 focused on M-TRP eMBB scenario, for URLLC, more restrictions(e.g., same RI/PMI) and reduced CSI payload can be considered.

19 – CATT

Starting from Rel-15, DL MIMO has been studied extensively throughout all the subsequent releases of NR. For DL, based on current spec and the work items to be finalized in Rel-17, comprehensive functionalities such as single-TRP and multi-TRP transmissions as well as enhancements for URLLC and HST can/will be supported.

Therefore, in our view, only the items which can be identified as critical and commercially essential to the system are necessary to be studied and standardized in Rel-18 for DL. For example, CSI enhancement for medium to high mobility and C-JT can be considered.

20 – CATT

Sorry for repeating by mistake as in comments #19.

As mentioned above, we support to further enhance CSI feedback for medium to high mobility scenarios. The reason is that for low mobility case, we already have solid mechanisms to guarantee relative accurate enough for SU/MU-MIMO operation, while for medium to high mobility cases, notable loss in performance can be observed in practical deployment scenarios. Therefore, potentially large improvement can be expected if further enhancement for such cases can be specified in Rel-18.

21 – Fraunhofer IIS

We support the CSI enhancement objective for Release 18. Current NR Type-II CBs are pivotal for SU/MU-MIMO transmissions. However, all Type-II CB variants specified so far target mainly static or very low UE mobility scenarios. For mid- to high-mobility UEs, the following is observed in practical deployment scenarios: large performance loss especially in fast varying channels due to insufficient CSI update rate. Need for increased CSI update rate to efficiently handle the fast channel variations. Increased use of UL/DL resources due to frequent PMI measurements and reporting because of high CSI update rate. To overcome all these issues, the CSI report should contain Doppler or Doppler-delay spectrum-related information of the channel. Therefore, the following enhancement should be considered:

Evaluate and specify enhancements on Type-II codebook based on Doppler-information for time-domain CSI compression. Consider reporting mechanism(s) including Doppler-information for CSI overhead reduction and for tackling CSI aging assuming moderate to high speed UEs, mainly targeting FR1.

22 – LG Uplus

- In FDD, phase compensation CSI report design is required to support multi-TRP operation.

23 – MediaTek Inc.

Enhancing CSI reporting to exploit time-domain correlation seems a clear gap to fill for DL MIMO, particularly for UEs experiencing high mobility, so we would support that objective.

24 – Sony Corporation

Support CSI enhancements for supporting high mobility, including utilizing the Doppler domain to further reduce overhead of CSI reports, specially for FDD.

25 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

CSI enhancements for high-speed scenarios

- Identify prioritized use cases for high-speed CSI enhancements, e.g., vehicles in highways, high-speed train, drones/UAV

- Study and, if beneficial, specify a unified framework for high-speed CSI enhancements considering faster CSI configuration/re-configuration, Doppler-compression based codebooks, and Correlation-based CSI reporting.

CSI enhancements for coherent joint transmission (distributed MIMO)

- Further verify commercial interest, in addition to the supported bands, e.g., whether the use cases are limited to <1 GHz bands, or at least FR1

- Gains/merits of supporting CJT/DMIMO should be assessed relative to Rel-17 mTRP CSI enhancements (can be used as baseline), and realistic assumptions for inter-TRP phase coherence, number of TRPs in joint transmission, backhaul delay, and deployment scenarios.

CSI enhancement to support dynamic TRP selection and dynamic TRP paring for NCJT with more than two TRPs.

26 – CEWiT

We support the following CSI enhancements for Rel18

- overhead reduction of CSI especially targeting low-mobility/stationary UEs.
- CSI enhancement to support M-TRP schemes upto Rel18
- If CPE has use cases related to CSI enhancements, it can also be treated under the same topic.

27 – Deutsche Telekom AG

We support CSI enhancement as many companies above and in particular what is outlined by Fraunhofer. Improvements have been shown for this in the past already and especially benefits are seen in high mobility scenarios, relvant for railway as well as automotive connectivity (remember: no general speed limit on German ”Autobahn” ;-))

28 – Samsung Electronics Co.

We support the following CSI enhancements for Rel-18 DL MIMO.

- Distributed RRH scenarios, e.g. Type-I/II codebook enhancement taking into account large phase offset across RRHs
- Higher speed, e.g. using Doppler-domain compression for Type-II codebook

29 – InterDigital France R&D

We support the proposed topics related to CSI enhancements for mTRP URLLC, CSI enhancements for high mobility UEs and also addressing issues related to CSI processing timeline. However, we think CSI enhancements for mTRP should have a higher priority than others.

30 – Verizon UK Ltd

Agree with Samsung. We are with interested in e.g., sub-1GHz spectral efficiency improvement using coherent JT applied on distributed RRHs.

2.3 Example Area 2: Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam

Feedback Form 3: Detailed proposals or comments for this area

1 – Ericsson LM

Here we see the following objectives:

- Introduce support for mixed mode intra-UE services (eMBB and URLLC)

    - Specify mixed mode single-DCI and multi-DCI based multi-TRP
- Transparent TRP switching for heavy data downloads to achieve fast load and interference management
    - Study, and if beneficial, introduce PDSCH DMRS based synchronization for large scheduling bandwidths, to avoid signaling of an TRS as QCL source
- Extend coverage of mTRP operation
    - Specify asynchronous mTRP (multi-TA)

2 – Futurewei

On evolved handling of multi-TRP and multi-beam, the following areas should be included:

- Cooperative massive MIMO (e.g., spatial domain interference avoidance via Bi-directional Training (BiT)) which provides significant performance gain [1]. Standard impact includes at least SRS triggering flexibility and signaling design beyond that of R17.
- Multi-beam enhancements including latency reduction (e.g., Issue 6 leftover from R17 FeMIMO WI).
- Multi-TRP/multi-UE panel enhancements (based on R17 framework) including support of multiple timing advance values and support of M>1 and/or N>1, which are leftovers from R17 FeMIMO WI.

[1] RWS-210036, "Enhancements for support of eMBB+ services for Rel-18", Futurewei, RAN Rel-18 Workshop

3 – vivo Communication Technology

For further enhancement of multi-TRP and multi-beam, Rel-17 TCI framework can be extended to multi-TRP scenario. Further study, specifiby CBM operation for multi-beam.

4 – Apple GmbH

We are interested in the general beam management enhancement and its applicability to multi-TRP deployment. Below are the areas that we think are important for Rel-18

- UE initiated beam selection/beam mangement procedure
    - This was discussed in Rel-17 but there seems to be no time to specify anything
- Extend the unified TCI framework to support multi-TRP operation
    - There is no time to finalize this feature in Rel-17
- Beam failure recovery enhancement to consider UL beam status
    - Currently the BFR only considers DL status, but we found sometimes DL beam can still work but UL beam fails due to asymmetric link budget between DL and UL
- UE coordination based beam measurement and report
    - For UEs in similar location, most likely the beam could be the same, and it is not necessary for every UE to perform beam measurement and report independently. With certain UE coordination, one UE among the group of UEs to perform beam measurement and report should be enough, which can save UE power and reduce the reporting overhead

5 – AT&T

On evolved handling of multi-beam/multi-TRP, both eMBB and non-eMBB (V2X, group mobility, IAB, etc.) use cases should be considered. In particular, the following areas should be included.

- Multi-beam enhancements on overhead and latency reduction beyond Rel. 17
- Multi-beam/multi-panel enhancements to include power control/interference management aspects
- Simultaneous multi-panel UL transmissions
- Multi-TRP enhancements on inter-cell operation with non-ideal synchronization

6 – HuaWei Technologies Co.

We are supportive on both areas for multi-TRP and multi-beams.

For multi-TRP:

Scenarios: support coherent joint transmission for intra-site and inter-site cases (including both indoor and outdoor) for FR1.

Enhancements:

- More than 12 orthogonal DMRS ports for supporting high-order MU-MIMO in multi-TRP joint transmission.
- Codebook/ CSI feedback enhancements for FDD case;
- SRS enhancements targeting interference mitigation;
- Smaller PRG size (1RB or smaller) for supporting flexible scheduling and interference mitigation;

For multi-Beam:

Scenarios: Support large array antennas (such as 4096 antenna elements at gNB, to increase coverage with beamforming gain) to support the real Macro deployment of FR2.

Enhancements:

- Beam management enhancements (overhead/latency) for mobility with narrow beams;
- FDM/SDM of multiple panels (gNB) for capacity enhancement.

For the detailed discussion and performance evaluation can be found in our Tdoc RWS-210437 and RWS-210438.

7 – Guangdong OPPO Mobile Telecom.

With Rel-17 spec, there are two different signaling frameworks for beam management, one is the R15/16 signaling framework, the other is the unified TCI framework introduced in Rel-17. They have two much redundant parts overlapped with each other since most of the functionalities are similar. In Rel-18, we need to decide which of the two frameworks should be the foundation stone for Rel-18 M-TRP and MB enhancement.

For multi-beam operation, the NR spec has provided a flexible framework for measurement, reporting and beam indication. The main drawbacks of the current mechanism are large signaling overhead and large latency. For instance, even though the UE knows which beam is the best beam for DL transmission and/or uplink transmission through measurement, the UE still need to wait for the beam switch command (for instance MAC CE command that indicates or activates TCI state for PDCCH/PDSCH or MAC CE

command that indicates spatial relation info for PUSCH or PUCCH). Therefore, we suggest L1-event-driven beam management techniques and UE-initiated beam management for Rel-18 to reduce the signaling overhead and latency.

For multi-TRP transmission, one challenge of UE is high power consumption. For better performance and user experience in multi-TRP system, reducing UE power consumption is one key factor. Thus, we propose to study and specify UE power saving for multi-TRP transmission, for instance, reduction of PDCCH blind decoding.

8 – Intel Corporation (UK) Ltd

We support objective related to multi-TRP and multi-beam enhancements. However, two aspects may be considered separately. In terms of detailed descriptions, the following enhancements should be considered:

Objective#1: Identify and specify enhancements for multi-TRP operation with received timing difference exceeding cyclic prefix (CP) duration

Comment: Rel-15/Rel-16/Rel-17 specifies multi-TRP transmission schemes under assumption of almost perfect synchronization and very small propagation delay difference from multiple TRPs. During workshop discussion we demonstrated that such assumption would be hard or almost impossible to fulfill in the practical scenarios even under perfect sync assumption at the NW. In particular for high subcarrier spacing (e.g., 120 kHz) due to propagation delay difference the Rx timing from TRPs exceeds CP duration with high probability. In order to support such scenario RAN1 should study the corresponding enhancements (e.g., multiple TA, beam management enhancements, etc) and RAN4 to specify requirements. The study should consider both FR1 and FR2.

Objective#2: Identify and specify enhancements for latency reduction in beam management (beam acquisition)

Comment: In Rel-17 RAN1 has specified DCI based beam indication to reduce latency in beam management procedures. However, based on some companies evaluation results, it has been found that such enhancement has limited performance gains, since the actual latency bottleneck mainly resides in the beam acquisition procedure. We propose RAN1 to address the corresponding real-life problem in Rel-18 with sufficient TU allocation.

Objective#3: Study and (if sufficient gains are shown) specify enhancements to support coherent joint transmission schemes.

Comment: Coherent JT is one of the multi-TRP transmission schemes that can be used to further improve DL performance in some scenarios. Considering that NR already supports several multi-TRP transmission scheme, RAN1 should perform study to identify performance gains of coherent JT in bursty traffic scenarios under different loading conditions. The study should consider practical RF impairments (e.g., frequency offsets, limited Tx power at each TRP, etc.) and issues related to propagation conditions (e.g. different propagation delays from TRPs, different Doppler shifts in outdoor deployment, etc.).

9 – Qualcomm Incorporated

SPS support

Rel-16/17 mTRP was optimized for dynamic grant-based use cases. SPS/CG support was not included. In Rel-18, support of mTRP should be extended to the SPS/CG use cases in both the DL and UL with more deterministic traffic while taking advantage of the mTRP benefits.

Multi-PDSCH grant for mTRP

In the current Rel-17 60GHz WI, multi-PDSCH grant for FR2-2 is introduced to reduce control overhead. However, in Rel-17, the multi-PDSCH grant was not designed for mTRP operation. To further improve the reliability of transmissions, a straightforward enhancement can be the extension of the design to allow multiple TB transmission with each TB repeated over different TRPs.

Multi-beam mTRP

For multi-beam, to facilitate timely beam/CSI update due to UE mobility/rotation, UE requested beam refinement and CSI report can be considered to reduce overhead/latency and UE power consumption. In addition, cell level BFR can be further enhanced in various aspects, including partial BFR, implicit BFD RS selection rule, group-CC based BFD, PCell BFR via SCell, etc.

10 – NEC Corporation

For MTRP, we see the need to

1. Extend the support of MTRP within the unified TCI framework developed in Rel-17, for which there is no consensus to support in Rel-17 according to RAN1 106e agreements, due to lack of time.

a) Identify and specify beam failure recovery enhancement based on unified TCI framework.

b) Identify and specify reliability and robustness enhancement based on unified TCI framework.

2. Support asynchronous MTRP for a more realistic FR2 deployment.

For MTRP in FR1, we are also open to support distributed MIMO/CJT.

For multi-beam, we see the need to further improve the efficiency, for example,

1. Specify UE-initiated/assisted BM.
2. Specify features to enable prediction-based BM for cases with fixed/predictable trajectories.

11 – NTT DOCOMO INC.

We support MTRP CSI enhancement for existing MTRP URLLC schemes.

We support further enhancement of unified TCI framework considering muti-TRP and multi-beam, e.g. M, N >1 for M-TRP and/or inter band CA, group-common beam indication.

12 – Spreadtrum Communications

We are interested in the following areas:

- Overhead/latency reduction for beam measurement and reporting
- Multi-TRP operation with unified TCI framework

13 – LG Electronics France

We suggest including the following in the scope

- M-DCI based MTRP reliability enhancement
- Further reliability enhancements
  - Support for multi-DCI based MTRP transmission
  - Combined MTRP schemes(e.g. SFN+repetition)
- Support for Cross-link BM (e.g. UE-to-UE BM)

14 – Beijing Xiaomi Mobile Software

We support further enhancement on Multi-TRP including:

- Extend unified TCI framework to Multi-TRP

- Consider both intra-cell and inter-cell Multi-TRP
- Simultaneously UL transmission of Multi-panel UE

And further enhancement on Multi-beam including:

- Support M>1 and/or N> 1
- Dynamic switching between joint TCI state and separate TCI state
- Beam management for latency reduction

15 – SHARP Corporation

We support the following objectives of mTRP and multi-beam

- DL asynchronous multi-TRP transmission
- UE initiated beam selection and beam management

16 – ZTE Corporation

Overall views:

- Regarding multi-TRP, we are open to consider more realistic assumptions for inter-cell mTRP operation and other leftover issues, e.g., panel-specific beam reporting (Option-1 in Rel-17 mTRP-BM).

- Regarding multi-beam, we identify that advanced tracking, refinement and reporting (as listed in issue 6 in Rel-17) for both DL and UL should be considered with high priority. Also, we are open to consider some further enhancement on unified TCI framework, e.g., for multi-band, or for multi-TRP. Finally, in the case of simultaneous transmission of different DL channel(s) and RS(s), how to handle beam collision (e.g., PDCCH+PDCCH, PDCCH+PDSCH, CSI-RS+CSI-RS, etc) should be considered for facilitating FR2 scheduling flexibility.

Objective:

- Multi-TRP: Async inter-cell mTRP operation (e.g., TA enhancement) involving both inter-cell beam management and inter-cell mTRP operation, and leftover issues, e.g., panel-specific beam reporting

- Multi-beam: Advanced beam refinement/tracking, unified TCI for mTRP, and leftover issues, e.g., beam collision with simultaneous Tx/Rx of different channel(s)/RS(s)

17 – Nokia Corporation

Please note these objectives have strong connection with those discussed in UL enhancements thread, and they should be considered jointly in the future.

Multi-TRP operation (FR1 & FR2)

- Support more realistic assumptions (e.g., different TA, beam switching gap) for Multi-TRP operation
- Multi-codeword encoding for Multi-TRP transmission with single-DCI

Multi-beam enhancements (FR1 & FR2)

- Enhance unified TCI framework

- Support dynamic operation with joint and separate DL and UL TCI states
- Support for number of indicated DL and UL TCI states beyond Rel17 (e.g. M, N > 1)

- Latency and overhead reduction (beyond Rel17), including
  - Support of P3 narrow beam alignment procedures
- Enhanced interference indication

18 – China Mobile Com. Corporation

We support to study the following areas:

a) M-TRP enhancement for asynchronous operations: beyond synchronization assumption in Rel-17, different TA values and timing assumptions may exist in practical network

b) Unified TCI enhancement for multi-TRP: extend unified TCI framework to M,N>1 for multi-TRP scenario

a) UE-initiated beam management and reporting to further reduce the latency and overhead

19 – Asia Pacific Telecom co. Ltd

We support the following example areas:

- Extend Rel-17 unified TCI framework to apply for M-TRP scenario (which means M>1 and/or N>1)
- Support dynamically switching function and simultaneous configuration of S-DCI and M-DCI M-TRP specified in Rel-16/17
- Enhance latency/signaling reduction on beam refinement and tracking (leftover in Rel-17 FeMIMO)

20 – CAICT

we support multi-TRP and multi-beam enhancements in R18. For multi-TRP, coherent joint transmission for intra-site and inter-site could be considered. For multi-beam, latency/overhead reduction schemes could be considered.

21 – CATT

In our view, based on continuous evolution ever since Rel-15, multi-beam operation in specification has already be optimized sufficiently. Therefore, if no critical issue can be specified, we think further enhancement to multi-beam is not necessary in Rel-18.

Especially for higher frequency band, from reliability and coverage perspective, it's of great importance to consider approaches such as coordination among multiple TRPs. Furthermore, compared with non-coherent JT introduced in Rel-16, larger performance gain can be observed with C-JT. So, we suggest to study and specify C-JT in Rel-18.

22 – LG Uplus

- Phase compensation CSI design is required to support multi-TRP operation in FDD.
- SRS capacity enhancement is required to support multi-TRP operation in TDD. Especially, it could be crucial for finer granularity codebook.
- Codebook design which can support the combination of various types of antennas with different antenna elements is required. It can reduce CAPEX since the legacy Antennas (RUs) can be reused to provide higher layer MIMO.

- RAN4 should check RF requirement such as power imbalance and RTTD for multip-TRPs.

23 – MediaTek Inc.

For multi-TRP and multi-beam, latency reduction for intra-cell mobility is still an important issue for FR2 (even after Rel-17 enhancements), and we the following as important (*includes also UL enhancement components*):

- UE-initiated beam operation at least including beam selection/activation, if not completed in Rel-17
- Extension of Rel-17 unified TCI framework to support M,N > 1 at least for multi-TRP, and potential use cases for single-TRP

The following could also be considered as slightly lower priority in our view:

- Enhancement to beam indication for grouped UEs for use cases e.g., HST
- Reducing activation delay of TCI states and PL-RSs involving RAN1 design and RAN4 requirement revision

24 – Sony Corporation

- UE-initiated/triggered beam reporting
  - For the use cases of MPE (maximum permissible exposure) avoidance and L1/L2-centric inter-cell mobility, UE can be the first one to identify such event(s) which requires NW-initiated UE reporting. To conduct time-sensitive reporting in the most recent occasion, UE should be able to initiate reporting.
- Extend Rel.17 beam management to Rel.18 multi-TRP/panel operation
  - Unified TCI states for either joint or separate DL beam indication was defined in Rel-17 for single-TRP operation. To avoid NW configuring UEs with two parallel beam indication mechanisms, it should be extended to Multi-TRP/panel operation in Rel-18.

25 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

Multi-TRP enhancements

- Rel-17 leftovers: support asynchronous mTRP operation (multiple TA)
- Support of dynamic TRP-group selection and dynamic TRP paring for NCJT with more than two TRPs (including CSI and beam management support)
- Coherent joint transmission (distributed MIMO) - Please refer to our comments in CSI enhancements section.

Multi-beam enhancements

- Rel-17 leftovers / further enhancements:
- Extension of unified TCI framework for potentially larger number (M/N>1) of TCI states
- Enhanced inter-cell beam management with unified TCI framework
- UE-initiated/event-triggered beam switching and reporting
- Beam management to support simultaneous multi-panel UL transmission

- New/advanced multi-beam enhancements to reduce signaling overhead
- Grouping/sharing based beam measurements to allow common beam measurements for a group of UEs
- (pseudo) Prediction-based beam indication to indicate beams and associating timing for deterministic UE movement (path and speed)
- Fast beam refinement in initial access

26 – CEWiT

We support the following enhancements for M-TRP and Multi-Beam

- Extension of unified TCI-framework for M-TRP schemes ??
- Enhancements to support Coherent Joint Transmission schemes for M-TRP
- Asynchronous M-TRP transmission supporting different TAs in UL

27 – China Mobile Com. Corporation

For multi-TRP enhancement, Rel-16/17 has supported NC-JT, we think C-JT should be considered in Rel-18 since it is promising for cell edge and cell average performance improvement based on our 4G deployment experience at least for intra-site outdoor scenario and indoor scenario in FR1.

28 – Fraunhofer IIS

We support the M-TRP enhancement objective for Release 18 with the following objective:

• Unified TCI framework for M-TRP

29 – China Telecommunications

We support CJT for NR for both FDD and TDD, including: CSI enhancement, high order MU-MIMO, as well as high resolution precoding.

30 – China Unicom

We are supportive on both multi-TRP and multi-beams.

For multi-TRP, we support coherent joint transmission for intra-site and inter-site cases (including both indoor and outdoor scenarios) for FR1. We also support codebook/ CSI feedback enhancements for FDD case, more than 12 orthogonal DMRS ports, SRS enhancements, and smaller PRG size (1RB or smaller), etc.

For multi-Beam, we support a large number of array antennas (up to 4096 antenna elements at gNB) for FR2, and further enhancements on beam management, multiple panels (gNB).

31 – Samsung Electronics Co.

We support the following issues on multi-beam and multi-TRP.

•Multi-beam:

- Extension of unified TCI to multi-TRP including beam indication
- Reduced overhead/latency beam measurement/reporting, including UE-initiated beam management

•Multi-TRP:

- Different timing offsets between TRPs (DL asynchronous) with different DL RX timing (UE side)

32 – InterDigital France R&D

We are interested in the following topics;

- Multi-beam enhancements including latency reduction; We understand that beam management process need to be further enhanced to have adequate agility when gNBs operate with several narrow beams.
- Extend R17 TCI framework to mTRP; The unified TCI framework in Rel17 need to be extended to other related operation for two reasons; first to assure the other MIMO operation can benefit from this enhancements, and second; simplify UE procedure by avoid mix use of R17 and pre-R17 framework.
- UE coordination (grouping) based beam measurement and report; In many scenarios, e.g., HST, the fact the UEs are in proximity of each other is ignore, and hence each UE has to conduct its beam and CSI related operation individually. However, by employing UE coordination, a significant reduction in signaling can be expected, e.g., beam report, implicit/explicit CSI report.
- UE initiated beam selection and beam management; This topic has been discussed for a couple of release thus far, and we need to address this in R18. In brief, we need a faster raster response to channel and change in UE orientation to maintain reliability.
- Simultaneous multi-panel UL transmissions; Similar to the previous item, this topic has also been discussed for a couple of releases, but no luck so far. Basically, multi-panel UEs can achieve a higher throughput and also reliability by performing simultaneous transmission. To that end, we need to discuss topics such as multiple per panel TA, power adjustments.

2.4 Example Area 3: CPE (customer premises equipment)-specific considerations

Feedback Form 4: Detailed proposals or comments for this area

1 – Futurewei

For CPE-specific consideration, we are supportive in principle on enhancements in this area. However, the details are unclear and studies may be needed first.

2 – vivo Communication Technology

study use cases, scenarios, typical antenna assumption, gap analysis etc.

3 – Apple GmbH

We view this as low priority

4 – CableLabs

CableLabs

It may seem not explicitly stated, but we see the support for NR Fixed Wireless Access as important. As part of this subtopic, we consider the study of 4kQAM targeting FWA as relevant. It should be noted that IEEE802.11be includes 4kQAM.

5 – AT&T

We think CPE-specific enhancements are very important and should be specified. In particular, the following is to be considered to improve the parity between DL and UL MIMO in Rel. 18.

- UL TPMI enhancements
- Higher order SU-MIMO (>4 layers) in UL
- Simultaneous UL Transmissions (mTRP/mPanel enhancements)

6 – HuaWei Technologies Co.

For CPE-specific cases, the channel is more invariant, so the RS overhead can be reduced without decreasing demodulation performance.

Enhancements:

- DMRS reduction for the invariant channels in CPE-specific cases, (such as reduce the DMRS for the bundled slots, where the channel estimation is reusing the first slot in the bundled slots.)
- For high order modulation such as 4096QAM, the benefits are only limited in specific scenarios and require more complexity in implementation, so it should be low priority.

For the detailed discussion and performance evaluation can be found in our Tdoc RWS-210440.

7 – Guangdong OPPO Mobile Telecom.

Due to the larger form factor, it is possible for CPE to use more than 4 Rx antennas in order to achieve higher data rate. It has been supported by RAN1 spec, but the RAN4 counterpart is still missing. Thus, we propose to specify RAN4 work to support UE with more than 4 Rx antennas (e.g., 6Rx, 8Rx).

8 – Intel Corporation (UK) Ltd

We support objective related to CPE enhancements. We may consider separate work item for CPE related enhancements for both UL and DL. In terms of detailed descriptions, the following enhancements should be considered:

Objective#1: Specify support of higher order modulation such as 4096QAM (and above). Study and specify techniques (if sufficient gains are shown) to improve performance of PDSCH such as non-uniform constellation and constellation shaping.

9 – Qualcomm Incorporated

4096-QAM

With the widely development of 5G, CPEs and smartphones with large number of receive antennas become another important device type. Low mobility, high SNR and rank deficiency associated with line-of-sight CPEs motivate exploring the possibility of adding 4096-QAM support. While the constellation can be a straightforward extension of the 1024-QAM Gray mapping, we propose that additionally receiver side learning and error correction should be employed to mitigate the various impairments, caused by both the transmitter and receiver, which would make achieving the required high SNR very challenging otherwise.

10 – NTT DOCOMO INC.

We see it as low priority and we can study the use case/scenario first.

11 – Spreadtrum Communications

We support to study, if needed, specify the potential enhancements. In our views, some of the enhancements can be categorized into other areas such as CSI enhancement for zero speed, >4 UL Tx antennas, etc.

12 – Ericsson LM

While very supportive of the use case, we think it is already well served by the existing MIMO framework. We have not identified any specific improvements with sufficient gains that would justify the added complexity.

13 – ZTE Corporation

Overall views:

- Further enhancements on improving DL capacity should be considered, e.g., support >1 CWs for ≤ 4 DL layers, and the case of > 2 mTRP

Objective:

- Support of two codeword mapping (≤ 4 DL layers)
- > 2 mTRP operations (involving group based reporting, increase of DMRS port groups, etc.)

14 – Nokia Corporation

CPE considerations impact several of the areas above, e.g. Multi-TRP, but also impacts areas not in the scope of this email thread, e.g. UL MIMO.

15 – China Mobile Com. Corporation

We suggest to first study the use case and DL performance bottleneck with existing MIMO framework.

16 – MediaTek Inc.

Although we are fine to consider as low priority / defer to later Release, we do believe that there is potential scope for CSI reporting improvements exploiting time-domain correlation to maximize performance for such stationary devices.

17 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

- Input on issues/challenges identified from current CPE deployments should be the starting point of the discussion.
- Both fixed CPEs and vehicle-mounted CPEs can be considered based on practical deployments (FFS: whether fixed CPE applications are prioritized).
- Enhancements related to DMRS overhead reduction and modifications to the codeword to layer mapping rules can be studied.
- In addition to conventional use-cases of CPE for coverage extension and increased capacity, CPE should also be considered to better facilitate or offload some of the UE procedures to reduce UE complexity and high power consumption

- One use-case that can be a good starting point is for CPE to perform downlink RS measurements/reporting and leverage such measurements for determining beams and corresponding parameters for UEs in vicinity of the CPE.

18 – CEWiT

We support to study potential use cases. We should also consider re-organizing the requirements under different topics like

- DL Enhancements for CPEs (PDCCH , PDSCH, CSI, etc.,)

- Simultaneous UL transmission and >4 antennas for CPEs

19 – Spark NZ Ltd

The support of high level modulation schemes such as 1024/4096 QAM is unlikely to increase the channel capacity. It might result in higher peak rates at a specific location where there required SNR criteria are met, but the location is likely to be very limited and unlikely to have any customer benefit. The additional modulation scheme introduced is likely to result in increased complexity in managing MCS table mappings with UEs/Networks spending more time switching schemes to the detriment of overall throughput.

2.5 Other Proposals

Feedback Form 5: Other proposals for new areas other than given 3 example areas

1 – Apple GmbH

We are also interested in the MU-MIMO enhancement in the following area

- Enhancement to facilitate more advanced UE reception algorithm, e.g., scheduling information enhancement

2 – Qualcomm Incorporated

Adaptive DM-RS

Up to and including Rel-17, DL DM-RS structure/type can only be adapted by RRC reconfiguration and by using fallback DCI format, with the latter providing very little actual adaptability. It is beneficial to introduce means of faster adaptation by DCI or MAC CE, for example. This can be used in a variety of scenarios, including HST, mobility, MU-MIMO.

Higher number of orthogonal DM-RS ports

Establish the need and benefits first. If found beneficial, introduce new DM-RS structure, preferably with minimum changes.

Reciprocity-based DL MIMO considering UE receiver strategy

UEs with large number of receive antennas may adopt different receiver strategy, e.g., either jointly or separately process signals received from all or some of the antennas. If the CSI is obtained by exploiting channel reciprocity, the gNB needs to match its precoding to the UE receiver. It is beneficial to introduce mechanisms to avoid the mismatch and to support all applicable UE architectures.

3 – NTT DOCOMO INC.

We support to enhance high speed train demodulation requirement with 996Hz Doppler shift (e.g. 500mk/h@2.15GHz) with 15kHz SCS in bi-directional SFN, which is important for our NW deployment.

- Alt.1: Rel-17/18 RAN4 specifies demodulation requirement based on Rel-17 RAN1 HST-SFN. No RAN1 work is expected in Rel-18.
- Alt.2: Rel-18 RAN1 specifies 3-symbol gap TRS, and Rel-18 RAN4 specifies its demodulation requirement.

4 – InterDigital France R&D

We are open to discuss this topic but with a lower priority and limited scope.

3 Moderator's Initial Phase summary

Based on the feedback, Moderator has made an initial summary for sections from section 2.1 to section 2.5

3.1 Initial summary for Section 2.1

Generally, majority companies are fine for supporting DL MIMO enhancement, although a few companies think UL is more important in R18, and focus should be put on essential part rather than on further optimizing single MIMO design aspect. There are some suggestion to separate Multi-TRP and Multi-beam discussion.

3.2 Initial summary for Section 2.2 ”Example Area 1”

Proposals from each company are summarized as below, which in some some sense reflects the temperature of each items in Example Area 1, even it may not be a perfect picture of a proposal list.

- Example Area 1: Further enhancements for CSI (e.g., mobility, overhead, etc.)
  - Enhancement for high/medium mobility or accuracy
    - Time-domain correlation/doppler-domain based CSI feedback or overhead reduction
  - Enhancement for M-TRP URLLC
  - Miscellaneous (only 1 or 2 propose)
    - DMRS based CSI report/post-PDSCH decoding based CSI report
    - UE processing load (CPU) related CSI report
    - CSI enhancement for MU-MIMO in high mobility
    - CSI enhancement for faster enabling DL MIMO
    - Mobility dependent RS
    - Phase compensation CSI report

3.3 Initial summary for Section 2.3 ”Example Area 2”

Proposals from each company are summarized as below, which in some some sense reflects the temperature of each items in Example Area 2, even it may not be a perfect picture of a proposal list.

- Example Area 2: Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam
  - Asynchronous M-TRP/Multiple TA for M-TRP
  - Extend Rel-17 Unified TCI framework to M-TRP
  - Overhead and/or Latency reduction, very generic, may include, e.g.,
    - UE initiated beam management
  - Overlapped parts of Example Area 1 and Example Area 2
    - Coherent Joint transmission/D-MIMO
    - SRS enhancement
  - Leftover
    - Simultaneous UL transmission of multi-panel UE
    - Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1
  - Miscellaneous (only 1 or 2 propose)
    - Mixed mode of single-DCI and multi-DCI based M-TRP
    - PDSCH DMRS based synchronization
    - More DMRS ports
    - Smaller PRG size
    - Mobility with narrow beams
    - SPS/CG on top of DG for M-TRP
    - multi-PDSCH grant for M-TRP
    - Mobility dependent RS
    - CSI report with multiple hypothesis for assisting scheduling
    - Combined MTRP schemes
    - Cross-link BM
    - UE power consumption

3.4 Initial summary for Section 2.4 ”Example Area 3”

Proposals from each company are summarized as below, which in some some sense reflects the temperature of each items in Example Area 3, even it may not be a perfect picture of a proposal list.

- Example Area 3: CPE (customer premises equipment)-specific considerations, generally not so strong, potential objectives are on the table
  - Supportive of 4096QAM
  - Miscellaneous (only 1 or 2 propose)
    - > 4 UL Tx antenna
    - Optimization for stationary UE
      - Multiple CW
      - DMRS reduction
      - UL TPMI
    - CPE Assistant UE complexity reduction and power saving

3.5 Initial summary for Section 2.5 ”Other Proposals”

- Others (only 1 proposes)
  - More advanced UE reception algorithm for supporting MU-MIMO
  - Adaptive DMRS
  - High number of orthogonal DMRS ports
  - Reciprocity-based DL MIMO considering UE receiver strategy
  - TRS enhancement or RAN4 enhancement for HST

4 Intermediate Phase

based on the above initial summary, Moderator would like invite you to further input your views on each items of the brief summary.

4.1 Further discussion on the items in Section 3.2 ”Example Area 1”

Are you fine with the skeleton for Example Area 1? If each company is allowed to escalate single additional item from miscellaneous set to be an individual bullet, which is your preference? if your favorite is not included in the skeleton but in your initial round feedback, please feel free to raise it. ***Of course, if you like, you can list all items based on the order of your preference.***

Feedback Form 6: Are you fine with the skeleton for Example Area 1? Which is your favorite additional item for this area?

1 – Futurewei

Thanks for the initial summary. We have a few comments below:

- SRS enhancement for mobility was missing in the summary. In addition to CSI enhancements (e.g., for FR1), SRS enhancement for high mobility (e.g., for FR2) is also important as mentioned in our initial round of comments. This is also supported by multiple companies based on our reading.
- CSI enh. for MU-MIMO in high mobility should not be singled out and put under “Miscellaneous” set. It is at least our understanding that MU-MIMO is the target use case for CSI/SRS enhancements for high mobility.

With the above comments, we would like to make the following modifications:

o Enhancement for high/medium mobility or accuracy for MU-MIMO performance enhancements

 Time-domain correlation/doppler-domain based CSI feedback or overhead reduction as well as SRS enhancements.

With the above changes, remove “CSI enhancement for MU-MIMO in high mobility” from the “Miscellaneous” set.

2 – Intel Corporation (UK) Ltd

We support the first two bullets in Section 3.2 in principle. The remaining items need further discussion. We also suggest adding study phase to the objective in the first bullet to better understand required specification changes and expected performance gains.

3 – SoftBank Corp.

We have a serious concern that MIMO scope is tend to enormous while implementation is no so easy. Our suggestion is just to pick up zero or one topic from further CSI enh.

4 – AT&T

We are supportive of studying and specifying time-domain correlation/doppler-domain based CSI feedback for overhead reduction, applicable to MU-MIMO and for moderate to high mobility UEs.

We are also supportive of other overhead reduction techniques such as DMRS-based CSI feedback.

We are fine to support CSI enhancements for MTRP URLLC.

5 – Apple GmbH

Our preference for escalation is the second bullet in miscellaneous, i.e., UE processing load (CPU) related CSI report. To be more accurate, we prefer the CSI reporting enhancement to accommodate UE with dynamic CSI processing load/condition

We would also like to understand the scope of the second bullet ”Enhancement for M-TRP URLLC” better.

6 – Spreadtrum Communications

We support CSI enhancement for high/medium mobility or accuracy. This is a big topic which may include procedural enhancement and/or codebook design. For the other issues, they can be discussed conditioned by a resaonable workload.

7 – Samsung Research America

Comment on Example Area 1:

The CSI enhancement for C-JT (distributed RRH), targeting use cases of interest to several FR1 operators, is missing. This enhancement includes C-JT codebook and CSI reporting for >32 ports. Some other aspects such as RS design and interference measurement with dynamic RRH selection can be addressed in mTRP (example area 2).

Enhancement for high/medium mobility scenarios or accuracy can be studied for potential spec enhancements which includes Rel.16 Type II codebook extension to time/Doppler domain.

Re CSI for MTRP URLLC and items in miscellaneous, numerous schemes have been proposed/discussed since Rel-15 and (in Rel-17 URLLC) have been excluded. If this amounts to repeating fruitless discussion in Rel-17 URLLC WI, it is not justified. Proponents are encouraged to converge on a few particular schemes considering the limited scope.

Proposal:

- Add the following bullet: “Enhancement for coherent-JT including codebook and CSI reporting”
- Clarify a well-defined scope for “Enhancement for M-TRP URLLC”

8 – HuaWei Technologies Co.

We cannot accept the CSI enhancement for mobility only for FDD case with CSI feedback. The mobility issue is for both TDD and FDD, while much more deployment of TDD currently. CSI enhancement needs include SRS based enhancement for TDD. So, SRS enhancement should be included, we also see there are multiple companies proposed it.

9 – Guangdong OPPO Mobile Telecom.

We support the first bullet.

For CSI for M-TRP URLLC, there were discussions in previous releases. However, the benefit/gain seems not justified based on previous discussion. For example, RAN1 are not sure whether additional CQI enhancement would be beneficial for reliability. Thus, it is preferred to refine a clear scope for this topic, and then check whether it should be in R18 WID or not.

For the part of miscellaneous, we think further discussion is needed since most of them (if not all) were discussed several times and not got much support.

10 – Qualcomm Incorporated

We are fine with the proposal.

From the miscellaneous list, we prefer the first bullet "DMRS based CSI report/post-PDSCH decoding based CSI report". We think this scheme has the benefit of providing additional CSI feedback on top of existing CSI-RS based CSI feedback. The additional CSI feedback can help the gNB make better scheduling decision such as selecting better MCS for a retransmission/new transmission. In Rel-17 URLLC, post-PDSCH decoding based CSI report is still under discussion. If post-PDSCH decoding based CSI report is adopted in Rel-17, this proposal is a natural continuation to extend the CSI report to DMRS based. If post-PDSCH decoding based CSI report is not adopted in Rel-17, Rel-18 should consider adopting CSI report based on DMRS and PDSCH decoding.

We would like to understand what's included in a "UE processing load (CPU) related CSI report". Any detailed examples?

11 – SHARP Corporation

We are fine with the first two bullets

1. CSI enhancement for medium-high mobility UE or overhead reduction by exploiting the time-domain correlation

2. CSI enhancement for MTRP URLLC

12 – vivo Communication Technology

list of items is too large, scope of work should be limited. CSI enhancement has evolved from Rel-15 to Rel-16/17. Further enhancement to supporting medium/high mobility scenario should be considered for TDD based on reciprocity with SRS enhancement, this is missing in the summary.

13 – LG Electronics Inc.

Overall, we think that the scope of CSI enhancement is too large. Agree with some comments from other companies that motivation for further CSI enhancement is not strong.

14 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

In general, as a first step, listing the potential topics for CSI enhancements in the skeleton is ok.

Regarding enhancements for M-TRP URLLC, we think we need to first study the gains relative to Rel-17 mTRP CSI enhancements, identify specific enhancements and specify if sufficient gains are shown.

CSI enhancement for MU-MIMO in high mobility can be included in the general Enhancement for high-/medium mobility or accuracy topic.

CSI enhancement for new M-TRP transmission schemes (e.g., CJT/D-MIMO, dynamic TRP selection and dynamic TRP pairing), if agreed, should be considered as well.

15 – CATT

CSI enhancements are essential to MIMO operation. However, it seems that the scope for CSI enhancements as in current version of Example Area 1 should be more focused on some certain critical issues which have not been considered during the past few releases. For example, majority companies think that CSI for medium to high mobility should be enhanced in Rel-18, and we also observed the potential gain with enhanced CSI feedback mechanism in such cases.

16 – NEC Corporation

Thanks for the summary. We are fine with the skeleton.

It might be possible also to mention here in example area 1 CSI enhancement for CJT, as overlapped part of area 1 and 2.

We do not plan to pick any additional item from miscellaneous set.

17 – Beijing Xiaomi Mobile Software

We are supportive of the first bullet: enhancement for high/medium mobility or accuracy. While for the second bullet: enhancement for M-TRP URLLC, more detailed information about it should be provided first, then we can decide to support it or not considering the MIMO scope.

18 – Fraunhofer IIS

We are fine with the skeleton and support the first bullet. Similar to other companies we think that for the remaining proposals further discussion is needed.

19 – China Mobile Com. Corporation

We support CSI enhancements for MTRP URLLC. However, we suggest adding some detailed directions to better understand the required specification changes and expected performance gains. In Rel-17, we have discussed CSI enhancements based on the Multi-TRP transmission scheme for eMBB. For Rel-18, we are also supportive to study CSI enhancement for single DCI based FDM and TDM schemes for Multi-TRP URLLC .

20 – ZTE Corporation

Firstly, we think the following two misc bullets can be merged into the enhancement for URLLC with high priority as well, considering that all of them are relevant to provide the reliability and flexibility for URLLC transmission. Meanwhile, it seem unnecessary to limit it into mTRP-only.

- DMRS based CSI report/post-PDSCH decoding based CSI report

- UE processing load (CPU) related CSI report

Therefore, we have the following suggestion:

- Enhancement for sTRP/mTRP URLLC, including CSI triggering flexibility considering CPU occupation restriction and DMRS based CSI report/post-PDSCH decoding based CSI report

Among the above (also related to QC's clarification question), we think it is important to enhance CSI triggering flexibility for fast CSI feedback targeted for URLLC service. In the current spec, if CPU is occupied, there is no chance for gNB to trigger fast CSI. This causes high CSI latency for URLLC service, which is an issue identified from deployment. It needs to be relaxed considering UE processing complexity.

Then, in our views, the usage and benefit for ''Time-domain correlation/Doppler-domain based CSI feedback'' in the first bullet should be justified before capturing them into the candidate sub-objective in DL-MIMO WID.

- Generally speaking, 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.

21 – LG Uplus

Firstly, thanks for your efforts on summarizing the initial round. However, please consider our concerns as following;

As similar concern by Samsung, here seems some missing points to consider C-JT (Coherent Joint-Trasmission) usage scenario. **We suggest to reorganize the features with usage scenario.** In our view, **regarding C-JT usage scenario**, the following seems essential.

- C-JT codebook and CSI reporting for various combinations of # of ports (e.g. 16+16+32, 64+64, 8+8+16+16, etc)
- SRS enhancement is essential but missing for TDD (We agree with Huawei.)
- Phase compensation CSI reporting for FDD

22 – Nokia Corporation

In general the summary seems to capture most of what has been proposed by the different companies, however enhancements on CSI processing timeline are notably missing, despite being proposed by some companies. Hence, we propose the following modification to the first bullet:

- Enhancement for high/medium mobility or accuracy
  - Time-domain correlation/doppler-domain based CSI feedback or overhead reduction
  - **Lower the latency of initial acquisition and improve the CSI processing timeline**

From the miscellaneous topics, "post-PDSCH decoding based CSI report" would be relevant, and it relates to Enhancement for M-TRP URLLC, which is also a relevant area. Having said that, it should be noted that the current list of topics is way too large, and we expect heavy pruning when preparing the WID for Rel-18.

23 – VODAFONE Group Plc

We are supportive of studying time-domain correlation/doppler-domain based CSI feedback or overhead reduction for overhead reduction applicable for moderate to high mobility UEs. We are also supportive of other overhead reduction techniques such as DMRS-based CSI feedback.

24 – CEWiT

Below are our views on Example Area 1

- We are fine with the first two bullets

- Regarding Miscellaneous, we support Samsung's suggestion in including a sub-bullet for "Enhancement for coherent-JT". Since in Area 2 we are already mentioning this as a overlapping topic, we can include this as another sub-bullet.

25 – Fraunhofer IIS

We are fine with the skeleton. As already mentioned by other companies, we also think that "Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1" is applicable to single-TRP and multi-TRP and belongs to "Extend Rel-17 Unified TCI framework to M-TRP".

26 – Fraunhofer IIS

Our comment (#25) belongs to "Example area 2". Please ignore it here.

27 – NTT DOCOMO INC.

Thank you for the nice summary. We support the first two bullets in Section 3.2. The remaining items need further discussion.

28 – Ericsson LM

First a few comments:

- We believe the "DMRS based CSI report/post-PDSCH decoding based CSI report" comes from Ericsson input. We'd like to clarify that our proposal is not to use DMRS, instead to use post-PDSCH decoding information. Using DMRS has many drawbacks and doesn't reach the full potential of post-decoding CSI reporting. Unless there are other companies proposing to use DMRS bases CSI-report, we suggest that this part is deleted: "DMRS based CSI report"
- We think the first bullet can be generalized to *'CSI Enhancement for high/medium mobility UEs and/or improved accuracy and/or reduced CSI reporting and RS overhead'*
- We think it is better to clarify this additional item 'CSI enhancement for faster enabling DL MIMO ***after initial access and handover***'

Then, our favorite additional items to be escalated are (in order of preference):

- post-PDSCH decoding based CSI report
- UE processing load (CPU) related CSI report (related to mixed URLLC and eMBB)
- CSI enhancement for faster enabling DL MIMO after initial access and handover

29 – MediaTek Inc.

Yes, we support progressing:

- Enhancement for high/medium mobility or accuracy
  - Time-domain correlation/doppler-domain based CSI feedback or overhead reduction

30 – InterDigital France R&D

We are generally OK with the first two bullets (CSI for high mobility and enhancements for mTRP URLLC), however further clarifications needed for mTRP URLLC discussion to avoid any scope creep.

As for the Miscellaneous list, despite the potential value and importance of each item, we should remove some of them to have a manageable workload. In particular, we should avoid copy/paste Miscellaneous items under further details of one the main bullets. For example, such proposal should not be considered;

Enhancement for x, including Miscellaneous-Topic1, Miscellaneous-Topic2, Miscellaneous-Topic3.

4.2 Further discussion on the items in Section 3.3 ”Example Area 2”

Are you fine with the skeleton for Example Area 2? If each company is allowed to escalate single additional item from miscellaneous set to be an individual bullet, which is your preference? if your favorite is not included in the skeleton but in your initial round feedback, please feel free to raise it. ***Of course, if you like, you can list all items based on the order of your preference.***

Feedback Form 7: Are you fine with the skeleton for Example Area 2? Which is your favorite additional item for this area?

1 – Futurewei

Thanks for the initial summary. We have the following comments:

- We also proposed a cooperative MIMO feature in initial round, that is Cooperative massive MIMO (e.g., spatial domain interference avoidance via Bi-directional Training (BiT)). We suggest changing the first sub-bullet under “Overlapped parts of Example Area 1 and Example Area 2” from “Coherent Joint transmission/D-MIMO” to “Cooperative MIMO (e.g., coherent joint transmission, D-MIMO, spatial domain interference avoidance via Bi-directional Training (BiT))”.

2 – Intel Corporation (UK) Ltd

We support the first three bullets in Section 3.3 in principle. The remaining items needs further discussion. Below our comments for the 2nd round.

1. “Overhead and/or Latency reduction” should be further clarified as “Overhead and/or Latency reduction for beam management procedures”. The corresponding item can be made even more focused by considering overhead and/or latency reduction for beam acquisition procedures.

2. We are not sure why simultaneous UL transmission has been mentioned as part of DL MIMO enhancement in the 5th bullet (leftover). Similar proposals are being discussed under UL enhancement, so we don’t need the same discussion/objective.

3. “Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1” can be treated under “Extend Rel-17 Unified TCI framework to M-TRP” and, therefore, can be also removed from the fifth bullet or added as subbullet under “Extend Rel-17 Unified TCI framework to M-TRP”.

3 – AT&T

We are supportive of the moderator’s summary in principle for the main bullets.

- On the leftover topics, we support to specify number of indicated DL and UL states for the unified TCI framework beyond rel. 17 e.g. M>1, N>1. This is applicable to both single and multi-TRP scenarios.
- On the leftover topics related to simultaneous UL transmission of multi-panel UE and fast UL selection, this seems to overlap with the objectives in UL enhancements. Nevertheless, regardless of which WID this is included in, we believe this item is very important to specify.
- On the miscellaneous items, we believe it is important to study and specify BM enhancements related to use cases other than eMBB, that require taking into account power control and interference management aspects, including CLI and self-interference.

4 – Apple GmbH

Our preference in order is

- Overhead and/or Latency reduction. As suggested by the moderator, the scope can be generic, at least for us, it can include the following topics
  - UE initiated beam management
  - Beam failure recovery enhancement to consider UL beam status
  - UE coordination based beam measurement and report
- Extend Rel-17 Unified TCI framework to M-TRP

5 – HuaWei Technologies Co.

MTRP and Multi-beam are better to be separate discussion. Then, for the listed items, we have the following comments:

1. For Overhead and/or Latency reduction, similar view as Intel, since the same thing discussed in R17 as well for beam indication, it is better to mention the target scenario: such as for narrow beams, for beam acquisition. Suggest to change as

“Overhead and/or Latency reduction (for narrow beams sweeping, beam acquisition, etc.), may include, e.g.,..”

2. For overlapped areas, we are fine for SRS enhancements discussed jointly in Area 1. Coherent joint transmission is for MTRP, so should be discussed in Area 2.

3. For the DMRS enhancement with more orthogonal ports and finer PRG, we observed multiple companies proposed, not only 1 or 2 companies. It is also very important for supporting high order MU-MIMO for high spectrum efficiency for M-TRP cases. So, it is better to be listed as examples for coherent joint transmission.

4. Leftover part is not needed as Intel pointed out. First sub bullet is for UL, second one is overlapped with unified TCI for MTRP.

6 – Samsung Research America

Comment on Example Area 2:

In general, UL/DL mTRP and multi-beam should be combined under one WI given the unified TCI framework developed in Rel-17 applies to UL and DL channels. We propose to include UL mTRP and UL multi-beam in this example area 2 (remove from UL enhancement).

Regarding overlap between area 1 and 2 on C-JT, a good solution would be to partition the work as follows (see comment on Example Area 1):

o Area 1: codebook and CSI

o Area 2: interference measurement for dynamic RRH selection, RS enhancement for >32 CSI-RS ports and potentially >8-layer DMRS as well as SRS to aid TDD CSI acquisition, and study on the need for UE-assisted inter-RRH calibration

Therefore, C-JT transmission can stand on its own.

The bullets under 'left-over' category should be rearranged as follows (since these items are not left over):

o 'Simultaneous UL ...' to UL enhancement (under thread 02) à remove from example area 2

o 'M/N>1' should be under 'Extension Rel-17 Unified TCI framework ...' (note that the extension can be used for other purposes, not only mTRP, but also inter-cell)

In Rel-17, the following schemes for overhead/latency reduction (under 8.1.1 'Issue 6') should also be included:

- Fast beam tracking and refinement.
- Group-based beam management

Proposal:

o Revise 2nd bullet as follows: "Extension of Rel-17 Unified TCI framework for indication of M>1 DL and N>1 UL TCI states, especially targeting mTRP and inter-cell use cases"

o Add 2 more examples under the third bullet: 1) fast beam tracking and refinement, 2) group-based beam management

o Replace 4th bullet by the following: "Enhancements for coherent joint transmission (C-JT) including dynamic RRH selection, RS enhancement (CSI-RS, DMRS, SRS), and study on the need for UE-assisted inter-RRH calibration"

o Remove 5th bullet and move UL simultaneous transmission to UL enhancement (thread 2)

7 – Guangdong OPPO Mobile Telecom.

For asynchronous M-TRP/Multiple TA for M-TRP, we have several comments as below

- it needs to be clarified that whether it focuses on FR2 or not?
- it is not clear about performance of asynchronous M-TRP so far. Thus, the first step should be to evaluate the performance and then we may go to discuss the solutions only the performance gain of the asynchronous scenario is justified by evaluation results.

- It should be clarified what value is assumed for the timing difference of different TRPs

For Extend Rel-17 Unified TCI framework to M-TRP, it needs to be clarified that whether it is only extended to Rel-16 DL M-TRP, or all the M-TRP enhancement in Rel-16/17. For the latter case, the scope may be too large and we need to check the benefits over the current scheme and workload case by case. One more thing, the sub-bullet of "Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1" of the leftover seems the same as or similar to the 2nd bullet "Extend Rel-17 Unified TCI framework to M-TRP"

Coherent Joint transmission was discussed and specified in LTE but never applied in practical deployments. The gain over NC-JT should be justified

8 – Qualcomm Incorporated

We are generally ok with the proposal, although would suggest the following modification:

- Leftover
  - Simultaneous UL transmission of multi-panel UE, and other use cases for panel specific UL Tx agreed in R17
  - Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1

For BM latency/overhead reduction, at least the following aspects can be considered in addition to UE initiated BM

- Pre-determined beam switch for HST/IIOT scenarios
- Beam updating DCI triggered beam measurement/report
- Beam management for initial access
- NACK triggered beam sweep/refinement

From the miscellaneous list, we prefer the bullet "SPS/CG on top of DG for M-TRP".

9 – SHARP Corporation

We are generally OK with the proposal.

From our perspective, we are supportive for asynchronous MTRP, UE-initiated beam management, and simultaneous UL transmission of multi-panel UEs.

10 – vivo Communication Technology

the list of items above is too large, need to identify real life issues at network and UE side. Rel-18 enhancement of multi TRP and multi beam should talk Rel-17 as baseline, remaining issues in RAN1/2/4 should be prioritized. CBM (common beam mode) is discussed extensively in RAN4 in Rel-17, which is beneficial for UE operation in FR2 inter-band CA scenario, and should be further optimized in RAN1 in Rel-18.

The first bullet "asynchronous MTRP/ Multiple TA for M-TRP" should be clarified whether it is for inter-cell MTRP.

SRS enhancement (requirement) for Example Area 1 and Example Area 2 may be different, hence should be captured in both areas.

11 – LG Electronics Inc.

We suggest to add multi-panel UE into the first bullet as 'Asynchronous M-TRP/Multiple TA for M-TRP/MPUE' since each TRP can be mapped to each panel. This bullet and STxMP are our first priority items but the scope seems overlapped with UL enhancement.

Another comment is that 'Mixed mode of single-DCI and multi-DCI based M-TRP' seems to be a special case of 'Combined MTRP schemes'. So they can be merged.

12 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

On Overhead and/or Latency reduction, in addition to UE initiated beam management, Grouping/sharing based and prediction-based beam management should also be considered.

The extension of the Rel-17 Unified TCI framework with M>1 and/or N>1 is applicable to both S-TRP and M-TRP. BFR should also be enhanced based on the extended Unified TCI framework.

Regarding Coherent Joint transmission/D-MIMO, we believe the Rel. 17 M-TRP CSI framework can still be functional for CJT, although it may be suboptimal. Realistic assumptions on the coherence between TRPs, as well as criticality and commercial interest of this feature from operators should be assessed. So, CJT is lower priority.

For SRS enhancement, we believe this should be discussed under R18Prep-02 for UL enhancements to avoid overlap. Also, Simultaneous UL transmission of multi-panel UE should be limited to beam management aspects in this email discussion with other aspects discussed under R18Prep-02.

Other Rel-17 leftovers after the November RAN WG meetings that could not be completed due to time-constraints should also be considered.

13 – CATT

We are a little bit confused about why mTRP and multi-beam related issues are mixed together in Example Area 2. For enhancement of mTRP in Rel-18, from performance perspective and considering the possible time budget available, we suggest to focus on the items which may lead to more fundamental improvement at least in the initial phase. Among all the potential enhancement, we suggest to prioritize C-JT.

14 – NEC Corporation

Thanks for the summary. We are fine with the skeleton in general.

For additional item from miscellaneous set, we would pick 'Combined MTRP schemes'. We are interested in combined mode to provide more reliability and robustness (e.g. SDM/FDM/TDM schemes for PDCCH/PDSCH) based on unified TCI framework. We believe it can be included in the second bullet.

In addition, for the second subbullet for leftover, i.e., 'Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1', we believe it could also be included in the second bullet.

Therefore our suggestion can be accommodated by the following update:

- Extend Rel-17 Unified TCI framework to M-TRP, e.g.
  - Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1
  - Combined MTRP schemes

Moreover, for the third bullet, it might be more accurate to say 'overhead and/or Latency reduction for multi-beam operation'. And it would be appreciated if our proposal 'prediction-based BM for cases with

fixed/predictable trajectories' could be included as an example for this bullet, which was also mentioned at least by Lenovo/MotM in this round of email discussion and other companies during RWS in June.

15 – Sony Corporation

Thanks for the nice summary.

Regarding the skeleton, we tend to believe it would be better to split DL M-TRP transmission and multi-beam operation as we did in Rel.16/17. Otherwise the work load may get overwhelming from our experience in Rel.17 MIMO.

Secondly, we understand the intention of initial round is to capture and categorize all inputs. But to avoid overlapping with UL enhancement, we hope the pure UL-related enhancement can be coordinated, e.g. simultaneous UL Tx of multi-panel UE, multiple TA for mTRP and SRS enhancement (if not for 'Antenna Switch' purpose).

16 – Beijing Xiaomi Mobile Software

We supportive of topics listed below:

− Example Area 2: Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam

- Leftover
  - Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1
  - Dynamic switching between joint TCI state and separate TCI state
  - Simultaneous UL transmission of multi-panel UE
- Extend Rel-17 Unified TCI framework to M-TRP
- Overhead and/or Latency reduction, very generic, may include, e.g.,
  - UE initiated beam management
- Asynchronous M-TRP/Multiple TA for M-TRP

As for simultaneous UL transmission of multi-panel UE, we are also fine if it will be discussed in UL enhancement.

17 – ZTE Corporation

Regarding second bullet 'Extend Rel-17 Unified TCI framework to M-TRP', we prefer to make this bullet a little bit general, considering that the extension for unified TCI framework may also involve inter-band or repurposing the field in DCI without DL assignment. Please review the following revision that also capture the second sub-bullet in leftover:

- Extend Rel-17 Unified TCI framework <u>with M>1 and N>1, e.g., for multi-band, for multi-TRP.</u>

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

Regarding Coherent JT, we are open to reconsider it but some justification is needed. In our views, coherent JT has been specified in LTE, but there are few corresponding deployments (unfortunately). Furthermore, for many cases, coherent JT can be implemented in a spec-transparent manner. It could be better for others to understand if we can have better description on the detailed enhancements the proponents are looking at for coherent JT.

18 – Spreadtrum Communications

We would like to focus on the enhancements that can improve operation efficiency. Therefore, our preference are 'Extend Rel-17 Unified TCI framework to M-TRP' and 'Overhead and/or Latency reduction (for beam management)'.

19 – China Mobile Com. Corporation

We suggest the following modifications:

1□"Extend Rel-17 Unified TCI framework to M-TRP"and "Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1"in Leftover have some overlapped issues, and can be merged to "Rel-17 Unified TCI framework extend to M> and/or N>1";

2) Simultaneous UL transmission of multi-panel UE in Leftover should be discussed in thread 02-UL enhancement.

20 – Nokia Corporation

We cannot identify the following topic from the list, though it has been proposed in the initial phase of discussions by a few companies:

- **Multi-codeword encoding for Multi-TRP transmission with single-DCI**

The following bullet has been proposed under multi-beam enhancements. We would like clarification if it is assumed to be included in "Extend Rel-17 Unified TCI framework to M-TRP" or not. It is not exclusively for M-TRP, as it is a general extension of the TCI framework, though. In any case it seems that explicitly capturing it would be more appropriate, as it is in the same level of detail as other topics that are explicitly mentioned, and hence we propose the following modification:

- Extend Rel-17 Unified TCI framework to M-TRP
  - **Support dynamic operation with joint and separate DL and UL TCI states**

Under latency and overhead reduction there is an indication that it is very generic but at the same time one example is listed. Here we believe it is important to be consistent, and hence we either list it as a generic enhancement, without any examples, or list all proposals in this area. We prefer the second approach as this gives more clarity to the scope of the discussion, and hence at least the following should be listed under latency and overhead reduction, as it leads to improved beam alignment procedure, consequently reducing overhead from measurements/reporting and improving latency on triggering of measurements:

- **Support of P3 narrow beam alignment procedures**

Finally, the following topic is missing from the summary altogether, which is an extension of Rel-15/16 DCI based interference indication (DMRS CDM group and ports) to support explicit indication of beam level interference for the UE. Explicit indication would allow UE determine its RX beam(s) according to indicated interference situation:~~:~~

· **Enhanced interference indication**

In any case, it should be noted that the current list of topics is way too large, and we expect heavy pruning when preparing the WID for Rel-18.

21 – LG Uplus

Our most priority is on the C-JT with the combination of various types of RUs (or Antennas). Hence, interesting features are as following;

- C-JT codebook and CSI reporting for various combinations of # of ports (e.g. 16+16+32, 64+64, 8+8+16+16, etc)
- SRS enhancement is essential but missing for TDD
- Phase compensation CSI reporting for FDD
- Interference measurement for dynamic selection of group of RUs by SRS or CSI reporting

We can also be interested in UL multi-TRP reception for coverage enhancement.

22 – CEWiT

Below are our preferences in Example Area 2:

- We support first two bullets and the overlapped parts.

- Regarding the leftover , we also recommend merging those sub-bullets under UL enhancements and Unified TCI framework

23 – Fraunhofer IIS

We are fine with the skeleton. As already mentioned by other companies, we also think that "Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1" is applicable to single-TRP and multi-TRP and belongs to "Extend Rel-17 Unified TCI framework to M-TRP".

24 – Asia Pacific Telecom co. Ltd

We are fine with current skeleton in principle. Some comments are provided as follows. Regarding the second bullet, it seems also related to supporting M/N >1 as listed in Leftover part. In addition, we are not sure whether it's appropriate to discuss simultaneous UL transmission of MP-UE here. In last, we support including BFR considering UL in the skeleton.

25 – NTT DOCOMO INC.

We think UL enhancement is more important than DL enhancement in Rel.18, and the work scope of DL MIMO should be much smaller than UL enhancement.

We can support the first three bullets in Section 3.3.

We think UL enhancement (e.g. Simultaneous UL transmission of multi-panel UE, and SRS enhancement) should be discussed in [RAN93e-R18Prep-02].

26 – Ericsson LM

First a few comments:

- For mTRP, the "Asynchronous M-TRP/Multiple TA for M-TRP" may need some clarification, i.e., for sDCI or mDCI? Multiple TA can be one of the solutions to deal with large time offset between TRPs, but not necessarily the only solution. We prefer to define the problem and use case first, e.g., time differences among TRPs are larger than the CP. On the other hand, this topic may fit better under UL enhancement discussion.
- "simultaneous UL transmission of multi-panel " can be removed since this is an UL enhancement, and not relevant for DL MIMO. We do not see this as a leftover – it was never considered in Rel-17.
- The 2nd sub-bullet of the 5th bullet (Number of indicated…) is essentially the same as the 2nd bullet (unified TCI states) , and could be combined (one of them to be removed)
- More DMRS ports is in our view not MTRP related (although highly important), so we suggest to remove this from MTRP and discuss this enhancement under example area 4 instead
- Further overhead and/or latency reduction beyond the Rel-17 functionality must be clearly motivated.

Then, our favorite additional items to be escalated are (in order of preference)

- Mixed mode of single-DCI and multi-DCI based M-TRP
- SPS/CG on top of DG for M-TRP
- PDSCH DMRS based synchronization

27 – MediaTek Inc.

On the moderator bullets, we have the following comments:

- In our view the following should also be captured under the latency and overhead reduction bullet, as the unified Rel-17 framework is defined to reduce latency and overhead:
  - Extension of Rel-17 unified TCI framework, to support M,N > 1 at least for multi-TRP
- Simultaneous UL multi-panel Tx should not be classed as a Rel-17 leftover, and is being discussed in the UL enhancements email thread.
- Asynchronous multi-TRP: We do not support this, but, some companies have argued that for FR2 the beams could be orthogonal at the UE, but interference would still exist in practice in our view. Therefore, receiver performance degradation should be assumed at the UE. Further clarity is also necessary on what sort of timing misalignment companies are really considering here.
- Coherent JT/D-MIMO: Considering some of the other comments about LTE CoMP, it might be a good idea to not rush into specifying this in Rel-18, and instead take some time to study to ensure we specify it for NR in a manner that will get market traction.

28 – MediaTek Inc.

Just to add that for Async M-TRP we are ok to consider some level of UL TA difference (as commented in the UL enhancements thread). And agree with others that the problem scenario really would need more analysis first.

29 – InterDigital France R&D

Again, we find the list too crowded and not realistic.

In our view, for this item we should have the main focus on the third and fifth bullets, as follows;

○ Leftover

 Simultaneous UL transmission of multi-panel UE

 Number of indicated DL and UL states beyond Rel-17, e.g., M> and/or N>1

 Asynchronous M-TRP/Multiple TA for M-TRP

 Extend Rel-17 Unified TCI framework to M-TRP

○ Overhead and/or Latency reduction, very generic, may include, e.g.,

 UE initiated beam management

As for CJT, we share a similar view as several other companies that CJT should be treated with a lower priority.

A kind reminder that we should avoid copy/paste Miscellaneous items under further details of one the main bullets. For example, such proposal should not be considered;

Enhancement for x, including Miscellaneous-Topic1, Miscellaneous-Topic2, Miscellaneous-Topic3.

4.3 Further discussion on the items in Section 3.4 ”Example Area 3”

Are you fine with the skeleton for Example Area 3? If each company is allowed to escalate single additional item from miscellaneous set to be an individual bullet, which is your preference? if your favorite is not included in the skeleton but in your initial round feedback, please feel free to raise it. **Of course, if you like, you can list all items based on the order of your preference.**

Feedback Form 8: Are you fine with the skeleton for Example Area 3? Which is your favorite additional item for this area?

1 – Futurewei

Thanks for the initial summary. We are ok with the sub-bullet “DMRS reduction” since it can lead to reduction of overhead and UE complexity. Regarding “Supportive of 4096 QAM”, it is unclear the possible gain and the related increased complexity.

2 – Intel Corporation (UK) Ltd

We support introduction of 4096QAM for NR. In addition we think that the corresponding objective should consider techniques improving efficiency of the corresponding modulation scheme under practical impairments. The examples of such schemes are non-unform constellation, constellation shaping, etc.

3 – AT&T

- We are supportive of the introduction of 4096QAM for DL.

- On the miscellaneous items, related to UL enhancements, such as support of >4Tx and TPMI enhancements, we are supportive of specifying these enhancements for CPE. The scope of these enhancements, however, seems to be more fitting for the UL enhancements item.

4 – HuaWei Technologies Co.

For CPE, since the channel is invariant, DMRS overhead is obviously can be reduced, where about 15% performance gain can be observed in our evaluation in RWS-210440. So, it is should be prioritized. It is also supported multiple companies, so better to listed separately. For 4096QAM, we have concerns on the use cases and benefits, both aspects are limited in real network. Furthermore, the complexity of 4096QAM need to be further studied.

5 – Samsung Research America

Comment on Example Area 3:

The support of >4Tx UL antennas and UL TPMI should fall under UL enhancements (thread 2).

Proposal: Consider the following examples under Miscellaneous as a part of UL enhancement (thread 2): 1) >4 UL Tx antennas, 2) UL TPMI

6 – Guangdong OPPO Mobile Telecom.

From our understanding, 6/8Rx is more important than 4096QAM. It is preferred to trigger RAN4 work to support it. Regarding 4096QAM, it can be used in only very limited scenarios. Thus, it is with lower priority in our view.

Not sure whether it is a typo for the 1st sub-bullet of Miscellaneous (UL -> DL) scine this email thread is for DL MIMO

7 – Qualcomm Incorporated

We are fine with the proposal on supporting 4096-QAM for CPEs.

From the miscellaneous list, we prefer the bullet "> 4 UL Tx antenna" for CPEs.

8 – SHARP Corporation

We are fine with the proposal.

In addition, we prefer to study >4 UL Tx antennas for CPE.

9 – vivo Communication Technology

UL enhancement should be discussed in related thread "RAN93e-R18Prep-02". Current specification already supports up to 8 layers in DL, need to identify CPE specific enhancement, if any.

10 – LG Electronics Inc.

To our understanding, > 4 UL Tx antenna is already captured as an example for UL enhancement item. If needed, enhancement scope needs to be justified from DL perspective to fit into this thread.

11 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

We support studying enhancements for fixed CPEs as well as mobile CPEs, which can also be helpful for scenarios in which the CPE is mounted on top of a vehicle (discussed in RAN4). Additionally, CPE use cases for assisting hand-held UEs to reduce complexity and improve power saving should be studied.

Regarding "> 4 UL Tx antenna" and "UL TPMI", we believe these two features should be better discussed under R18Prep-02 for UL enhancements to avoid overlap.

12 – ZTE Corporation

First of all, it seems that our following proposal has not been considered.

- > 2 mTRP operations (involving group based reporting, increase of DMRS port groups, etc.)

Then, in our views, 'multiple CW' enhancement should have high priority.

Finally, we have some concerns on the supportive of 4096 QAM. In our views, the benefits for this feature may be limited, but we have to experience a serious implementation complexity increase for both RF and Baseband in gNB and UE sides.

13 – China Mobile Com. Corporation

In our view, the market share of CPE is not large. We suggest to first clarify the use case and the necessity to introduce 4096-QAM.

14 – Spreadtrum Communications

Support to study CPE enhancement. We suggest to also include overhead reduction for CSI.

15 – Nokia Corporation

As noted earlier, we see CPE related enhancements as covered by several different functionalities, and not necessarily a specific area in itself. Given the very large number of topics already being addressed in this discussion, we do not see a particular need to add more objectives.

16 – CEWiT

In general we support enhancements targeting stationary CPEs. And in second bullet, we support >4 Tx antennas for CPEs and also DMRS reduction.

17 – NTT DOCOMO INC.

We think CPE enhancement is low priority. But, we can consider 4096QAM to improve CPE performance.

UL enhancement (e.g. > 4 UL Tx antenna, and UL TPMI) should be discussed in [RAN93e-R18Prep-02].

18 – Ericsson LM

We don't see a need for CPE specific enhancements, although we very much support the CPE and FWA use cases

19 – InterDigital France R&D

Given the workload, we consider this item a low priority discussion.

20 – CableLabs

We support 4096QAM for FWA applications

4.4 Further discussion on the items in Section 3.5 ”Other Proposals”

what’s your views on the items of the ”Section 3.5 Others”, which item would you support if you are allowed to select only one from the list? You can just ignore this part if you are not interested in part. If your favorite is not included in the skeleton but in your initial round feedback, please feel free to raise it. **Of course, if you like, you can list all items based on the order of your preference.**

Feedback Form 9: Which item would you support?

1 – Futurewei

Thanks for the initial summary. Regarding the sub-bullet “High number of orthogonal DMRS ports”, it seems there is also one sub-bullet “More DMRS ports” listed under “Miscellaneous” set for “Example Area 2” in Section 3.3. If these two are talking about the same thing, maybe they can be considered together.

2 – Intel Corporation (UK) Ltd

If there are sufficient TUs for DL MIMO enhancement in Rel-18, we also support the following two objectives:

- TRS enhancement or RAN4 enhancement for HST
- High number of orthogonal DMRS ports

3 – Apple GmbH

Our preference for escalation is the first bullet, i.e., more advanced UE reception algorithm for supporting MU-MIMO. To be more accurate, the intention is not to discuss advanced UE repletion algorithm explicitly in RAN1, the goal is to support enhancement to facilitate more advanced UE reception, e.g., scheduling information enhancement

4 – HuaWei Technologies Co.

We also support high number of orthogonal DMRS ports. DMRS ports number is the key to support high order MU-MIMO and also important for obtaining high spectrum efficiency for dense UEs cases. The DMRS enhancement can be discussed in coherent joint transmission for MTRP cases, where more UEs are in the cooperated areas.

5 – Samsung Research America

Comment on Other Proposals:

In general, we are supportive of increasing the number of orthogonal DL DMRS ports. This can be useful not only for DL MU-MIMO, but also for C-JT targeting UEs with higher capabilities. This can be considered as a part of Example Area 2 (under C-JT transmission)

Proposal: Consider "increasing the number of orthogonal DL DMRS ports" as a part of Example Area 2 (under C-JT transmission)

6 – Qualcomm Incorporated

From the list, our preference is "Adaptive DMRS" followed by "Reciprocity-based DL MIMO considering UE receiver strategy".

7 – ZTE Corporation

We are open to consider 'TRS enhancement or RAN4 enhancement for HST'. In our initial views, Option-1 leaving this issue to RAN4 seems to be sufficient.

8 – Nokia Corporation

As observed above, given that there is very large number of topics already being addressed in this discussion, we do not see a particular need to add more objectives.

9 – CEWiT

We support high number of orthogonal DMRS ports. Since this is specifically beneficial for MU-MIMO pairing and reception, and also for increasing the capacity of stationery UEs with more antennas.

10 – NTT DOCOMO INC.

We support TRS enhancement or RAN4 enhancement for HST. We have clear/real use-case in Japan (500mk/h@2.15GHz with 15kHz SCS in bi-directional SFN).

11 – Ericsson LM

We believe this item is highly important for Rel.18 enhancements: Higher number of orthogonal DMRS ports without increasing DMRS overhead (i.e. higher DMRS port density). This also applies for UL DMRS.

5 Moderator's Intermediate Phase Summary

We will continue to use the Example Area 1, Example Area 2, Example Area 3 as containers for the proposals, additionally, Moderator will put all UL related proposals into "UL Related". For "UL Related" area there are different views on where to discuss it, so Moderator just lists the proposals, regardless of the popularity of each proposal, mainly for reference, waiting for the decision on the umbrella for UL parts. For the DMRS port proposal, moderator also uses [and UL] instead of "and UL" for the same reason.

Reviewing all the comments on the skeleton, Moderator understands some of the objectives receive more positive and quite convergent feedback on solutions, some of the objectives converge in general framework but divergent in detailed solutions, in this sense, Moderator tries to make the proposals a bit clearer but quite generic at this moment. We can leave the refinement of the objectives to a later step. Some of the proposals, I put note in the [] at the end of the objective, just to reflect the status a bit. Some note writing "more justification maybe necessary" is based on comments saying it has ever been discussed in Rel-17 package, and some note writing "need to converge" is due to several quite divergent mechanisms on the table.

For Example Area 1, Moderator would like to propose following objectives:

- Example Area 1: Further enhancements for CSI (e.g., mobility, overhead, etc.)
  - Enhancement for high/medium mobility or accuracy
    - Time-domain correlation/doppler-domain based CSI feedback or overhead reduction
  - SRS enhancement for TDD
  - Enhancement for M-TRP URLLC[**more justification maybe necessary**]
  - Leftover (R17 leftover)

Feedback Form 10: Are you fine with proposals for Example Area 1? Are there any views for accommodating other divergent proposals?

1 – Futurewei

Thanks for the summary. We are supportive of the moderator's proposals for Example Area 1.

2 – Samsung Research America

Comment on Example Area 1:

In general, since the moderator is proposing this as a part of the objective, it is customary to start the discussion (perhaps in the next round) on action designation, that is, whether a sub-objective comprises "specify ..." or "perform study and, if needed, specify ...".

For now, we are fine to finalize the list first before starting discussion on the action designation.

In the previous round, we proposed to add a bullet on CSI enhancement for C-JT. The moderator includes that as a part of Example Area 2. We are fine and will comment there.

In addition:

· Bullet 1 (mobility/accuracy): To ensure the scope is clear, "including codebook design and reporting formats" should be included.

· Bullet 2 (SRS TDD): It should be clarified that the purpose of this bullet is to enhance CSI acquisition for TDD (else the wording can cause confusion between RS and CSI enhancements)

· Bullet 3 (MTRP URLLC): We agree that more justification (hence discussion) is necessary for this item since the scope is still ambiguous. It is fine to keep this for now as a placeholder.

· Bullet 4 (R17 leftover): Since CSI in Rel-17 progresses very well within the WID scope, it is unclear what leftover we will have.

Proposal:

· Bullet 1 (mobility/accuracy): Revise as follows: "Time-domain correlation/doppler-domain based CSI feedback or overhead reduction including codebook design and reporting format"

· Bullet 2 (SRS TDD): Revise as follows: "Enhancement on CSI acquisition for TDD via, e.g. SRS enhancement ~~for TDD~~"

· Bullet 3 (MTRP URLLC): No revision necessary

· Bullet 4 (R17 leftover): Remove this bullet

3 – Apple GmbH

The following two proposed bullets are not well defined regarding its scope and motivation, we do not support those two bullets

- SRS enhancement for TDD
- Enhancement for M-TRP URLLC [more justification maybe necessary]

4 – AT&T

We are in general supportive of the following two items.

- Enhancement for high/medium mobility or accuracy
  - Time-domain correlation/doppler-domain based CSI feedback or overhead reduction
- Enhancements for M-TRP URLLC (with more justification and scope clarity)

5 – NTT DOCOMO INC.

We're generally OK with the summary.

Regarding 'Enhancement for M-TRP URLLC[**more justification maybe necessary**]', we suggest following revision:

- Enhancement for M-TRP URLLC, including CSI enhancement for existing multi-TRP URLLC schemes, e.g., the same RI and/or PMI for MTRP CSI.

6 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

We are supportive of the first item: "Enhancement for high/medium mobility or accuracy".

Regarding "SRS enhancement for TDD", further clarification is needed on the motivation/use case and scope of enhancement as there are diverse proposals on SRS enhancements such as for high mobility, M-TRP, or non-PMI feedback. Also, SRS enhancements should be discussed in [RAN93e-R18Prep-02].

On the enhancement for M-TRP URLLC, we agree with the moderator's view that more justifications is needed and sufficient gains relative to Rel-17 mTRP CSI enhancements need to be shown.

For Rel-17 leftovers for CSI, any leftovers should assessed and discussed only after the November RAN WG meetings and in RAN#94e.

7 – LG Electronics Inc.

We agree that more justification is needed for 'Enhancement for M-TRP URLLC'. Need for 'SRS enhancement for TDD' is also unclear to us.

8 – Guangdong OPPO Mobile Telecom.

We are supportive of the first bullet.

Regarding the 2nd bullet (SRS), it is not clear what the scope is. Rel-17 SRS enhancement has considered the triggering flexible, capacity, coverage and DCI overhead. Would the proponent like to elaborate what specific enhancement is for this bullet? If the scope is not clearly stated, we prefer to remove it.

Regarding the 3rd bullet (URLLC), we prefer the proponents to clarify the scope/solution so that we can have a clear view what we will do and we can evaluate whether it is beneficial or not.

Regarding the 4th bullet, it is not clear what "Rel-17 leftover" refers to. More clarification is needed before we can discuss this bullet.

9 – HuaWei Technologies Co.

Generally we are supportive.

1. High priority for "SRS enhancement for CSI acquisition for TDD" in this area, since the TDD deployment is much more than FDD for NR currently. The SRS enhancement is very important for CSI acquisition in mobility and coherent joint transmission. We are fine to merge the SRS enhancement for CSI acquisition for "coherent joint transmission" and "mobility" in here. Suggest to update to be more clear

- SRS enhancement for CSI acquisition for mobility and Coherent Joint transmission in TDD

2. Then, for MTRP URLLC, we agree with Moderator, more justification is needed, such as use case, benefits, etc. Then, leftover is not clear, may need to be removed.

10 – vivo Communication Technology

The 2nd bullet, "SRS enhancement for TDD" can be revised to reflect the motivation as "SRS enhancement for CSI acquistion in medium/high speed scenario in TDD".

The fourth bullet, "Rel-17 leftover" can be removed.

11 – CATT

We are supportive to the first three bullets. Regarding the 4th bullet, we think it's not clear and more clarification is needed.

12 – Qualcomm Incorporated

We think that except for the first bullet, the other three bullets are too vague with their scope not clearly defined. Regarding "SRS enhancement for TDD", it is not clear to us what SRS enhancement is needed for TDD, given that Rel-17 already did enhancement for SRS. We are open to discuss this topic if the problem and the solutions can be better defined with more clarity. For "Enhancement for M-TRP URLLC", the scope is simply too broad. A more specific scope is needed, before we can commit to support it in Rel-18. For "Leftover (R17 leftover)", we have similar comment. There are quite a few left-over issues in Rel-17 on CSI, it needs to be clarified what exact left-over issues are included in Rel-18 package.

13 – SHARP Corporation

We are supportive for the 1st bullet.

Regarding the 2nd and 3rd bullet, the scope is unclear, so more clarification is needed

14 – NEC Corporation

Thanks for the proposal.

The first objective (for high mobility) has a higher priority from our perspective.

15 – Nokia Corporation

It is not 100% clear if the "Enhancement for high/medium mobility or accuracy" includes full CSI enhancement framework or only the reporting aspects. The current formulation is also a bit ambiguous, for example the accuracy target is somewhat conflicting with overhead reduction, if taken in isolation as currently proposed. The "DMRS based CSI report/post-PDSCH decoding based CSI report" can apply to both high/medium velocity and mTRP URLLC enhancements, and hence we think they should be mentioned under both topics for the time being. In any case, we need to still evaluate the potential enhancements in this area, and hence we should not list a single solution as potential way forward as outcome of this email discussion.

On the M-TRP URLLC, since more justification has been requested, it should be noted that mTRP schemes may include FDMschemeA, FDMschemeB, TDMschemeA, TDMschemeB, SDM modes. Also, all these schemes allow dynamic switching between sTRP and mTRP. These are using different scheduling parameters, and the traditional CSI reporting is not fully optimized for generating these scheduling parameters (e.g. MCS, F/T allocations, number of repetitions, etc..). In one example, the CQI may not be fully able to derive link adaptation parameters for schemes like FDMschemeB as it transmits two codewords in non-overlapping frequency locations with a single MCS (CQI cannot directly map to derive such a single MCS as the selection of this single MCS assumes soft combining at the UE). Also, it is in general understood that URLLC require more accurate feedback information than any other use cases due to reliability targets, and extending/improving such methods for mTRP URLLC follows the same logic.

As for SRS enhancement for TDD, we do not think it is properly justified, especially in light of the amount of items under consideration for CSI enhancements already. Same applies for the general bullet on Rel-17 leftovers, as there are no clearly outstanding items from Rel-17 known at the moment, and we should not have a blank reservation to revisit items for which there was no consensus to support them in Rel-17.

Consider revising the summary as follows:

- Evaluate and if needed specify enhancement on CSI reporting accuracy for high/medium velocity ~~or accuracy~~
  - Time-domain correlation/doppler-domain based CSI feedback for overhead reduction
  - DMRS based CSI report/post-PDSCH decoding based CSI report
- Enhancement for M-TRP URLLC
  - Scheme specific CSI feedback and/or DMRS based CSI report/post-PDSCH decoding based CSI report

16 – Intel Corporation (UK) Ltd

RE: Justification to mTRP URLLC CSI.

- We support revision proposed by DOCOMO.
- The motivation has been provided in workshop papers, e.g. RWS-210370, which is similar to eMBB mTRP CSI in Rel-17. Just one example to illustrate the problem, assuming Rel-17 per TRP CSI, it is possible that the reported RIs / PMIs per TRP are different. When it comes to the actual PDSCH scheduling with repetition, gNB should align the number of MIMO layers from TRPs which leads

to RI overriding issue. As the consequence PMI and and actually selected MCS becomes inaccurate which is not acceptable for URLLC type of applications.

RE: Proposed list of objectives.

- It is not clear which Rel-17 leftovers should be addressed and which are really important. Suggest to remove.

Based on the comments above the following revisions are proposed.

Further enhancements for CSI ~~(e.g., mobility, overhead, etc.)~~

- Enhancement for high/medium mobility or accuracy
  - Time-domain correlation/doppler-domain based CSI feedback, or overhead reduction
- Enhancement for M-TRP URLLC [~~more justification maybe necessary~~], including CSI enhancement for existing multi-TRP URLLC schemes, e.g., the same RI and/or PMI for MTRP CSI.
- ~~Leftover (R17 leftover)~~

17 – Beijing Xiaomi Mobile Software

We are supportive of the first item: Enhancement for high/medium mobility or accuracy.

For the SRS enhancement for TDD, it is better to clarify the scope.

For the leftover, it is not clear to us. It is better to clarify it first.

18 – China Mobile Com. Corporation

1) For the 2nd bullet, it can be clarified as SRS enhancement for CSI acquisition for mobility/ CSI acquisition for CJT.

2) For the 3rd bullet, the enhancement for URLLC is under M-TRP scenario, it should based on Multi-TRP URLLC transmission schemes. To be more clear, it can be revised as "Enhancement on CSI reporting for single DCI based FDM and TDM schemes".

19 – CEWiT

We are fine with the moderator's proposal.

20 – MediaTek Inc.

CSI enhancements:

- We are fine with "Enhancement for high/medium mobility or accuracy, Time-domain correlation/doppler-domain based CSI feedback or overhead reduction".
- Regarding "DMRS based CSI report/post-PDSCH decoding based CSI report", we are not ok to include this. This topic was evaluated and discussed in two releases so far under URLLC SI/WI (as "A-CSI on PUCCH" in R16 and as "delta-MCS" in R17). In both releases, there was no consensus in RAN1 to support this feature. The possible gain is marginal in the best-case scenario and the impact to the UE and specs is significant. There is no justification to repeat the discussion again in R18.

- We propose to remove ”Rel-17 leftover”. What is leftover is very subjective, and leaves everything wide open so does not help here.
- SRS enhancements may need a bit more justification first, given the work done in Rel-17.

21 – ZTE Corporation

In our views, the usage and benefit for “Time-domain correlation/Doppler-domain based CSI feedback” in the first bullet should be justified before capturing them into the candidate sub-objective in DL-MIMO WID.

- Generally speaking, 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.

So we have the following suggestion for first bullet:

Enhancement for high/medium mobility or accuracy **[more justification maybe necessary]**

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

Regarding bullet for ‘Enhancement for M-TRP URLLC’, as we clarified in last round, our intention for URLLC CSI enhancement is not to repeat the discussions in previous releases, but to solve newly identified issues. We are open to exclude schemes discussed in Rel-17 URLLC WI” to address companies’ concern when drafting WID. In addition, we think the issues being discussed are not restricted in M-TRP. Hence we suggest to remove “M-TRP” or add STRP as we suggested in previous round. Alternatively, we can add a note saying “including enhanced URLLC CSI triggering flexibility considering CPU occupation restriction” to align the understanding that the enhancements under this bullet also apply on STRP case. Further details can be discussed when drafting WID.

But, for the last bullet of ‘Leftover (R17 leftover)’, we do not identify what is the leftover issues for Rel-17, and therefore, we suggest to remove the last bullet.

22 – VODAFONE Group Plc

Proposal seems ok overall. We are supportive of enhancements for high/medium mobility or accuracy as a priority. We also agree that for the SRS enhancement for TDD, the scope should be better clarified.

23 – Fraunhofer IIS

We thank the Moderator for the proposal. We are supportive of the first bullet. In addition, we propose to add at least “including codebook design” to ensure that the scope is clear. The fourth bullet “Leftover (R17 leftover)” is unclear to us. What kind of leftovers are considered for R18?

24 – HuaWei Technologies Co.

Further comments on the first bullet: as we mentioned before, CSI for mobility and accuracy are for both TDD and FDD, so the first bullet should include the information. Look at the sub-bullet, it seems only for FDD enhancement, while TDD is major deployment for NR till now, so we do have concerns on it. Both TDD and FDD should be included in the main bullet.

From companies' comments, SRS for TDD here is not clear for the scope. To clarify that, SRS is better included in mobility enhancement for TDD case. and the TDD enhancement for coherent joint transmission is more clear to be discussed in MTRP session.

Suggest update:

Enhancement for high/medium mobility or accuracy for TDD and FDD. e.g.,

- Time-domain correlation/doppler-domain based CSI feedback or overhead reduction
- SRS enhancement for TDD CSI acquisition

25 – Ericsson LM

Post-PDSCH decoding based CSI feedback reporting is mentioned as important from both Operator, UE chipset and network vendors (AT&T, Vodafone, Ericsson, Nokia, ZTE, Qualcomm). This seem to be an important area that has been overlooked in the summary. We suggest it is added back as a separate bullet for further discussion. (**DMRS based CSI report and/or post-PDSCH decoding based CSI report)**

Regarding the "[more justification needed]" for "CSI enhancement for M-TRP URLLC", we give the motivation here: First of all, the M-TRP is important for the robustness and there is commercial interest of URLLC applications. The M-TRP URLLC schemes (FDMSchemeA, FDMSchemeB, TDMSchemeA, slot based repetition) have been specified since NR Rel-16. However, there is no corresponding CSI reporting defined for these schemes as the NC-JT CSI enhancement specified in Rel-17 is not suitable for these M-TRP URLLC schemes since NC-JT involves inter-layer interference while the multi-TRP URLLC schemes may involve repetitions. Hence, this enhancement is a missing piece in the spec which is well justified. We are also ok to use the phrase "study and if needed specify" this feature in Rel-18 if some companies have concerns on the benefits. In our view, the scope of this bullet may also include 'enhanced URLLC CSI triggering flexibility considering CPU occupation restriction for the more general case of sTRP and mTRP, as a specific detail which can be discussed later in the work item description drafting phase. To reply to Qualcomm, the intention from our side is to prioritize a CSI low latency (URLLC) CSI report if there is an ongoing low latency (eMBB) CSI report processing, i.e. to time prioritize URLLC CSI. Current specifications are too restrictive. And note again, that this is not only for mTRP, it is a general enhancement for CSI.

There are proposals to study SRS enhancements, but we believe the intention is for high/medium speed UE CSI in TDD. In addition, the use of the word "mobility" is confusing, as there is a parallel discussion about mobility. We suggest using "UE speed" instead. Moreover, we don't understand the addition of ",or accuracy", since the sentence mentions enhancement, we can remove "or accuracy". We thus suggest the "**SRS enhancements ~~for TDD~~**" is a subbullet to **"Enhancement for high/medium UE speed, ~~or accuracy~~**

We think "R17 leftover", should instead (if there are any TU left), be reserved for critical enhancements based on real life observations in the field. Such issues emerge continuously as we have seen, and it would be good if we have a mechanism to address these with immediate release standard changes. Such corrections have large commercial value as they solve problems observed by operators in the field

26 – Deutsche Telekom AG

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 efficient / improved support of high-/medium velocity scenarios (automotive, train connectivity etc) and hence deserves to be clearly part of the potential objectives –

For Example Area 2, Moderator would like to propose following objectives:

- Example Area 2: Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam
  - 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**]
  - 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
  - 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

Feedback Form 11: Are you fine with proposals for Example Area 2? Are there any views for accommodating other divergent proposals?

1 – Futurewei

Thanks for the summary. We are supportive of the moderator's proposals for Example Area 2. Just some editorial comments:

- The first sub-bullet under "Extend Rel-17 Unified TCI framework to M-TRP", "M>" should be "M>1"
- The second bullet, e.g., "Increasing the number of orthogonal DL **[and UL]** DMRS ports …" should be divided into two bullets. The part starting with "Enhancement for Coherent-JT/D-MIMO …" should be listed as a new bullet.

2 – Samsung Research America

Comment on Example Area 2:

In general, since the moderator is proposing this as a part of the objective, it is customary to start the discussion (perhaps in the next round) on action designation, that is, whether a sub-objective comprises "specify ..." or "perform study and, if needed, specify ...".

For now, we are fine to finalize the list first before starting discussion on the action designation.

In addition:

· Bullet 1 (extend unified TCI):

o Typo on 1st sub-bullet "e.g. M> and/or N>1". "1" is missing after "M>". In addition, it should be clarified that this is for multiple DL and UL TCI states. Finally, other than indication, we can add "configuration"

o 2nd sub-bullet is not clear and can be removed for now. We can focus on the spec feature (signaling) rather than scenarios (MTRP schemes)

· Bullet 2 (C-JT): The wording of this bullet is a bit confusing (perhaps the moderator intends to have this as two sub-bullets for C-JT). Also CSI-RS enhancement to support >32 ports is missing (which is essential for C-JT).

· Bullet 3 (BM): There is no need for making this more generic. We can simply add "including ...". Based on Rel-17 discussion, UE-initiated beam management and beam refinement/tracking are understood

to be important for this sub-objective. IN addition, it should be clarified that this is based on Rel-17 unified TCI framework

· Bullet 4 (asynchrononous): OK

Proposal:

· Bullet 1 (extend unified TCI): Revise as follows: "Extend Rel-17 Unified TCI framework to M-TRP, at least for configuration and indication of multiple DL and UL TCI states (e.g., M>1 and/or N>1)

o Remove the sub-bullet "Combined MTRP schemes, more generic"

· Bullet 2 (C-JT): Revise as follows

o Enhancement for coherent joint transmission (C-JT), including:

§ Increasing the number of orthogonal DL **[and UL]** DMRS ports

§ CSI-RS enhancement to support >32 ports

§ Enhancement on CSI acquisition including codebook, CSI reporting, spatial domain interference avoidance

· Bullet 3 (BM): Revise as follows: "Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, ~~more generic [**need to converge**]~~ including UE-initiated beam management and beam tracing/refinement, based on Rel-17 unified TCI framework"

· Bullet 4 (asynchrononous): OK

3 – Apple GmbH

We are supportive of the following two bullets

- Extend Rel-17 Unified TCI framework to M-TRP
- Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures. We also agree that we need to converge on the detailed scopes. For us, we are interested in the following areas in the decreasing order of priority
  - UE initiated beam management
  - Beam failure recovery enhancement to consider UL beam status
  - UE coordination based beam measurement and report

We view the following bullets as low priority

- Increasing the number of orthogonal DL [and UL] DMRS ports
  - At least we want to ensure that UE related procedure largely stays the same, especially that maximum 8 layers PDSCH for SU-MIMO and maximum 4 layers for MU-MIMO
- Enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance
  - We do not observe enough motivation in the real deployment of NCJT that we specified in Rel-16. The feedback we got both in and out of 3GPP is it is even hard to assume ideal-backhaul between two TRPs. During Rel-17/Rel-18 discussion, companies even brought up synchronizations issues between two TRPs.

- Furthermore, CJT or distributed MIMO can largely be supported by the current specification in a transparent way. Overall, we do not think we need to start CJT at this stage

We do not support, and are strongly against, the following proposed bullet on Async mTRP. As we explained, we do not think asynchronous Multi-TRP has any deployment importance especially considering it requires UE to handle multiple TA and could potentially cause various RF issues. Ever since LTE COMP, further into the NR multi-TRP, it is assumed that TRPs are synchronized, i.e., MRTD < CP. Even with this assumption, there is no meaningful mTRP deployment as far as we know, enhancement for async mTRP will make this feature even less deployable since there is even less reason for UE to support it especially in FR2 and even less performance benefit. Asynchronous OFDM operation makes the interference coordination almost impossible since it destroys the orthogonality of OFDM waveform.

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

4 – AT&T

We are in general supportive of the items in example area 2 of the moderator summary

5 – NTT DOCOMO INC.

We're supportive of following two bullets:

- 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).
- Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic [**need to converge**].

Other bullets have lower priority.

There is no 'other proposals' in final round, but 'enhanced high speed train demodulation requirement with 996Hz Doppler shift' is very important for our NW deployment. We'd like to ask companies to consider about it.

6 – Verizon UK Ltd

We are supportive of the moderator's summary for example area 2. It is true that some of early MTRP adoption could have been faster, but that is usually because the inefficiency of early specifications, which further impacts the availability of commercial products. Unlike cost-saving features, performance enhancement features should be introduced sooner because staying on deficient specs only delays the adoption process. CJT can be by implantation in some circumstances, but we think 1) they are not optimized without std assistance and 2) not exactly in the direction we would like to see the NW evolves. For these reason, we support CJT for FR1 (or low band) with possible enhancement on CSI and RS. We also would like to see async mTRP - otherwise the deployment is quite restrictive.

7 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

For the Unified TCI framework extension, we are supportive of the first sub-bullet "For indication of DL and UL TCI states (e.g., M> and/or N>1)". Also, M>1 and/or N>1 is applicable to both S-TRP and M-TRP and needs to be clarified - so suggest to delete "to M-TRP" in the main bullet "Extend Rel-17 Unified TCI framework to M-TRP".

Regarding “Combined MTRP schemes”, we believe more discussion is needed on potential enhancements, e.g., which schemes can be combined, as well as the potential gains/tradeoffs of such combining.

Regarding “Enhancement for Coherent-JT/D-MIMO”, clarity is needed from the proponents of CSI enhancements for CJT on the expected improvement over NCJT CSI framework. Also, the wording “spatial domain interference avoidance” is too specific, and suggest to generalize it e.g., “interference management”.

We support the third item “Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures”. To help converge on the scope the item, we suggest including the following as a sub-bullet, “UE-initiated and/or group-based beam reporting”.

8 – LG Electronics Inc.

We support the first bullet and the last bullet. The fourth bullet (further overhead/latency reduction) could be considered additionally depending on Rel-17 FeMIMO progress.

9 – Guangdong OPPO Mobile Telecom.

In general, the scope of Area 2 is too large. We should down-scope the objectives in order to keep reasonable workload .

The sublet “Combined MTRP schemes” is vague and the motivation/beneftis needs further justification.

For asynchronous M-TRP/Multiple TA for M-TRP, we think it should be low priority. All R16/17 M-TRP scheme is based on the synchronous scenarios and the performance gain is verified by evaluations. For asynchronous scenarios, it is not justified whether M-TRP schemes can achieve any gain. Thus, we suggest to remove it to keep the scope manageable.

For coherent JT/D-MIMO, we first check the typical use case and the performance gain by evaluations before we agree to do enhancement for it.

Moreover, ”coherent JT/D-MIMO” and ”asynchronous M-TRP” are leading to the opposite directions. the former assumes the coordination of TRP/gNB can be almost perfect, while the latter emphasizes the TRP/gNB cannot ensure synchronization with sufficient accuracy. Then, the question is which is more typical for practical deployment?

10 – HuaWei Technologies Co.

Generally we are supportive for the proposal.

1. For the questions for coherent joint transmission, we provide some clarifications. For the use case, CJT can be used for both intra-site and inter-site Multi-TRPs. Currently, a lot of FR1 deployments are already feasible for coherent joint transmission for TDD and FDD, such as C-RAN structure, indoor factory, and intra-site cooperation. For the benefits of CJT, we showed the significant performance gain of CJT in RWS-210437. By the way, compared to LTE system, we know there is no CRS in NR, so it is much easy and possible to use CJT without the strong interference from CRS. So, both RS and CSI need to be enhanced for CJT in Rel-18.

In addition, for CJT, we believe small PRG size (1RB or less) is also beneficial in coherent joint transmission, which fit for the frequency selective channels and enable flexible scheduling and interference mitigation. We provided evaluation results in RWS-210347. We suggest to add an example

Enhancement for Coherent-JT/D-MIMO, including e.g., codebook, CSI reporting, spatial domain interference avoidance, small PRG size

2. For DMRS enhancement, we also support increasing number of orthogonal DMRS ports, since in the practical cases, much more orthogonal ports will be used for high order MU-MIMO transmission shown in RWS-210347, especially for M-TRP (CJT) and factory cases.

3. We are fine for the overhead/Latency reduction, but the scenarios need some further discussion, in our understanding, the enhancement should be for narrow beam sweeping.

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

- *Further discuss scenarios, e.g., narrow beams*

4. For the extension of unified TCI framework, we are not clear for the benefits, but it is fine to study, better to remove "M-TRP" at this stage for further discussing the scenarios, such as for S-TRP (M,N>1) and inter-band cases, etc.

We also agree that asynchronous MTRP/Multi-TA for MTRP and combined MTRP schemes need further clarified, not clear for the scenarios and benefits.

11 – CATT

In our view, optimization to beam management operation is sufficient with current spec. More justification is needed if further enhancement of beam management is to be introduced in Rel-18.

12 – China Telecommunications

Thanks for the summary, we are supportive for this proposal in general.

13 – Qualcomm Incorporated

In Rel-17, for single TRP, using only a single beam in DL/UL was agreed due to lack of time to develop a complete solution. However, this simplification sacrifices reliability, e.g. beam diversity for CORESET, which is actually supported in Rel-15. Without beam diversity, BFR may have to be triggered if the only beam fails. To maintain at least same reliability as in Rel-15, we strongly recommend to add multi-beam support for single TRP.

- Example Area 2: Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam
  - Extend Rel-17 Unified TCI framework to M-TRP, e.g.,
    - For indication of DL and UL TCI states (e.g., M> and/or N>1)
    - Combined MTRP schemes, more generic [**need to converge**]
  - Enhance Rel-17 Unified TCI framework for S-TRP, e.g.,
    - For indication of DL and UL TCI states (e.g., M> and/or N>1)
  - 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
  - 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

It seems to make more sense to consider the two parts of the 2nd bullet individually. We don't think the second part should be included, so the moderator's proposal should be changed as shown below:

- 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~~

In addition, more orthogonal DMRS ports may be beneficial in both single and multi-TRP scenarios. Keeping it in Area 2 (mTRP) only seems to be restrictive.

14 – SHARP Corporation

We are supportive for moderator's proposals.

15 – NEC Corporation

Thanks for the proposal.

One clarification question: does the ordering of objectives in moderator's proposal imply the priority or popularity?

We prefer to have the following objectives with a higher priority.

- 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

16 – Nokia Corporation

We think it would be beneficial to clarify the objectives on unified TCI framework, as RAN1 should not extend Unified TCI framework differently for different mTRP modes (large workload) or defining any new mTRP transmission modes to match with unified TCI framework (it doesn't seem to be the intension of supporting companies).

Regarding the enhancement for coherent-JT/D-MIMO, we do not see it justified to have it raised to higher priority, given that it implies large workload and it doesn't seem to have widespread support. Given the expected limited TUs for the work, we should ensure there is enough time for finishing the missing aspects of mTRP, in which Asynchronous operation is a critical one.

Hence, please consider revising the summary as follows:

- Extension of Rel-17 Unified TCI framework for Rel-16/Rel-17 defined mTRP transmission schemes, including,
  - Extend the supporting of indicating of more than one DL and/or UL TCI states (via joint TCI and/or separate DL/UL TCI) considering a common framework for supporting different mTRP schemes
  - Extend the supporting of dynamic switching between joint TCI and separate DL/UL TCI states
- Asynchronous M-TRP/Multiple TA for M-TRP

17 – vivo Communication Technology

Without going into details, we propose to revise following bullet points. The reason for removing ”to M-TRP” in first bullet is, as couple of companies also commented, there S-TRP scenario should be also be included. A sub-bullet ”including inter-band scenarios” considering complexity reduction, simplified beam managment. Another sub-bullet on ”more finer beam” is added considering very large scale antenna. And, finally aynchronous MTRP is for intercell MTRP.

Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam

- 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**
  - including inter-band scenarios
- ..
- Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic [**need to converge**]
  - including scenarios with more finer beams
- Asynchronous M-TRP/Multiple TA for intercell M-TRP

18 – Intel Corporation (UK) Ltd

Intel: We are fine with the list of proposals in principle (including UL for DMRS port enhancement). We think that larger number of ports is useful not only for coherent JT, but also in other scenario. From this perspective we support proposal from Qualcomm.

In addition, as commented in the previous phases, it would be useful to consider study phase for the following elements:

- Coherent-JT/D-MIMO (check how impairments impacts performance)
- Spatial domain interference avoidance (not clear benefits comparing to Rel-15/16/17)

We strongly support ”Asynchronous M-TRP/Multiple TA for M-TRP”. In our view Rel-16 assumption on Rx timming < CP is artificial and impossible to fulfill in most of the cases even when NW is perfectly synchronized. As demonstrated in our simulations (during workshop discussion), due to propagation delay difference from TP, the Rx timming > CP is more common scenario that should be supported from specification perspective. We don’t agree to remove the corresponding bullet or make it low priority.

19 – Beijing Xiaomi Mobile Software

We are supportive of the following topics:

− Example Area 2: Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam

- Extend Rel-17 Unified TCI framework to M-TRP, e.g.,
  - For indication of DL and UL states (e.g., M>1 and/or N>1)
- Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures
- Asynchronous M-TRP/Multiple TA for M-TRP

As for combined MTRP schemes, we suggest to make it more clear. Does it mean both S-DCI MTRP and M-DCI MTRP, and both intra-cell MTRP and inter-cell MTRP?

20 – China Mobile Com. Corporation

1) 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 RS enhancement, e.g., DMRS enhancement for more orthogonal ports.

2) Regarding overhead and/or latency reduction for beam management, for convergence, we support to focus on UE-initiated and/or group-based beam reporting.

21 – CEWiT

We are fine with the proposal except for the sub-bullet "Combined MTRP schemes" as the scope of this work is not clearly defined.

22 – ZTE Corporation

In our views, the usage and benefit for "Enhancement for Coherent-JT/D-MIMO" should be justified before capturing them into the candidate sub-objective in DL-MIMO WID. After reviewing the feedbacks from other companies, it seems that at least 6 companies provided negative views.

- Technically speaking, coherent JT has been specified in LTE, but there are few corresponding deployments (unfortunately). Furthermore, for many cases, coherent JT can be implemented in a spec-transparent manner.

So we have the following suggestion for first bullet:

- Enhancement for Coherent-JT/D-MIMO **[more justification maybe necessary]~~, including e.g., codebook, CSI reporting, spatial domain interference avoidance~~**

Regarding 'Extend Rel-17 Unified TCI framework to M-TRP', we share the same views with vivo that inter-band CBM operation mode should be considered, e.g., with the following modification:

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), **considering inter-band CBM operation mode.**
- Combined MTRP schemes, more generic [need to converge]

Regarding overhead and/or latency reduction, in our views, beam acquisition can be assumed as a small topic of beam management procedure. For making this bullet more clear, we have the following suggestion:

- Overhead and/or Latency reduction for beam management procedure (involving **beam acquisition, activation, and indication procedures**, more generic [need to converge])

23 – Sony Corporation

Thanks for the summary.

For the 4th sub-bullet (overhead and/or latency reduction for BM), we think it's not necessary to go back the general description. Like the 3rd sub-bullet, we would like to suggest to include specific items, e.g. UE initiated beam management. The revision from Samsung looks good to us.

For the last sub-bullet, we tend to understand the 1st part relates to DL asynchronous reception from TRPs. If that's the case, can we try a slight change as "Asynchronous reception from M-TRP/Multiple TA for M-TRP". Thanks.

24 – China Unicom

We support coherent joint transmission in both FDD and TDD, and it is beneficial for improving cell edge and cell average performance. To support more UEs, we would like to focus on DMRS, SRS enhancement for both TDD and FDD. e.g., DMRS enhancement for more orthogonal ports.

25 – Fraunhofer IIS

We are supportive of the first sub-bullet of the unified TCI framework. The second sub-bullet is unclear and needs more explanation.

26 – MediaTek Inc.

Overhead and/or Latency reduction for beam management procedure/beam acquisition procedures, more generic [need to converge]

- We would like to add "UE initiated beam management" as a sub-bullet, as this seems to have got lost.
- The motivation for extending the TCI framework in general is a solution for overhead and latency reduction, so should be somehow linked.

Increasing the number of DL DMRS ports

- It is not clear to us why this is needed for anything other than C-JT. Please can the proponents clarify why it is required for normal MU-MIMO? Otherwise it should be combined with C-JT.

Coherent-Joint Transmission

- We understood there is quite limited support for this, so a bit surprised that it was included in the list. Given the lack of success of this feature in the past, we really think it would be best to wait a bit before rushing into specifying this feature, so that we can make sure we don't fail like we did in LTE. **We would like to remove it from the list, or alternatively suggest that at most we study this in Rel-18.**

Asynchronous Multi-TRP: Trying to summarize our perception:

- Performance concerns have been raised from some key stakeholders on this topic in rounds 1 and 2 that this could lead to quite some receiver performance degradation.
- There is a lack of clarity on exactly whether proponents all target the same issue - some people mention UL TA, some mention DL misalignment >CP. Do we assume that Base Stations are fully synchronized or not? Quite unclear. The UL TA issue is more recognizable.
- There is a lack of robust analysis on the amount of >CP misalignment and for which SCS.

Therefore, we believe that Asynchronous Multi-TRP (especially in DL direction) is not ready to add as a specification objective at this stage, and more study would be needed in the first instance to identify better the issue and limits, and whether there are workable solutions if the issue is properly justified.

27 – CATT

To make our view more clear, we would update our response.

Regarding 'overhead and/or Latency reduction for beam management procedure/beam acquisition procedures', current spec is always sufficient. We don't think further enhancement is needed.

We are supportive of the bullet: Extend Rel-17 Unified TCI framework to M-TRP. We also think inter-band scenarios shall be included.

28 – LG Uplus

Coherent joint transmission have highest priority. We have really big gain in the indoor commercialization. It is justified. We want to extend C-JT to outdoor. It will have benefit on cell edge throughput. Further, we expect reusing legacy antenna deployment.

29 – Ericsson LM

We are supportive of the bullet 'combined MTRP schemes". Ericsson proposed 'Mixed mode of single-DCI and multi-DCI based M-TRP' in order to served mixed eMBB/URLLC traffic, which has commercial value . This is one example of a combined MTRP scheme with a well justified use case. We are also open to consider other combined MTRP schemes. So, we suggest to keep the 'combined MTRP schemes' bullet.

On the DMRS port enhancement, we note that this is not only for mTRP, but for general MIMO. Unfortunately, we don't have such example area, so can we be flexible and rephrase to "Increasing the number of orthogonal DL **[and UL]** DMRS ports both for sTRP and mTRP"

On overhead and latency reduction for beam management, we agree that we need to converge on the usefulness of this. We don't see a clear use case and need to understand better the benefits

On "Asynchronous M-TRP/Multiple TA for M-TRP", this is an UL enhancement and is out of scope of DL MIMO. So it should be removed.

On C-JT/D-MIMO, we share the view with several other companies that this has low priority, there seem not be any "tangible commercial interest" as phrased by Mr. Chairman.

30 – HuaWei Technologies Co.

For the coherent joint transmission

we already replied the questions and comments from the previous rounds, including the clarification of background, use cases, and benefits as well. Since in the current NR network, coherent joint transmission are also can be enabled with such as C-RAN structure, intra-site TRP deployment, and distributed MIMO in factories, so it is very important in Rel-18. We can see there are a lot of supporting from operators support coherent joint transmission in their replies. So, it should be enhanced for both TDD and FDD.

For unified TCI framework

For the unified TCI framework, as I mentioned, it need some more justification on the use case and benefits. Since in Rel-17, the unified TCI was proposed to reduce signaling overhead and latency. There is a separate overhead and latency reduction, we are confused the relationship between the two items. It should be an sub-bullet for the overhead/latency reduction.

For Example Area 3 - CPE (customer premises equipment)-specific considerations, Moderator would like to propose:

Low priority

Feedback Form 12: Are you fine with proposals for Example Area 3? If not, How to proceed it?

1 – Futurewei Thanks for the summary. We are supportive of the moderator's proposals for Example Area 3.
2 – Samsung Research America **Comment on Example Area 3**: We are fine with the moderator proposal to assign low priority on this example area
3 – Apple GmbH We are supportive for CPE related enhancement to be low priority
4 – NTT DOCOMO INC. Fine with the summary.
5 – LG Electronics Inc. Fine with the summary
6 – Guangdong OPPO Mobile Telecom. We are fine with moderator's summary.
7 – HuaWei Technologies Co. For CPE, there are still many deployments for home broadband service and in factories. So, we prefer to specify the DMRS overhead reduction for increasing the average spectrum efficiency in real deployments due to the channel is invariant in a long time for CPE users.
8 – Qualcomm Incorporated We don't think CPE should be treated as low priority item, given that many companies showed interested in this topic. We would also like to clarify that the 4096-QAM proposal is for CPE DL, not for the UL.
9 – vivo Communication Technology we support moderator's proposal
10 – Nokia Corporation We are fine with the moderator's proposal.

11 – Intel Corporation (UK) Ltd As commented in the other phases support of 4096QAM is essential for PDSCH considering other technology already supports such modulation. We are not sure why proposal on 4096QAM is moved to UL (we don't have 1024QAM in UL)? We proposed to move it back. **Objective**: Specify support of higher order modulation such as 4096QAM (and above). Study and specify techniques (if sufficient gains are shown) to improve performance of PDSCH under practical impairments.
12 – Beijing Xiaomi Mobile Software we are fine with the summary.
13 – China Mobile Com. Corporation Support moderator's proposal
14 – CEWiT We are fine with the moderator's proposal
15 – ZTE Corporation In our views, 'multiple CW' enhancement should have high priority, based on real-field test.
16 – Sony Corporation Thanks for the summary. We are fine to assign CPE-related enhancement with low priority.
17 – Fraunhofer IIS We agree with the Moderator's proposal.
18 – Ericsson LM We support to classify this as low priority
19 – AT&T Fully agree with Qualcomm, and others. CPE/FWA should *not* be low priority

For "UL Related" area, Moderator lists all related schemes below for reference, and would like to propose to suspend the discussion at this moment, waiting for the decision on the umbrella for UL part.

- UL Related
  - Supportive of 4096QAM
  - > 4 UL Tx antenna
  - UL TPMI

Feedback Form 13: Are you fine with proposals for ”UL Related” area? If not, How to proceed it?

1 – Futurewei

Thanks for the summary. We are supportive of the moderator’s proposals for “UL Related” area.

2 – Samsung Research America

Comment on ‘UL Related’ Proposals:

We are fine with the moderator proposal to sync up with UL enhancement (thread 2) and suspend discussion for the time being

3 – Apple GmbH

We prefer to suspend the discussion due to the UL enhancement discussion. We are not supportive of 4096QAM. 4096QAM requires both RAN1 and RAN4 work at least, it is not practical for UE implementations and its gain in the real cellular deployment is very questionable.

4 – NTT DOCOMO INC.

Fine with the summary.

5 – Motorola Mobility UK Ltd.

Lenovo/Motorola Mobility :

We still believe the second and third issues “> 4 UL Tx antenna” and “UL TPMI” should be only discussed in [RAN93e-R18Prep-02] for UL. Discussing the same items in two threads is quite confusing and so conclusions should only be reached in one thread.

Regarding the first issue “Support of 4096QAM”, our understanding is this proposal is for DL transmission and not for UL.

6 – Guangdong OPPO Mobile Telecom.

We are fine with moderator’s summary. Reagrding the support of 4096QAM, we share the similar view as Apple. Moreover, we think there are very rare cases where UE can be scheduled with 4096QAM in practical network.

7 – HuaWei Technologies Co.

Agree that the UL part is not discussed in DL MIMO, but ok with adding UL DMRS to the example Area 2 since DMRS design are symmetric/same design for UL and DL.

8 – Qualcomm Incorporated

For UL related areas, we agree with the Moderator that it is better to discuss them in email thread #2 dedicated to UL enhancements.

Beside the above comment, can the Moderator please kindly clarify what the proposed tentative conclusion is for the discussion of the “other proposals”?

9 – vivo Communication Technology

We support moderator’s proposal

10 – SHARP Corporation We are supportive for the moderator's summary
11 – Nokia Corporation We are fine with the moderator's proposal.
12 – Intel Corporation (UK) Ltd 1. We are not sure why 4096QAM is listed under UL related enhancements? The original proposal is made for DL and supported by many companies. It should be included in the list of Rel-18 objectives, 2. We are not sure whether we need to repeat discussion for UL enhancements. To avoid potentially conflicting proposal we suggest not to consider the last two bullets.
13 – CEWiT We are fine with the moderator proposal to suspend this discussion in the DL thread.
14 – China Mobile Com. Corporation Support moderator's proposal.
15 – ZTE Corporation Reagrding the support of 4096QAM, we share the similar view as Apple and OPPO.
16 – Fraunhofer IIS We agree with the Moderator's proposal.
17 – Ericsson LM We are fine to suspend the discussion, as these are out of scope for DL MIMO. In addition, the multiple TA from Example Area 2 should be moved to this list as it is UL related.
18 – AT&T We support 4096QAM for DL, not UL

6 Conclusions/Observations

Based on the final phase discussion, Moderator would like to provide following conclusions/observations.

For Example Area 1 - Further enhancements for CSI (e.g., mobility, overhead, etc.), further discussion could focus on following items:

- 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**)

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

- Example Area 2: Evolved handling of multi-TRP (Transmission Reception Points) and multi-beam
  - 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**)

For Example Area 3 - CPE (customer premises equipment)-specific considerations, further discussion could focus on:

- Priority of CPE
  - Lower Pority **(Controversial)**

For "UL Related" area, which is raised in this week, Moderator lists all related schemes below for reference, and would like to propose to suspend the discussion at this moment, waiting for the decision on the umbrella for UL part.

- UL Related
  - Supportive of 4096QAM (**Controversial**)
  - > 4 UL Tx antenna
  - UL TPMI