**3GPP TSG RAN WG1 #106b-e R1-2110430**

**e-Meeting, October 11th – 19th, 2021**

**Source: Moderator (Intel Corporation)**

**Title: Summary#1 of AI: 8.1.2.4 Enhancements on HST-SFN deployment**

**Agenda item: 8.1.2.4**

**Document for: Discussion and Decision**

# Introduction

In RAN#86 meeting the work item on enhanced MIMO support was agreed for Rel-17 [1]. The objectives of WID include enhancements to multi-TRP transmission scheme in HST-SFN scenario.

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| 2. Enhancement on the support for multi-TRP deployment, targeting both FR1 and FR2:  …  d. Enhancement to support HST-SFN deployment scenario:  i. Identify and specify solution(s) on QCL assumption for DMRS, e.g. multiple QCL assumptions for the same DMRS port(s), targeting DL-only transmission  ii. Evaluate and, if the benefit over Rel.16 HST enhancement baseline is demonstrated, specify QCL/QCL-like relation (including applicable type(s) and the associated requirement) between DL and UL signal by reusing the unified TCI framework |

The document contains summary of the companies’ and moderator’s proposals.

# Possible enhancements for HST-SFN deployment

## General issues

### Issue #1-1 (Combination of the schemes for PDCCH and PDSCH)

Regarding combinations of the transmission schemes for PDCCH and PDSCH that can be supported with enhanced SFN transmission schemes. In RAN1#105e meeting it was agreed to support the same configuration of the transmission schemes on PDCCH and PDSCH. In RAN1#106e meeting, support of single-TRP PDCCH and Rel-17 SFN PDSCH were also agreed. However, it should be further discussed whether to support other transmission schemes in combination with enhanced SFN transmission scheme for PDSCH or PDCCH.

#### Round-1

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|  |  | PDSCH | | | |
| PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation |
| Rel-15 | N/A | N/A | Supported | Supported |
| Rel-17 URLLC | N/A | N/A | Yes: Futurewei,  No: OPPO, Qualcomm, Sony | Yes: Futurewei,  No: OPPO, Qualcomm, Sony |
| Scheme 1 | Yes (9): HW/HiSi, Futurewei, ZTE, Spreadtrum, CATT, CMCC, Nokia / NSB, Intel, LGE, Convida  No (7): InterDigital, OPPO, Mediatek, Lenovo / MotMob, Apple, Qualcomm, Sony | Yes: Futurewei, Nokia / NSB, Intel, Convida  No: OPPO, Qualcomm, Sony | Supported | Not supported |
| Pre-compensation | Yes (5): HW/HiSi, Futurewei, CATT, CMCC, LGE,  No (6): InterDigital, OPPO, Mediatek, Lenovo / MotMob, Qualcomm, Sony | Yes: Futurewei,  No: OPPO, Qualcomm, Sony | Not supported | Supported |

**Proposal #1-1:**

* Support of Rel-17 SFN PDCCH scheme 1 and single-TRP PDSCH

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| **Company** | **Comment** |
| Moderator | Please provide your preference directly in the table above.  In the table with comments, please also provide justification why certain combination should or should not be supported taking into account discussion in RAN1#106e (e.g., support of scenario with mix URLLC and eMBB traffic). |
| InterDigital | Don’t support, we don’t believe there is a meaningful use-case for this combination. |
| Lenovo/MotM | Do not support, agree with InterDigital. For UEs that support dynamic switching between single-TRP and SFN Scheme A/B PDSCH transmission, a reasonable alternative would be using single-TRP PDCCH transmission |
| ZTE | Support.  I think we have explained very clearly. Rel-17 SFN PDCCH is not only for HST but also for URLLC which was agreed in agenda 8.1.2.1 first. SFNed PDCCH ia a parallel solution as PDCCH repetition, and it should be allowed together with any PDSCH schemes including sTRP PDSCH. Moreover, for PDSCH scheduled by DCI 1\_0, it is sTRP PDSCH which should exist together with SFN PDCCH. We don’t see any UE implementation issues to agree this combination. |
| Ericsson | Support. We share similar view as ZTE. |
| MediaTek | Don’t support. Agree with InterDigital and Lenovo/MotM. |
| QC | Don’t support. Not enough motivation or justification why only PDCCH reliability is important than PDSCH even for URLLC use-case. |
| DOCOMO | Support. We share similar view as ZTE. There is no need to introduce restriction. |
| Sony | Not support. We also see no strong motivation to protect reliability of PDCCH over that of PDSCH. If SFN transmission is applied, it would be simpler for UE to assume both channels can be handled in the same manner. |
| Spreadtrum | Support. |
| Samsung | Support, agree with ZTE and Docomo’s view. |
| LGE | Support. Similar view with ZTE. Furthermore, if the proposal is not supported, only STRP PDCCH can be configured to support dynamic switching between STRP PDSCH and SFN PDSCH. It is hard to see why such a restriction is needed.  Regarding Rel-17 SFN PDCCH and Rel-16 PDSCH, we also support that scheme combination. If UE supports Rel-16 PDSCH, combination of Rel-17 SFN PDCCH and Rel-16 PDSCH can be supported without additional complexity and can provide flexible scheme configuration. |
| Nokia/NSB | Support. Same view as ZTE and Ericsson. |
| Huawei, HiSilicon | Support. And we support both Rel-17 SFN PDCCH Pre-compensation and single-TRP PDSCH can be combined with single-TRP PDSCH.  We think Scheme 1 and Pre-compensation based PDCCH can increase the reliability for PDCCH transmission, which is beneficial for URLLC traffic. |
| CATT | Support this proposal. We also agree with ZTE’s views. |
| Convida | Support. The SFN PDCCH isn’t only for HST. The discussion was moved here from 8.1.2.1 for convenience of discussion, so no need to add restriction. |

### Issue #1-2 (Common or separate RRC parameter for PDCCH and PDSCH)

Reagrding details of RRC configuration of SFN scheme for PDCCH and PDSCH. Several companies provided preference whether common or separate RRC parameters should be used for configuration of enhanced SFN transmission scheme for PDCCH and PDSCH.

**Issue#1-2:**

* Enhanced SFN (scheme 1 or TRP-based pre-compensation scheme) for PDCCH and PDSCH is configured by using
  + Separate RRC parameter for PDCCH and PDSCH
    - **Supported (10)**: Huawei / HiSilicon, CATT, CMCC, Ericsson, Nokia / NSB, Lenovo / MotMob, Mediatek, NTT DOCOMO, Samsung, LGE
  + Common RRC parameter for PDCCH and PDSCH
    - **Supported (4)**: vivo, Qualcomm, Sony, OPPO,

Based on the companies’ views the following proposal is made.

#### Round-1

**Proposal #1-2:**

* Enhanced SFN (scheme 1 or TRP-based pre-compensation scheme) for PDCCH and PDSCH is configured by using separate RRC parameters

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| **Company** | **Comment** |
| InterDigital | Support FL’s proposal, but where possible we could have some common configuration parameters between the two schemes. |
| OPPO | Support common RRC parameter for PDCCH and PDSCH. When RRC configures SFN transmission, single/two TCI states can be activated for PDCCH. |
| Lenovo/MotM | Support |
| ZTE | Support.  We don’t think common RRC workable as we have agreed sTRP based PDCCH can schedule SFNed PDSCH. |
| Ericsson | Support. |
| MediaTek | Support |
| QC | Don’t support FL proposal #1-2.  Support only common RRC parameter for both PDDCH and PDSCH. As agreed earlier, the SFN scheme (either sfnSchemeA or sfnSchemeB) is identified by two factors, the configuration of an RRC parameter plus two TCI states for either PDCCH (by activation of CORESET with two TCI states) or DCI indication of two TCI states.  Again, the common configuration doesn’t mandate SFN scheme for both PDCCH and PDSCH. This depends on UE capability and gNB MAC-CE indication for PDCCH (CORESET) and PDSCH. |
| DOCOMO | Support. Creating separate RRC parameter is simpler. We don’t see any issue on that. |
| Sony | Similar view with QC that even common RRC parameter configured for both PDCCH and PDSCH, it also depends on how many TCI state(s) (1 or 2) are activated for each CORESET. It implies either sTRP or mTRP PDCCH can be applied by NW.  For the sake of minimizing RRC signaling, we tend to think common RRC parameter for both PDCCH and PDSCH is enough. |
| Samsung | Support LF proposal. |
| LGE | Support |
| vivo | Share the same view with OPPO, QC and Sony, using the common RRC parameter for the indication of SFN PDCCH and SFN PDSCH doesn’t mean they are both SFN-based, it also depends the number of TCI states indicated for PDCCH and PDSCH. |
| Nokia/NSB | Support.  Because PDCCH has DMRS at every symbol, receiver complexity is not as high as SFN PDSCH but required overhead is lower than FDM/TDM PDCCH repetition. So, having only SFN PDCCH is enough to be justified. |
| Huawei, HiSilicon | Support. We don’t need to bind the parameter here with the supported combinations. Obviously, separate RRC parameter can support the combination we have agreed, especially single-TRP PDCCH and SFN PDSCH. And if no other combination is needed, we can add the corresponding restriction of configuration later. |
| CATT | Support. |
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#### Round-2

**Proposal #1-2:**

* Enhanced SFN (scheme 1 or TRP-based pre-compensation scheme) for PDCCH and PDSCH is configured by using separate per-BWP RRC parameters
  + In Rel-17 all BWPs (except initial BWP) should be have the same configuration of SFN scheme

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| **Company** | **Comment** |
| OPPO | Our preference is per CC configuration. We can accept the proposal for progress if “the same configuration of SFN scheme” here doesn’t include the case that only part of BWPs are configured with SFN. |
| Samsung | Support the FL proposal. |
| Spreadtrum | Support the proposal |
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### Issue #1-3 (RRC configuration of SFN scheme for PDCCH/PDSCH)

Regarding configuration of SFN transmission scheme for PDSCH and PDCCH. Several companies provided preference one granularity of RRC configuration of the transmission scheme. The preference is summarized below.

**Issue#1-3:**

* RRC parameter for PDCCH (scheme 1 or TRP-based pre-compensation scheme) is configured
  + Per BWP:
    - **Supported (6)**: vivo, Nokia / NSB, DOCOMO, ZTE, Samsung, vivo
  + Per CORESET:
    - **Supported (9)**: Huawei / HiSilicon, CMCC, Lenovo / MotMob, Ericsson, Samsung, LGE, Nokia / NSB, Huawei / HiSilicon, CATT
  + Per CC:
    - **Supported (6)**: Qualcomm, Intel, Sony, InterDigital, Mediatek, Spreadtrum
  + Per UE:
    - ….
* RRC parameter for PDSCH (scheme 1 or TRP-based pre-compensation scheme) is configured
  + Per BWP:
    - **Supported (10)**: Huawei / HiSilicon, CATT, Nokia / NSB, DOCOMO, Lenovo/MotM, ZTE, Samsung, LGE, vivo, CATT
  + ~~Per CORESET:~~
    - **~~Supported~~**~~:~~
  + Per CC:
    - **Supported (6)**: Qualcomm, Intel, Sony, InterDigital, Mediatek, Spreadtrum
  + Per UE:
    - …

#### Round-1

**Proposal #1-3:**

* TBD

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| **Company** | **Comment** |
| Moderator | Please provide you preference directly to the options listed in the description of Issue #1-3. In addition, please add comment to this table, if any. |
| InterDigital | Per CC for both cases. |
| OPPO | Support per CC configuration. |
| Lenovo/MotM | Support per BWP config for PDSCH, and per CORESET config for PDCCH |
| ZTE | As similar as PDSCH transmission scheme, we prefer per BWP which is a compromise between per CC and per CORESET |
| Ericsson | This is somehow related to #1-2. If separate configuration for PDCCH and PDSCH is supported: for PDSCH, SFN can be configured in the PDSCH-Config; for PDCCH the SFN can be configured in PDCCH-Config (BWP) or per CORESET. If the only interested scenario is applying SFN for HST in this discussion, PDCCH-Config (BWP) is sufficient; otherwise the configuration shall be per CORESET for further extending the SFN scheme for URLLC or other non-HST scenarios. Per CORESET configuration can also provide better flexibility for network configuration. |
| MediaTek | Per-CC for both PDCCH and PDSCH |
| Ericsson2 | The SFN can be configured in PDCCH-Config and for each CORESET, whether SFN is used will be determined with number of TCI states activated for the CORESET. |
| QC | Per-CC configuration for both PDCCH and PDSCH for the follow reasons:   1. Less RRC overhead as compared to finer granularity (per-BWP or per-CORESET). 2. As explain in issue #1-2, SFN scheme is indicated by RRC configuration + two TCI states. For some capable UE of dynamic switching between single TRP and SFN schemes, gNB can have different CORESETs with single and two TCI states while the RRC parameter is configured per CC. 3. The switching between SFN schemes and M-TRP schemes is semi-static (RRC). So, no need to follow per-BWP configuration as RRC reconfiguration is required. 4. Legacy transparent rel-16 SFN configuration is per-CC. |
| DOCOMO | Support per BWP for both PDCCH and PDSCH. |
| Sony | Support per-CC RRC configuration for both PDCCH and PDSCH.  We totally agree what QC mentioned in their listed reasons and we would like to re-state our understanding that the SFN transmission scheme(s) are not only determined by RRC parameter(s), but also the MAC CE activating TCI state(s) for PDCCH and PDSCH.  One additional observation we have is that once per BWP configuration is applied, the dynamic BWP switch might enable dynamic switch unsupported combinations, e.g. SFN PDCCH and sTRP PDSCH, if without any constraint added. |
| Spreadtrum | Support Per-CC configuration for both PDCCH and PDSCH |
| Samsung | Support per BWP for PDSCH and per BWP or CORESET for PDCCH. |
| LGE | Support per CORESET for PDCCH and per BWP for PDSCH |
| vivo | Support per BWP for both PDSCH and PDCCH. |
| Nokia/NSB | Support Per BWP for PDSH and per-BWP or CORESET for PDCCH.  No transmission parameter is configured in ServingCellConfig.  Especially, PDCCH/PDSCH are configured per BWP.  For PDCCH, we are open to per CORESET. |
| Huawei, HiSilicon | Support per CORESET configuration for PDCCH. The CORESET linked with CSS may be shared with other UEs, it is too restrictive to force the UEs receiving the CSS to use SFN transmission for PDCCH. |
| CATT | Support per BWP for PDSCH, and per CORESET for PDCCH |
| Moderator | The following proposal is made based on majority view:  **Proposal #1-3:**   * RRC parameter for PDCCH (scheme 1 or TRP-based pre-compensation scheme) is configured per CORESET * RRC parameter for PDSCH (scheme 1 or TRP-based pre-compensation scheme) is configured per BWP |

### Issue #1-4 (RRC configuration of CC sets for MAC CE activation)

Regarding configuration of the CC list that can be addressed by single MAC CE entry. Several companies provided preference whether the existing Rel-16 parameters for PDSCH can be reused for PDCCH or new Rel-17 RRC parameters should be introduced to indicate set of the serving cells that can be addressed by single MAC CE entry.

**Issue#1-4:**

* A set of the serving cells which can be addressed by a single MAC CE for activation of two TCI states of CORESET with the same CORESET ID for all the BWPs is determined by
  + New Rel-17 RRC parameters analogous to Rel-16 RRC parameters *simultaneousTCI-UpdateList1*, *simultaneousTCI-UpdateList2*
    - **Supported**: Huawei / HiSilicon,
  + Legacy Rel-16 RRC parameters *simultaneousTCI-UpdateList1*, *simultaneousTCI-UpdateList2* defined for PDSCH
    - **Supported**: ZTE, Mediatek, Ericsson, Lenovo / MotMob, Intel, DOCOMO, Sony
  + Leave the decision between new or the existing RRC parameters to RAN2
    - **Supported**: Nokia / NSB, Qualcomm,

There are more companies that prefer to reuse the existing RRC parameters, therefore, it is proposed.

#### Round-1

**Proposal #1-4:**

* Reuse legacy Rel-16 RRC parameters *simultaneousTCI-UpdateList1, simultaneousTCI-UpdateList2* to define set of the serving cells which can be addressed by a single MAC CE for activation of two TCI states of CORESET with the same CORESET ID for all the BWPs

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| **Company** | **Comment** |
| OPPO | Support the proposal. |
| Lenovo/MotM | Support reusing legacy Rel. 16 RRC parameters |
| ZTE | Support |
| Ericsson | Support |
| MediaTek | Support |
| QC | Our preference is to let RAN2 decide whether to reuse or define new configuration. If RAN1 to decide, we prefer to have new RRC parameter. |
| DOCOMO | Support Rel.16 RRC parameter. If there is no benefit of creating new RRC parameter, we don’t need to ask RAN2 to create new RRC parameter. |
| Sony | Support the FL proposal. |
| Samsung | We are fine with leaving the decision in RAN2. |
| LGE | Support |
| vivo | Support |
| Nokia/NSB | Similar view as QC. We only need for agreeing the function such as.  Proposal:  For SFN PDCCH, support simultaneous TCI update for set of the serving cells by single MAC-CE. |
| Huawei, HiSilicon | If reusing the legacy Rel-16 RRC parameters, there would be problem on how to update the CORESET that is not configured with SFN scheme. In order to have flexible configuration without compromising the inherent features of Rel-16, we prefer to introduce a new RRC parameters to update indicated CCs which support the SFN scheme.  In fact, this is related to issue#1-3. If the PDCCH is configured in a granularity less than a BWP, then there’s possibility that gNB can configure SFN CORESETs in a list, and non-SFN CORESETs in another list, and update the TCI for them separately. |
| CATT | Support |
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### Issue #1-5 (CORESET with other transmission scheme)

In RAN1#106-e meeting it was agreed to study whether and how to update the CORESET with TCI state that is not configured to SFN scheme in the indicated CCs set. The following proposal is made.

#### Round-1

**Issue#1-5:**

* UE doesn’t expect to receive a MAC-CE activating two TCI states of a CORESET that is not identified for SFN scheme by RRC.
  + **Supported by**: Qualcomm, LGE, CATT (2nd priority)
* The TCI state of other CORESETs with the same CORESET ID in the indicated CCs set that is not identified for SFN scheme by RRC is determined by one of two TCI states of MAC-CE, i.e. the first one of two TCI states activated by MAC-CE
  + **Supported by**: CATT

**Proposal#1-5:**

* UE doesn’t expect to receive a MAC-CE activating two TCI states of a CORESET that is not identified for SFN scheme by RRC.

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| **Company** | **Comment** |
| InterDigital | Question: How is a CORESET is identified for SFN? A new type with new set of RRC parameter? |
| OPPO | Support the proposal. |
| Lenovo/MotM | We prefer further clarification on the underlying hypothesis corresponding to this proposal (whether it corresponds to Hypothesis1 or Hypothesis2), as follows:  Hypothesis1: a CC list includes only CORESETs supporting SFN scheme and another CC list includes only CORESETs that are not supporting SFN scheme.  Hypothesis2: a CC list may include some CORESETs supporting SFN scheme and some CORESET not supporting SFN scheme and a MAC-CE only activating one TCI state |
| ZTE | This issue relies on the outcome of section 2.1.3, and can be discussed later. |
| Ericsson | We can comeback to this issue after we agreed on issue #1-2 and #1-3 |
| MediaTek | Support |
| QC | Support |
| DOCOMO | Question: The intention of the proposal is not only for “*in the indicated CCs set*” but also for general case? |
| Sony | Same view as ZTE and Ericsson that we could come back to this issue later when other related issues are solved or ready to be decided. |
| Spreadtrum | Support |
| Samsung | We prefer to discuss after finalizing the issue 1-2 and 1-3. |
| LGE | Our view was captured incorrectly. We prefer to simultaneously update two TCI states for all CORESETs in a CC list according to MAC-CE indication and perform SFN transmission even if a CORESET included in the CC list is not configured as SFN transmission in advance. |
| vivo | Support in principle, but could be further discussed after the issue 1-2 and 1-3. |
| Nokia/NSB | This proposal is redundant. No need for discussion. |
| Huawei, HiSilicon | The issue is related to issue #1-4. Our understanding is that gNB should be able to configure SFN list and non-SFN list, so that they can be updated separately. |
| CATT | Not support this proposal. We think this proposal has big restriction for gNB and lack of flexibility for transmission scheme.  For flexibility of configuring different transmission schemes, a CC list can include CORESETs supporting SFN scheme and some CORESET not supporting SFN scheme. If one single MAC-CE activating two TCI states, the CORESETs not supporting SFN scheme can only activated with the first one TCI state. |
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### Other issues

This section contains other issues that companies want to highlight for discussion regarding general issue.

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## UE-based solutions

### Issue #2-1 (Dynamic switching of scheme 1 and scheme-1a)

Regarding support of switching of scheme 1 and Rel-16 scheme-1a. In RAN1#104b-e meeting it was agreed to support semi-static switching and to further study possible support of dynamic switching. Views on this issue are summarized below.

**Issue#2-1:** Additional support of dynamic switching of scheme 1 and Rel-16 scheme-1a

* **Supported**: Huawei / HiSilicon, CATT, …
* **Not supported:** Qualcomm, OPPO, NEC, Nokia/NSB, Lenovo/MotMobility, Apple, …

Based on the preference above the following proposal can be made.

#### Round-1

**Proposal #2-1 (for conclusion):**

* Dynamic switching of Rel-17 scheme 1 and Rel-16 scheme-1a is not supported

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| **Company** | **Comment** |
| Moderator | This is low priority issue |
| InterDigital | Support FL’s proposal. |
| OPPO | Support the proposal. |
| Lenovo/MotM | Support |
| NEC | Support the proposal. |
| Ericsson | Fine with the proposal. |
| MediaTek | Support |
| QC | Support |
| DOCOMO | We are fine with either (support or not support). |
| Sony | Support |
| Spreadtrum | Support |
| Samsung | Support the proposal. |
| vivo | Support |
| Nokia/NSB | Support |
| Huawei, HiSilicon | We do not support the proposal.  In Rel-16, scheme 1a can be dynamically switched with other schemes. We do not see anything special for scheme 1/ TRP-based pre-compensation here.  For HST, the rapid changes of environment would result in channel property changes and rank adaptation, which means that proper transmission scheme should be used. For low rank environment, SFN transmission would be more suitable. While for high rank, it’s difficult to align the phases between both TRPs for all layers in SFN, while NCJT is more efficient in such scenarios. Therefore, to adapt to changing channels, it's beneficial in terms of spectral efficiency and reliability to switch NCJT and SFN dynamically. |
| CATT | We can accept this proposal for compromise. |
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### Issue #2-2 (Support of scheme 2)

Regarding support of scheme 2. A few companies expressed their preference regarding support of scheme 2 in Rel-17. Summary of the companies’ views are provided below.

**Issue#2-2:** Whether to support scheme 2 in Rel-17

* Scheme 2 is supported
  + **Supported by**: InterDigital, Intel …
* Scheme 2 is not supported / low priority
  + **Supported by**: Apple, Sony, Nokia/NSB, Qualcomm, ZTE, …

Since there is no majority to support scheme 2 in Rel-17, it is recommended to make the following conclusion on Issue #2-2.

#### Round-1

**Proposal #2-2 (for conclusion):**

* Scheme 2 is not supported in Rel-17

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| **Company** | **Comment** |
| Moderator | This is low priority issue |
| OPPO | Support the proposal. We don’t need to discuss this issue. |
| Lenovo/MotM | Given the limited time before concluding RAN1 Rel. 17, we believe this issue should be dropped |
| ZTE | Support |
| Ericsson | Fine with the proposal. |
| MediaTek | Support |
| QC | Support |
| DOCOMO | Support. |
| Sony | Support |
| Spreadtrum | Support |
| Samsung | Support the proposed conclusion |
| vivo | Support |
| Nokia/NSB | Support |
| Huawei, HiSilicon | Support |
| CATT | Support. |
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### Other issues

This section contains other issues that companies want to highlight for discussion regarding support of UE-based schemes.

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## TRP-based solutions

### Issue #3-1 (TRP-based pre-compensation in FR2)

Regarding support of TRP-based pre-compensation scheme for FR2. Several companies proposed to extend support of TRP-based pre-compensation to FR2, while some other companies mentioned lack of technical justification of such enhancement. Summary of the companies’ preference is provided below.

**Issue#3-1:**

* TRP-based pre-compensation scheme for PDSCH / PDCCH is only supported in FR1
  + **Supported**: Futurewei, Ericsson
* TRP-based pre-compensation scheme for PDSCH / PDCCH is supported in both FR1 and FR2
  + **Supported**: Huawei/HiSilicon, CMCC, NTT DOCOMO, Qualcomm, Sony

Based on majority view the following proposal can be made.

#### Round-1

**Proposal #3-1:**

* TRP-based pre-compensation scheme for PDSCH / PDCCH is supported in both FR1 and FR2 with UE capability per FR

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| **Company** | **Comment** |
| InterDigital | As we already agreed for operation in FR1, suggest to revise the proposal to:  **Proposal #3-1:**   * TRP-based pre-compensation scheme for PDSCH / PDCCH is supported in ~~both FR1 and~~ FR2 ~~with~~ per UE capability. ~~per FR~~ |
| ZTE | Support.  From specification perspective, we think the previous agreements can be used for both FR1 and FR2. There is no needed to explicitly restrict this feature in FR2. |
| Ericsson | Pre-compensation for FR2 has NOT been proved to be beneficial for any HST deployment. We suggest to NOT further discuss this on this meeting unless the benefit can be justified by proponents’ companies. |
| MediaTek | Support |
| QC | Support.  There is nothing that prevents the UE from supporting pre-compensation in FR2. |
| DOCOMO | Support. There is no issue for RAN1 spec. to support both FR1 and FR2. RAN4 related issue can be discussed in RAN4. |
| Sony | Support.  With UE capability per FR and RRC configuration on this SFN scheme, there seems no mandatory implementations for both sides. |
| Samsung | Support the proposal. |
| LGE | Support |
| vivo | Support TRP-based pre-compensation in FR2. But in our understanding, it’s a network capability. I wonder what is the bottleneck for UE in FR2 when TRP-based pre-compensation is used at the network side. |
| Huawei, HiSilicon | Support.  The Doppler shift is proportional to the carrier frequency, and the carrier frequency of FR2 could be 10 times that of FR1, which would lead to a Doppler shift in FR2 10 times that of FR1. As a result, FR2 is more affected by the frequency offset between different TRPs. With pre-compensation scheme, this can be handled at gNB side instead of UE side, which increases the UE complexity.  The scheme 1 for PDSCH/PDCCH for FR2 has been agreed. And there’s no further spec effort for TRP based pre-compensation in FR2 compared to scheme 1. |
| CATT | Support. |
| Moderator | One possible way forward for now is to have discussion on this issue as part of UE capability. |
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### Issue #3-2 (Support of Variant B for TRP-based pre-compensation)

In RAN1#106e meeting working assumption on QCL assumptions to assist TRP-based pre-compensation scheme was confirmed. However, it is FFS whether Variant B should be additionally supported as QCL assumptions. Companies’ views on this issue are summarized below.

**Issue#3-2:** Whether to support Variant B for TRP-based pre-compensation as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states

* Variant B is supported
  + **Supported**: Qualcomm, Intel, …
* Variant B is not supported
  + **Supported**: Huawei / HiSilicon, Futurewei, CATT, Mediatek, Nokia / NSB, Lenovo / MotMob, DOCOMO, Sony

Based on the companies’ preference the following proposal is made.

#### Round-1

**Proposal #3-2 (for conclusion):**

* Variant B is not supported for TRP-based pre-compensation as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states

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| **Company** | **Comment** |
| Moderator | This is low priority issue |
| InterDigital | Support FL’s proposal. |
| OPPO | Support the proposal. |
| Lenovo/MotM | Support |
| ZTE | We support Variant B but can accept majority views. |
| Ericsson | Fine with the proposal. |
| MediaTek | Support |
| DOCOMO | Support. We have concern on supporting variant B and making both variant A and B will be optional. It makes market fragmentation (e.g. some UEs supports variant A only and others supports variant B only). To avoid this, we believe supporting only variant A is safer and enough. |
| Sony | Support the FL proposal. |
| Spreadtrum | Support |
| Samsung | Support the proposed conclusion. |
| LGE | Support |
| vivo | Support |
| Nokia/NSB | Support |
| Huawei, HiSilicon | Support |
| CATT | Support. |

### Issue #3-3 (SRS enhancements for TRP-based pre-compensation)

In RAN1#106-e meeting it was agreed to support SRS-based Doppler measurements to assist TRP-based pre-compensation scheme. It was also agreed to further study whether enhancements to SRS are required to improve accuracy of the corresponding Doppler shift measurements. Companies’ view on this issue are summarized below.

**Issue#3-3:** For TRP-based pre-compensation

* **Alt-1**: Support SRS enhancements for Doppler shift estimation, e.g., non-contiguous SRS with configurable time gap, SRS with new usage, efficient SRS triggering, etc.
  + **Supported**: InterDigital, Qualcomm, Nokia / NSB, Sony…
* **Alt-2**: Not support of SRS enhancements in Rel-17
  + **Supported**: Huawei / HiSilicon, ZTE, Mediatek, DOCOMO

Based on the companies’ preference the following proposal is made.

#### Round-1

**Proposal #3-3 (for conclusion):**

* SRS enhancements to support TRP-based pre-compensation scheme are not supported in Rel-17

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| **Company** | **Comment** |
| Moderator | This is a low priority issue |
| InterDigital | Support Alt1 |
| OPPO | Support Alt2. |
| Lenovo/MotM | Support Alt2 |
| ZTE | Support FL proposal |
| NEC | Support the proposal. |
| Ericsson | We are supportive for SRS enhancement to achieve more accurate doppler information at low UL SNR case. |
| MediaTek | Support FL proposal |
| QC | Support Alt 1, We did some studies and presented the results in our tdoc R1-2110169. There are clear benefits to improve the estimation of Doppler shift by introducing new pattern especially at low SINR. |
| DOCOMO | Support Alt.2. We don’t see benefit of enhancing SRS. |
| Sony | Support Alt.1.  Since the Doppler-related reporting has been excluded, the only way left for NW to estimate Doppler shift and spread is to estimate SRS from UE. It may be worthy to study and then enhance SRS accordingly, if not overlapped with the AI 8.1.3 of SRS enhancement. |
| Spreadtrum | Support |
| LGE | Support |
| vivo | Support |
| Nokia/NSB | Do not support.  We still see need for possible update for SRS configuration. Because SRS spatial relation and/or pathloss\_RS are configured per SRS resource set, it is difficult to send two SRS to different TRP via existing SRS configuration.  Only AP-SRS can be supported for the use case. We don’t think single SRS transmission to two TRPs are applicable to this option.  However, we don’t support any enhancement for SRS pattern. So, we prefer to categorize Alt-1 as   * Alt1-1: non-contiguous SRS with configurable time gap * Alt1-2: enhancement for SRS configuration |
| Huawei, HiSilicon | Support |
| CATT | Support. |

### Other issues

This section contains other issues that companies want to highlight for discussion regarding support of TRP-based pre-compensation scheme.

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## Issues related to SFN transmission of PDCCH

### Issue #4-1 (Default QCL for single-beam PDSCH)

Regarding default beam assumption for PDSCH reception. When two TCI states are indicated for CORESET, several companies proposed to define rule(s) to determine default beam (TCI state) for PDSCH reception. In particular, whether and which TCI state should be used for PDSCH reception.

#### Round-1

**Proposal #4-1:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or if TRP-based pre-compensation is supported in FR2) is configured and CORESET with lowest CORESET ID in the latest slot is indicated with two TCI states and UE is not configured with *enableTwoDefaultTCI-States* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*

* Select the first TCI state of the CORESET as default TCI state for PDSCH reception
* UE not capable of dynamic switching between single-TRP and SFN transmission is expected to be configured with *enableTwoDefaultTCI-States*
* It is optional UE feature

**Supported**: ZTE, vivo, Samsung, NTT DOCOMO, Nokia / NSB, Intel, Convida Wireless,

Companies are invited to provide their views regarding the above options.

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| **Company** | **Comment** |
| Moderator | To be discussed taking into account conclusion for issue #1-1 |
| InterDigital | Should be discussed once Issue #1-1 is closed. |
| OPPO | Discuss it later when issue 1-1 and 1-2 is solved. The second sub-bullet should only be applied when SFN transmission is also configured to PDSCH. We proposal to delete it for now or add the condition “when SFN transmission is also configured to the PDSCH” for this sub-bullet. |
| Xiaomi | It can be discussed after Issue#1-1 |
| Lenovo/MotM | Support in principle |
| ZTE | We agree the main bullet and the first sub-bullet.  This issue does not have to reply on the issue#1-1. That’s because the default TCI less than the threshold should be also used for PDSCH scheduled by DCI 1\_0 (SFNed PDCCH with DCI format 1\_0).  The second sub-bullet is confused to us because it seems a condition of configuring *enableTwoDefaultTCI-States,* but UE is not configured with the parameter in the main bullet. We suggest deleting it.  For the third bullet, we don’t think it is needed. If UE supports Rel-15 default TCI behavior and also support Rel-17 SFN PDCCH, UE has to support this feature suggested in this proposal. The extra UE capability is necessary. So we suggest deleting it as well. |
| Ericsson | We are fine with the first sub-bullet. The second sub-bullet seems to be a separate discussion on dynamic switching between S-TRP and SFN transmission, our previous agreement on dynamic switch as optional UE feature is only related to DCI 1\_1/1\_2. |
| MediaTek | Support |
| QC | No support. This implies a transmission scheme of SFN PDCCH + single TRP PDSCH which is not supported (issue #1-1) |
| DOCOMO | Support.  We agree with ZTE that second sub bullet is not needed. |
| Spreadtrum | Support |
| Samsung | Support the proposal except 2nd sub-bullet. |
| LGE | We support the main bullet and the first sub-bullet.  Regarding the second sub-bullet, we can consider the following solution.  When the UE has the capability of dynamic switching or is configured as SFN PDSCH, there is at least one TCI codepoint indicating two TCI states. So, the two TCI states configured in the CORESET can be applied for SFN PDSCH reception if there is at least one TCI codepoint indicating two TCI states. However, when the UE does not have the capability of dynamic switching or is not configured as SFN PDSCH, there is no TCI codepoint indicating two TCI states. So, in this case, the UE can select one of the two TCI states based on the first sub-bullet. |
| vivo | Support the first sub-bullet. |
| Nokia/NSB | We think this can be discussed in Issue #4-6. |
| CATT | Support the main bullet and the first sub-bullet.  We also agree with ZTE that both the second sub bullet and the third sub bullet are not needed. |
| Convida | Support the first sub-bullet. |
| Moderator | **Proposal #4-1a:**  If enhanced SFN PDCCH transmission scheme (scheme 1 or if TRP-based pre-compensation is supported in FR2) is configured and CORESET with lowest CORESET ID in the latest slot is indicated with two TCI states and UE is not configured with *enableTwoDefaultTCI-States* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*   * Select the first TCI state of the CORESET as default TCI state for PDSCH reception * ~~UE not capable of dynamic switching between single-TRP and SFN transmission is expected to be configured with~~ *~~enableTwoDefaultTCI-States~~* * ~~It is optional UE feature~~ |

#### Round-2

**Proposal #4-1a:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or if TRP-based pre-compensation is supported in FR2) is configured and CORESET with lowest CORESET ID in the latest slot is indicated with two TCI states and UE is not configured with *enableTwoDefaultTCI-States* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*

* Select the first TCI state of the CORESET as default TCI state for PDSCH reception

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| **Company** | **Comment** |
| OPPO | Fine with the proposal. |
| Samsung | Support the FL proposal. |
| Spreadtrum | Support |
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### Issue #4-2 (CORESET overlapping with PDSCH)

One company has mentioned that the existing specification supports prioritization of PDCCH reception, in case qcl-Type set to 'typeD' of PDSCH DM-RS is different from that of the PDCCH DM-RS with which it overlaps in at least one symbol. In Rel-17 further clarification of the specification may be required in case SFN and non-SFN CORESET is overlapped with non-SFN and SFN PDSCH respectively.

**Issue #4-2:**

* Support prioritization of the reception in case CORESET activated one or two TCI states is overlapping with scheduled Rel-17 SFN PDSCH reception in same carrier or intra-band CA
  + FFS other details
* Support prioritization of the reception in case CORESET is overlapping with the scheduled single-TRP PDSCH reception in same carrier or intra-band CA
  + FFS other details
* **Supported by**: Samsung

Based on the companies’ preference the following proposal is made.

#### Round-1

**Proposal #4-2:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are needed |
| OPPO | We had similar issue in Rel-15 for overlapping of PDCCH and PDSCH with different QCL assumption and no conclusion was made. Suggest treat it as low priority. |
| Xiaomi | It need to be discussed case by case.   * Case 1: SFN CORESET + SFN PDSCH   + Prioritize the PDCCH reception by using two QCL TypeD of CORESET. * Case 2: SFN CORESET + non-SFN PDSCH   + Prioritize the PDCCH reception by using two QCL TypeD of CORESET. * Case 3: non-SFN CORESET + SFN PDSCH   + Prioritize the PDCCH reception by using the QCL TypeD of CORESET as the first QCL TypeD. And then determine the second QCL TypeD from two QCL TypeDs of PDSCH. The second QCL TypeD must be simultaneously received with the first one by the UE. If both QCL TypeDs of PDSCH can’t be simultaneously received with the first one by the UE, no second QCL TypeD is supported. * Case 4: non-SFN CORESET + non-SFN PDSCH   + Prioritize the PDCCH reception by using the one QCL TypeD of CORESET. |
| ZTE | We think the current specification would be sufficient to handle this issue as the spec says UE will prioritize PDCCH reception rather than drop PDSCH in the case they have different QCL-TypeD. How to receive PDSCH will be up to UE. For instance, PDCCH is activated with beam 1, and PDSCH is beam 1 and 2, their beams are still different based on the current specification. In such case, UE will prioritize PDCCH reception, and receiving PDSCH based on beam 1 and 2 are still possible as specification does not prohibit UE behavior. |
| Ericsson | In same view as ZTE, the same Rel-15 rule is used, i.e., prioritize PDCCH reception |
| QC | Similar views at ZTE and Ericsson. |
| DOCOMO | Same view with ZTE. |
| Samsung | We also have similar view on ZTE. Our basic intention is to extend a rule in current specification into the CORESET with two TCI states case. |
| vivo | Share similar views with ZTE, we can follow the Rel-15 rule. |
| Nokia/NSB | Same view as ZTE. |
| CATT | Similar views as ZTE. |
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### Issue #4-3 (Aperiodic CSI-RS overlapping with CORESET)

Some companies observed that in Rel-15 CSI-RS configured with repetition set to 'off' and overlapping in time domain with a search space set of CORESET, default beam used for the CSI-RS reception is based on TCI state of CORESET. In Rel-17, when the CORESET is indicated with two TCI state, the corresponding assumption for default TCI should be clarified to select only one TCI state. Based on the companies’ inputs the following proposal is made.

**Issue #4-3:**

* If CSI-RS other than those configured with repetition set to 'on' is overlapping in the time domain with CORESET with two TCI states, support the first TCI state of the CORESET as the default TCI assumption for the CSI-RS.
* **Supported by**: vivo, Lenovo / MotMob

#### Round-1

**Proposal #4-3:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are needed |
| Xiaomi | Support to select the first TCI state of the CORESET as the default TCI for the CSI-RS. |
| Lenovo/MotM | We support the proposal for default TCI assumption for CSI-RS |
| ZTE | Support |
| Ericsson | We think that the scenario needs further discussion. Using the 1st TCI state may not always make sense, e.g., one of two CSI-RS symbols with a 3rd TCI state overlaps with the CORESET activated with a 1st and 2nd TCI states, and the 2nd and 3rd TCI states are associated with a different TRP than the 1st TCI state. |
| DOCOMO | Support on selecting the 1st TCI state. |
| Samsung | Support to select one TCI, which can be the first one. |
| vivo | Support, the first TCI state of the CORESET as the default TCI assumption for the CSI-RS. |
| Nokia/NSB | We are fine with the principle, but good to check further detail. |
| CATT | Support |
| Moderator | **Proposal #4-3:**   * If CSI-RS other than those configured with repetition set to 'on' is overlapping in the time domain with CORESET with two TCI states, support the first TCI state of the CORESET as the default TCI assumption for the CSI-RS. |
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### Issue #4-4 (Default QCL for aperiodic CSI-RS)

In RAN1#106-e meeting, it was agreed that if *enableTwoDefaultTCI-States* is not configured, UE would use one of two TCI states of CORESET with the lowest CORESET ID as default beam for aperiodic CSI-RS reception. It is proposed to use the same UE behavior also for the case when *enableTwoDefaultTCI-States* is configured.

**Issue #4-4:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or if TRP-based pre-compensation is supported in FR2) is configured and CORESET is indicated with two TCI states, and scheduling offset for AP CSI-RS is less than the threshold and *enableTwoDefaultTCIStates* is configured

* If there is no other DL signal on the same symbol, use one of two TCI states as default beam for aperiodic CSI-RS reception, i.e.
  + using one TCI state of the CORESET with the lowest CORESET ID in the latest slot as default beam for aperiodic CSI-RS reception. If there are two activated TCI states for the CORESET with the lowest CORESET ID, one of two TCI states will be selected, i.e., always selects the first TCI state if the CORESET has two TCI states
* If there is other DL signal on the same symbol, reuse Rel-15/16 mechanism
* **Supported by**: OPPO,

#### Round-1

**Proposal #4-4:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are needed |
| OPPO | Support. |
| Lenovo/MotM | Support in principle since CSI-RS reception is always using one TCI state no matter whether *enableTwoDefaultTCIStates* is configured or not |
| ZTE | Don’t support this proposal. Following Rel-16 rules in such case should be sufficient.  ----------------- 38.214----------------------  - else if a UE is configured with *enableTwoDefaultTCIStates* and at least one TCI codepoint is mapped to two TCI states  - if there is any other DL signal with an indicated TCI state in the same symbols as the CSI-RS, the UE applies the QCL assumption of the other DL signal also when receiving the aperiodic CSI-RS. The other DL signal refers to PDSCH scheduled with offset larger than or equal to the threshold *timeDurationForQCL,* as defined in [13, TS 38.306], aperiodic CSI-RS scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming* when the reported value is one of the values {14,28,48} and *enableBeamSwitchTiming* is not provided, aperiodic CSI-RS scheduled with offset larger than or equal to 48 when the reported value of *beamSwitchTiming-r16* is one of the values {224, 336} and *enableBeamSwitchTiming* is provided, periodic CSI-RS, semi-persistent CSI-RS. If there is a PDSCH indicated with two TCI states in the same symbols as the CSI-RS, the UE applies the first TCI state of the two TCI states when receiving the aperiodic CSI-RS.  - else, the UE applies the first one of two TCI states corresponding to the lowest TCI codepoint among those mapped to two TCI states and applicable to the PDSCH within the active BWP of the cell in which the CSI-RS is to be received when receiving the aperiodic CSI-RS. |
| Ericsson | Don’t support the proposal. The same view as ZTE. |
| DOCOMO | Not support. Same as ZTE. |
| Samsung | Same view with ZTE. |
| LGE | Agree with ZTE. |
| Nokia/NSB | Agree with ZTE |
| CATT | Agree with ZTE |
| Moderator | No more discussion on this issue |
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### Issue #4-5 (Default TCI for PDSCH without TCI field in DCI formats 1\_1 / 1\_2)

Several companies discussed the issue of PDSCH reception when TCI field is not present in DCI scheduling PDSCH. In particular, whether to additionally support DCI formats 1\_1 and 1\_2 for PDSCH reception scheduled with DCI without TCI field with scheduling offset larger than threshold. The following two alternatives were identified as possible solutions.

**Issue #4-5**:

* Alt 1: Remove brackets around [1\_1 and 1\_2] in RAN1#106-e meeting agreement on default beam for PDSCH scheduled by DCI without TCI field
  + **Supported by**: NTT DOCOMO, Lenovo / MotMob, Intel, Convida Wireless, ZTE
* Alt 2: TCI field should be always present in the DCI format 1\_1 and 1\_2 scheduling SFN PDSCH scheme 1 with two TCI states.
  + **Supported by**: Qualcomm, Xiaomi

Based on the contributions the following proposal is made.

#### Round-1

**Proposal #4-5:**

* Apply the same rule for determining default TCI state for PDSCH scheduled by DCI format 1\_1 and DCI format 1\_2 as PDSCH scheduled by DCI format 1\_0, for the case when the time offset between the DL DCI and the corresponding PDSCH is equal or larger than a threshold, and if there is no TCI field in the scheduling DCI

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| **Company** | **Comment** |
| Xiaomi | We slightly prefer Alt 2, which is the same as that in Rel-16 PDSCH with two TCI states. |
| Lenovo/MotM | Support the proposal |
| ZTE | Support this proposal.  This feature is useful. TCI field overhead can be saved. Like unified TCI framework specified in agenda 8.1.1 in which PDCCH and PDSCH always use the same beam. Hence, TCI field should not be enforced presenting in DCI.  To Xiaomi, this issue is different from Rel-16 as PDCCH can be activated with two TCI states in Rel-17.  In addition, this proposal is related with issue 4-7 as there is no ‘threshold’ in FR1. So we prefer using the wording based on the current 38.214. The suggested revision is   * Apply the same rule for determining default TCI state for PDSCH scheduled by DCI format 1\_1 and DCI format 1\_2 as PDSCH scheduled by DCI format 1\_0, if there is no TCI field in the scheduling DCI, and if the time offset between the DL DCI and the corresponding PDSCH is equal or larger than a threshold if applicable,   ----- 38.214------  If the PDSCH is scheduled by a DCI format not having the TCI field present, and the time offset between the reception of the DL DCI and the corresponding PDSCH of a serving cell is equal to or greater than a threshold *timeDurationForQCL* if applicable, where the threshold is based on reported UE capability [13, TS 38.306], for determining PDSCH antenna port quasi co-location, the UE assumes that the TCI state or the QCL assumption for the PDSCH is identical to the TCI state or QCL assumption whichever is applied for the CORESET used for the PDCCH transmission within the active BWP of the serving cell |
| Ericsson | We are fine with the proposal. |
| QC | Don’t support. This proposal means SFN scheme can be indicated by an SFN CORESET which contradicts with RAN1 agreement where SFN PDSCH is identified by two TCI indicated in the DCI.  **Agreement**  Scheme 1 for PDSCH is identified by   * New RRC parameter and the number of TCI states indicated by DCI   + FFS RRC configuration details, e.g., per BWP or per CC   FFS whether or not restriction to a single CDM group for DM-RS is also supported |
| DOCOMO | Support. We believe this proposal is beneficial. We don’t think this proposal is against with the previous agreement by Qualcomm. |
| Samsung | Support the proposal. |
| LGE | Support |
| vivo | Support |
| Nokia/NSB | Support |
| CATT | Support |
| Convida | Support |
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#### Round-2

**Proposal #4-5:**

* Apply the same rule for determining default TCI state for PDSCH scheduled by DCI format 1\_1 and DCI format 1\_2 as PDSCH scheduled by DCI format 1\_0, for the case when the time offset between the DL DCI and the corresponding PDSCH is equal or larger than a threshold, and if there is no TCI field in the scheduling DCI

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| **Company** | **Comment** |
| Moderator | Let’s keep FR1 discussion separate |
| OPPO | Support the proposal. |
| Samsung | Support the FL proposal. |
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### Issue #4-6 (Default TCI for PDSCH without TCI field and offset smaller than threshold)

Several companies discussed the issue of PDSCH reception when TCI field is not present in DCI and PDSCH scheduling offset is less than threshold according to FFS from RAN1#106-e meeting agreement. It was noted that UE behavior should be the same as to the case when scheduling offset is equal or larger than the threshold *timeDurationForQCL*

**Issue #4-6**: Default TCI, if the time offset between the reception of the DCI without TCI field and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL*

Based on the companies inputs the following proposal is made.

#### Round-1

**Proposal #4-6:**

* For PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,* support configuration when there is no TCI field in the DCI scheduling PDSCH
  + If *enableTwoDefaultTCIStates* is not configured,
    - If the lowest CORESET ID in the latest slot is indicated with two TCI states, the 1st TCI state of the two TCI states is used for the PDSCH reception
    - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH
  + If *enableTwoDefaultTCIStates* is configured, UE applies the QCL assumption of the lowest TCI coodepoint with two active TCI states for PDSCH

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| **Company** | **Comment** |
| OPPO | We can accept the proposal with the following sub-bullet:   * UE not capable of dynamic switching between single-TRP and SFN transmission is not expect to be configured with the following cases:   + Single TCI state when the scheduling offset is smaller than the threshold *timeDurationForQCL*, and SFN transmission when the scheduling offset is equal to or larger than the threshold *timeDurationForQCL*   + SFN transmission when the scheduling offset is smaller than the threshold *timeDurationForQCL*, and single TCI state when the scheduling offset is equal to or larger than the threshold *timeDurationForQCL* |
| Xiaomi | We are confused that why the case is without TCI field and offset smaller than threshold, not the case with offset smaller than threshold only? |
| Lenovo/MotM | Support the proposal |
| ZTE | We are a bit confused for this proposal. Save view as Xiaomi, for the case of smaller offset than the threshold, there is no need to distinguish whether TCI field is present or not.  Further more, for the second sub-bullet, we have had the following agreement which is also applicable when TCI field is not present.  **Agreement**  If enableTwoDefaultTCI-States is configured and at least one TCI codepoint indicates two TCI states and time offset between the reception of the DL DCI and the PDSCH is less than the threshold timeDurationForQCL, default beam(s) for Rel-17 enhanced SFN PDSCH (scheme 1 or if supported TRP-based pre-compensation) reception:   * **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a   This is a UE optional feature  **Here is our suggested revision:**   * For PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,* ~~support configuration when there is no TCI field in the DCI scheduling PDSCH~~   + If *enableTwoDefaultTCIStates* is not configured,     - If the lowest CORESET ID in the latest slot is indicated with two TCI states, the 1st TCI state of the two TCI states is used for the PDSCH reception     - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH |
| MediaTek | Support |
| Ericsson | We are fine with ZTE’s modified proposal. |
| QC | It is not clear to us what is the difference between this proposal and the one in issue #4-. It seems both discuss the same issue which is the default beam for single TCI PDSCH. |
| DOCOMO | Support FL proposal. For ZTE’s proposal, we should add condition of “no TCI field”, because DCI format 1\_1/1\_2 may have TCI state field. |
| Samsung | Support ZTE’s modified proposal. |
| LGE | Similar view with ZTE/Xiaomi. We also think there is no need to distinguish whether TCI field is present or not for the case of smaller offset than the threshold. So, for the case that *enableTwoDefaultTCI-States* is configured, we can just follow the previous agreement, and for the case that *enableTwoDefaultTCI-States* is not configured, we can follow the result from issue #4-1. |
| vivo | In our understanding, this issue is to discuss the FFS in one agreement in the last meeting as follows, when TCI field is not present in DCI and PDSCH scheduling offset is less than the threshold.  **Agreement**  For PDSCH reception scheduled by DCI format 1\_0, [1\_1 and 1\_2], if the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL*   * Support configuration when there is no TCI field in the DCI scheduling PDSCH   + UE applies the state(s) of the scheduling CORESET when receiving the PDSCH     - if there are two active TCI states for the CORESET, UE applies the both QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH     - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH * FFS if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL*   As in the case that *enableTwoDefaultTCI-States* is configured, we have agreed to reuse the Rel-16 rule as follows, no matter whether there is TCI field in the DCI.  **Agreement**  If enableTwoDefaultTCI-States is configured and at least one TCI codepoint indicates two TCI states and time offset between the reception of the DL DCI and the PDSCH is less than the threshold timeDurationForQCL, default beam(s) for Rel-17 enhanced SFN PDSCH (scheme 1 or if supported TRP-based pre-compensation) reception:   * **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a   Therefore, the remaining issue is how to determine the default TCI state when *enableTwoDefaultTCI-States* is not configured when the TCI field is not present in DCI. Thus, we suggest modifying the proposal as:  **Proposal #4-6:**   * For PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,* ~~support configuration when~~ there is no TCI field in the DCI scheduling PDSCH   + If *enableTwoDefaultTCIStates* is not configured,     - If the lowest CORESET ID in the latest slot is indicated with two TCI states, the 1st TCI state of the two TCI states is used for the PDSCH reception     - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH |
| Nokia/NSB | Fine with ZTE proposal.  We think this is related with issue #4-1. |
| CATT | agree with ZTE proposal. |
| Convida | Share ZTE’s view and fine with their proposal. |
| Moderator | Updated proposal according to suggestions above:  **Proposal #4-6a:**   * For PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,* ~~support configuration when~~ and there is no TCI field in the DCI scheduling PDSCH   + If *enableTwoDefaultTCIStates* is not configured,     - If the lowest CORESET ID in the latest slot is indicated with two TCI states, the 1st TCI state of the two TCI states is used for the PDSCH reception     - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH   + ~~If~~ *~~enableTwoDefaultTCIStates~~* ~~is configured, UE applies the QCL assumption of the lowest TCI coodepoint with two active TCI states for PDSCH~~ |

#### Round-2

**Proposal #4-6a:**

* For PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL* and there is no TCI field in the DCI scheduling PDSCH
  + If *enableTwoDefaultTCIStates* is not configured,
    - If the lowest CORESET ID in the latest slot is indicated with two TCI states, the 1st TCI state of the two TCI states is used for the PDSCH reception
    - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH

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| **Company** | **Comment** |
| OPPO | We think the proposal from ZTE in Round-1 is better. The same solution can be applied regardless of TCI field in the DCI, when *enableTwoDefaultTCIStates* is not configured. |
| Samsung | Support the proposal from ZTE and agree with OPPO. It can be applied regardless of TCI field in the DCI. |
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### Issue #4-7 (Default TCI for PDSCH with absent TCI field in FR1)

One company has mentioned, that *timeDurationForQCL* is only reported in FR2. In this case the agreement made for default TCI state scheduled by DCI without TCI field is not applicable to FR1. At the same time SFN-ed PDSCH for HST deployment would be mainly used in FR1, and it is beneficial to allow DCI format 1\_0/1\_1/1\_2 without TCI state field to schedule SFN-ed PDSCH in FR1

**Issue #4-7:** Support configuration of DCI format 1\_0/1\_1/1\_2 without TCI state field for PDSCH transmission using SFN scheme in FR1

* Reuse default TCI states agreed for FR2, i.e., UE applies TCI state(s) of the scheduling CORESET when receiving the PDSCH
  + if there are two active TCI states for the CORESET, UE applies both QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH
  + otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH
* **Supported by**: NTT DOCOMO

#### Round-1

**Proposal #4-7**:

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are needed |
| Lenovo/MotM | Support in principle |
| ZTE | We don’t think this proposal is needed. A slight revision for proposal 4-5 is sufficient. Please see our comment on proposal 4-5. |
| Ericsson | Don’t support the proposal.  Default TCI state only applies to FR2. For FR1, the indicated TCI states are always used regardless the offset value, see text below from 38.214 section 5.1.5  - *In all cases above, if none of configured TCI states for the serving cell of scheduled PDSCH is configured with qcl-Type set to 'typeD', the UE shall obtain the other QCL assumptions from the indicated TCI state(s) for its scheduled PDSCH irrespective of the time offset between the reception of the DL DCI and the corresponding PDSCH.* |
| QC | No support, similar views to the issue in #4-5 |
| DOCOMO | Issue is that *timeDurationForQCL* is only reported in FR2. So, even if proposal 4-5 is agreed, it only applied to FR2, because there is condition of *timeDurationForQCL* in proposal 4-5.  The consequence of not supporting proposal 4-7 is that DCI format without TCI state field can schedule SFN-PDSCH in FR2, but it cannot schedule SFN-PDSCH in FR1.    **Agreement**  For PDSCH reception scheduled by DCI format 1\_0, [1\_1 and 1\_2], if the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL*   * Support configuration when there is no TCI field in the DCI scheduling PDSCH   + UE applies the state(s) of the scheduling CORESET when receiving the PDSCH     - if there are two active TCI states for the CORESET, UE applies the both QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH     - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH * FFS if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL*   This is a UE optional feature. |
| Nokia/NSB | We don’t see need. Same view as Ericsson. FR1 doesn’t apply default QCL. |
| CATT | Support in principle |
| Moderator | Let’s take it as separate issue from 4-5.  Re: Ericsson, Nokia/NSB. It would be good to clarify why default QCL is not needed in FR1? It is a new release and the benefit may be the similar to FR2 i.e., reduction in the DCI overhead. |
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#### Round-2

**Proposal #4-7**:

Support configuration of DCI format 1\_0/1\_1/1\_2 without TCI state field for PDSCH transmission using SFN scheme in FR1

* Reuse default TCI states agreed for FR2, i.e., UE applies TCI state(s) of the scheduling CORESET when receiving the PDSCH
  + if there are two active TCI states for the CORESET, UE applies both QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH
  + otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH

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| **Company** | **Comment** |
| OPPO | We don’t think the proposal is needed. For FR1, the indicated TCI state can be applied as in Rel-15/16. |
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### Issue #4-8 (Default spatial / PL RS for Rel-17 multi-TRP PUSCH/PUCCH)

One company mentioned that default spatial relation and PL-RS are only defined in the case of single-TRP PUSCH/PUCCH/SRS transmission. However, for multi-TRP based PUCCH/PUSCH/SRS transmission, default spatial relation and PL-RS are not defined. It is therefore proposed to clarify default assumptions.

**Issue #4-8:**

* If a CORESET is indicated with two TCI states and PL-RS and spatial relation information are not configured and default beam is enabled for the PUCCH transmission
  + If PUCCH repetition is configured, the two TCI states activated for the CORESET with the lowest ID on the active DL BWP are used to determine the spatial relation and PL-RS of PUCCH transmission occasions, and each TCI state is associated to one PUCCH transmission occasion group
* If a CORESET is indicated with two TCI states, and default spatial relation and PL-RS of PUSCH are determined by QCL assumption of CORESET with lowest ID
  + If PUSCH repetition is configured, the two TCI states activated for the CORESET with the lowest ID are used as the default spatial relation and PL-RS, and each TCI state is associated to one PUSCH transmission occasion group.
* If a CORESET is indicated with two TCI states and default spatial relation and PL-RS of SRS are determined by QCL RS of CORESET with lowest ID
  + If two SRS resource sets for codebook or non-codebook PUSCH are configured, the two TCI states activated for the CORESET with the lowest ID are used as the default beam and PL-RS of SRS, and each TCI states is associated to one SRS resource set
* **Supported by:** ZTE, Samsung, Mediatek, DOCOMO, CATT,
* **Not supported by:** OPPO, Xiaomi,

#### Round-1

**Proposal #4-8:**

* + TBD

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| **Company** | **Comment** |
| Moderator | More inputs are needed |
| OPPO | Not support.  For multi-TRP based PUCCH/PUSCH/SRS transmission, whether to apply default spatial relation and PL-RS agreed in Rel-16 has not been agreed even for case of CORESET with single TCI state. After the decision is made in 8.1.2.1, we can further discuss this issue. If it is not agreed for legacy CORESET, we don’t need to discuss it for enhanced CORESET. |
| Xiaomi | It can be discussed in later release |
| Lenovo/MotM | For PUCCH, if a PUCCH with repetition is configured or indicated as M-TRP PUCCH, two default beams and two PL-RSs are determined for the PUCCH resource; if a PUCCH with repetition is configured or indicated as S-TRP PUCCH, only one of the two default beams and two PL-RSs are determined for the PUCCH resource. Therefore, we propose to first configure or indicate whether a PUCCH resource is an M-TRP PUCCH resource or S-TRP PUCCH resource in default beam mode.  For SRS, we support the proposal where 2 default beams and 2 PL-RSs are determined for two SRS resource sets.  For PUSCH, the default beam and PL-RS are determined by the associated SRS resource set. Considering that there is a two-bit field to indicate the SRS resource set(s) associated with a PUSCH transmission, the actual beam of the PUSCH should be indicated according to a two-bit field where one of 2 default beams and 2 PL-RSs is determined for the PUSCH or two default beams and two PL-RSs are determined for the PUSCH |
| ZTE | Support this proposal.  In last meeting, we only agree the default spatial/PL for STRP PUSCH/PUCCH/SRS. However, we don’t know how to distinguish whether it is STRP or MTRP. **It should be clarified what is STRP or MTRP PUSCH/PUCCH/SRS**. In our view, it will depends on whether ‘repetition’ is configured, or depends on whether ‘cyclic/sequential’ PUCCH/PUSCH beam mapping is configured.  That is, when ‘cyclic/sequential’ PUCCH/PUSCH beam mapping is configured, and PDCCH is configured with two TCI states, the default spatial/PL of PUCCH/PUSCH/SRS can follow the two TCI states to achieve MTRP diversity and save signaling overhead. |
| MediaTek | Support |
| Ericsson | The issue #4-8 needs further clarification.  As far as we know, there was no agreement in mTRP PUCCH discussion that PUCCH repetition can be supported for a PUCCH resource not configured with two power control related parameters. The same is true for PUSCH. We think this type of discussion should be in the mTRP PUCCH/PUSCH session instead of here. |
| QC | We don’t think this proposal is needed since we do not have a default beam / PL-RS for mTRP PUCCH/PUSCH repetitions in that context. The only case that a default power control param is needed is when SRI field is not present, and in that case, the rule is independent of CORESET, and the rule is already agreed in other agenda. Also, as Ericsson mentioned, this issue should be discussed in the mTRP PUCCH/PUSCH session. |
| DOCOMO | Support. |
| Samsung | Support the proposal. |
| LGE | We open to discuss this issue. If some companies want to discuss this issue in the mTRP PUCCH/PUSCH session, we think it is better to at least make conclusion. Based on that conclusion, experts in that session can discuss further details related to this issue. |
| vivo | It is better to discuss this issue in AI 8.1.2.1. |
| Nokia/NSB | We are open to discuss. Further clarification is required. |
| CATT | Support |
| Moderator | Would it be acceptable to have discussion on this issue in AI 8.1.2.1? |

### Issue #4-9 (PDCCH monitoring with different QCL-TypeD)

Several companies proposed to discuss priority rules for PDCCH monitoring of PDCCH candidates in overlapping monitoring occasion with different QCL-TypeD when CORESET is indicated with two TCI states. Companies’ views on this issue are summarized below.

**Issue #4-9:**

* When a CORESET is activated with two TCI states which overlaps with another CORESET, support PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with QCL-TypeD properties identified according to prioritization rule
  + Down-select one alternative
    - Alt 1: Search Space (SS) type > serving cell index > SS set ID
      * **Supported by:** OPPO, ZTE, Qualcomm,
    - Alt 2: SS type > serving cell index > SS set ID > the number of TCI states of CORESET
      * If prioritized CORESET has one TCI state, the second QCL type D is identified by the first TCI of a CORESET with the second highest priority
      * **Supported by:** Huawei / HiSilicon, ZTE,
    - Alt 3: SS type > serving cell index > SS set ID > the number of TCI states of CORESET
      * If prioritized CORESET has one TCI state, the second QCL type D is identified according to one of the SS sets that is linked with a CORESET with the first QCL-TypeD among the multiple overlapping CORESETs); and
      * In case of multiple such CORESETs, Rel. 15 priority order is used for the second QCL-TypeD determination.
      * **Supported by:** Spreadtrum?, CATT
    - Alt 4: the number of TCI states for CORESET > SS type > serving cell index > SS set ID
      * **Supported by:**
    - Alt 5: SS type > the number of TCI states for CORESET > serving cell index > SS set ID
      * If prioritized CORESET has one TCI state, all CORESETs associated with at least the one active TCI state are also monitored.
      * **Supported by:** NTT DOCOMO, Lenovo / MotMob, LGE, Xiaomi, Samsung, LGE,
    - Note: SS type with CSS has higher priority than SS type with USS, SS set with lower index has higher priority than SS set with higher index, serving cell with lower index has higher priority than serving cell index with higher index, two TCI states for CORESET has higher priority than one TCI state
  + PDCCH candidates in CORESET(s) that have one or two QCL-TypeD properties wherein at least one of them is different from two QCL-TypeD properties determined form prioritization rule above are not monitored by the UE.

#### Round-1

**Proposal #4-9:**

* TBD

Companies to provide their views on the proposal above.

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| **Company** | **Comment** |
| Moderator | Please indicate your preference to the alternatives directly in the description above. |
| OPPO | We prefer Alt 1 to reuse current rule. |
| Xiaomi | We prefer Alt 5 |
| Lenovo/MotM | We support Alt5 which provides higher priority for monitoring two QCL-TypeD associated with SFN transmission. Also, we are fine with Alt1: SS type > serving cell index > SS set ID in order to resemble the legacy rule as much as possible. Moreover, we do not prefer to monitor one QCL-TypeD associated with non-SFN based PDCCH and another QCL-TypeD from one of QCL-TypeD associated with SFN based PDCCH, since UE may not support the capability to monitor both QCL-TypeD if they are associated with the same UE panel |
| ZTE | We support Alt 1 or Alt 2 which have no much difference for us. Our motivation is to reuse Rel-15 rule to determine two QCL-TypeD. To make proposal clearer, we suggest to revise Alt 2 as   * Alt 2: Reuse Rel-15 prioritization to identify one or two CORESET   + If prioritized CORESET has one TCI state, the second QCL type D is identified by the first TCI of a CORESET with the second highest priority     - If UE is not able to proceed the identified two TCI simultaneously, UE just proceed the first one.   Alt.5 is not clear for us why CORESET with two TCI should be prioritized, this is not aligned with Rel-15 design. |
| Ericsson | CSS is typically shared with all Rel15/16/17 UEs and the SFN shall not change the behavior of UE monitoring CSS. The prioritizing rule shall only impact USS.    **Alt 6. The legacy QCL-D prioritization rule is enhanced by prioritize SFN USS over non-SFN USS.**   * If there are CSS in the monitoring occasion, select a CSS with legacy rules   + If there is a SFN USS having a same QCL-D as the CSS, also select the SFN USS. If there are more than one such SFN USS, select a SFN USS based on the legacy rules * Else if there is one or more SFN USS across all CCs   + select a SFN USS based on the legacy rules * Otherwise   + Select a USS based on legacy rules   Monitoring CORESET(s) with the same QCL-D as the selected CSS and/or USS. |
| QC | We don’t support defining a new rule.  Also, giving the diverge views and different proposals, it seems hard to find a solution that provide common ground for the different companies. Suggest reducing the number of alternatives first in this meeting and then select one rule in the next RAN1 meeting.  Also, the 2nd sub bullet seems non-controversial which can be agreed first. “PDCCH candidates in CORESET(s) that have one or two QCL-TypeD properties wherein at least one of them is different from two determined QCL-TypeD properties ~~determined form prioritization rule above~~ are not monitored by the UE.” |
| DOCOMO | Support Alt.5. We believe CORESET with two TCI states should be higher priority than CORESET with one TCI state, to enable SFN-PDCCH. Also, we believe Alt.5 is align with the basic Rel.15/16 principle that CSS is always higher priority than USS. |
| Spreadtrum | Support Alt.3. On one hand, Alt 3 still follows Rel-15 principle where CSS type prioritize over USS type by identifying the first QCL-typeD properties based on Rel-15 rule; on the other hand, identifying the second QCL-typeD properties by combing with SFN feature could priority SFN transmission and improve the performance. |
| Samsung | Our preference is mis-captured. Support Alt.5. |
| LGE | We prefer Alt5.  Based on Alt5, if the selected SS set with highest priority is related to SFN PDCCH, multiple PDCCHs can be simultaneously monitored based on the preferred QCL-TypeD property combination from MTRP point of view because the combination from MTRP point of view can be configured based on CSI feedback from UE, e.g., by group based beam reporting. |
| CATT | In order to align with current specs, we also think that SFN-ed CORESET should not be prioritized.  According to the description of Alt 2, if the prioritized CORESET has one TCI state, then no SFN-ed CORESET will be monitored in this overlapping occasion.  For Alt 3, if the prioritized CORESET has one TCI state, i.e. {QCL#1}, then one SFN CORESET with the first TCI state, i.e. {QCL#1, QCL#2} can also be monitored. And if more than one CORESET including QCL#1, Rel-15 priority order is used for the second QCL-TypeD determination, which is more aligned with current specs.  Therefore, Alt 3 is more preferred. |
| Moderator | It seems majority prefers Alt 5:  **Proposal #4-9:**   * When a CORESET is activated with two TCI states which overlaps with another CORESET, support PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with QCL-TypeD properties identified according to prioritization rule   + **Alt 5**: SS type > the number of TCI states for CORESET > serving cell index > SS set ID     - If prioritized CORESET has one TCI state, all CORESETs associated with at least the one active TCI state are also monitored.   + Note: SS type with CSS has higher priority than SS type with USS, SS set with lower index has higher priority than SS set with higher index, serving cell with lower index has higher priority than serving cell index with higher index, two TCI states for CORESET has higher priority than one TCI state   + PDCCH candidates in CORESET(s) that have one or two QCL-TypeD properties wherein at least one of them is different from two QCL-TypeD properties determined form prioritization rule above are not monitored by the UE. |
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#### Round-2

**Proposal #4-9:**

* When a CORESET is activated with two TCI states which overlaps with another CORESET, support PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with QCL-TypeD properties identified according to prioritization rule
  + **Alt 5**: SS type > the number of TCI states for CORESET > serving cell index > SS set ID
    - If prioritized CORESET has one TCI state, all CORESETs associated with at least the one active TCI state are also monitored.
  + Note: SS type with CSS has higher priority than SS type with USS, SS set with lower index has higher priority than SS set with higher index, serving cell with lower index has higher priority than serving cell index with higher index, two TCI states for CORESET has higher priority than one TCI state
  + PDCCH candidates in CORESET(s) that have one or two QCL-TypeD properties wherein at least one of them is different from two QCL-TypeD properties determined form prioritization rule above are not monitored by the UE.

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| **Company** | **Comment** |
| Samsung | Support the FL proposal. |
| Spreadtrum | Not support.  In our understanding, SFNed CORESETs should not be over prioritized. In Proposal 4-10, Type3 CSS can support scheme1. Then according to Alt5, it means that the priority of Type3 CSS configured with scheme 1 is higher than Type0/0A/1/2 CSS. It is not preferable.  Suggest to defer the discussion, and wait the decision of issue#4-10. |
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### Issue #4-10 (SFN transmission of PDCCH associated with CSS)

Several companies discussed whether SFN transmission scheme can be used to transmit PDCCH in CSS and which QCL assumptions UE should use for PDCCH reception when CSS is associated with CORESET with two TCI states. Based on the discussion the following alternatives were identified for further discussion.

**Issue #4-10**: For CSS associated with SFN CORESET, support one of the following options:

* Alt 1: UE doesn’t expect PDCCH candidates in CSS 0/0A/1/2/3 to be associated with an CORESET that activated with two TCI states and configured with scheme 1 or TRP-based pre-compensation scheme
  + **Supported by**:
* Alt 1a: UE doesn’t expect PDCCH candidates in CSS 0/0A/1/2/3 to be associated with an CORESET that activated with two TCI states and configured with TRP-based pre-compensation scheme
  + **Supported by**: Qualcomm
* Alt 2: UE doesn’t expect PDCCH candidates in CSS to be associated with an CORESET that activated with two TCI states, except CSS type 3 and CORESET configured with scheme 1
  + **Supported by**: Ericsson, ZTE, Samsung
* Alt 3: If PDCCH candidates in CSS are associated with an SFN CORESET that activated with two TCI states and configured with scheme 1 or TRP-based pre-compensation scheme support to select one of the two TCI states for CSS reception
  + **Supported by**: vivo, OPPO, Lenovo/MotM, LGE

#### Round-1

Proposal #4-10:

* + TBD

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| **Company** | **Comment** |
| OPPO | We support Alt 3. It can be applied only when TRP-based pre-compensation scheme is configured or for both schemes. |
| Xiaomi | To align with AI 8.1.2.1 Multi-TRP PDCCH transmission, CSS type 3 can be supported by SFN PDCCH transmission scheme 1. But Alt 2 is much more restrictive that CSS other than CSS type 3 can’t be associated with a CORESET that activated with two TCI states. We suggest Alt 4 as below:  Alt 4:   * If PDCCH candidates in CSS type 3 are associated with an SFN CORESET that activated with two TCI states and configured with scheme 1, support two TCI states for CSS reception. * If PDCCH candidates in CSS 0/0A/1/2 are associated with an SFN CORESET that activated with two TCI states and configured with scheme 1 or if PDCCH candidates in CSS 0/0A/1/2/3 associated with an SFN CORESET that activated with two TCI states and configured TRP-based pre-compensation scheme, support to select one of the two TCI states for CSS reception. |
| Lenovo/MotM | We think it is possible that the CORESET associated with CSS can be the same as the CORESET associated with USS with two TCI states for SFN transmission. Thus, we support Alt3, which resembles the legacy scheme as much as possible. Otherwise, we prefer a more stringent restriction such as Alt1 |
| ZTE | SFN PDCCH was agreed in agenda 8.1.2.1, and it is a parallel solution with PDCCH repetition which has been agreed for CSS type 3. So we think SFN PDCCH should also be applicable for CSS type 3 in high blockage scenarios. Similarly, SFN PDCCH should not be used for CSS type 0/1/1A/2.  We suggest firstly agreeing the following general proposal   * SFN PDCCH is not supported other than CSS type 3 with SFN scheme 1 |
| Ericsson | We share ZTE’s view that -- whether and what CSS type is supported for SFN should be discussed first. |
| QC | We don’t think that TRP pre-compensation scheme can be used for PDCCH candidates in all CSS types. How would it work with the mix of legacy UE and rel-17 UEs and the mix of rel-17 UEs with different Doppler shifts? |
| Samsung | Support only for CSS type 3. |
| LGE | Support Alt3. We have similar view with Lenovo on Alt3. |
| vivo | Support Alt 3, it can allow the SFN-based CORESET to be used simultaneously for both CSS (for Broadcast or group) and USS. It is more flexible for SS monitoring and CORESET configuration. |
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#### Round-2

Proposal #4-10:

* SFN PDCCH schemes (scheme 1 or TRP-based pre-compensation) are not supported in CSS, except scheme 1 in CSS type 3

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| **Company** | **Comment** |
| OPPO | According to the discussion in Round-1, Alt 3/4 has more support than Alt 2. Can we try the following proposal?  **Proposal:**  If PDCCH candidates in CSS 0/0A/1/2/3 are associated with an CORESET that activated with two TCI states, the first TCI state is applied for the CSS reception.   * Not applied to CSS type 3 associated with CORESET configured with scheme 1, where both TCI states can be applied. |
| Samsung | Support the FL proposal to align with the outcome of AI 8.1.2.1 PDCCH repetition. |
| Spreadtrum | Support. Share the same view with Samsung. |
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### Issue #4-11 (Broadcast PDSCH scheduled by a PDCCH in CSS)

Two companies discussed issue of PDSCH transmission carrying broadcast info (e.g., SIB1, OSI, paging) in SFN scenario. In particular whether PDSCH can be transmitted using SFN scheme (e.g., using TRP-based pre-compensation scheme). It is proposed to further study possible enhancements for SFN scenario, e.g., whether SFN scheme can be assumed by the UE for PDSCH / SSB reception and whether current QCL assumptions in Rel-16 can be reused for PDSCH reception scheduled by DCI format 1\_0.

**Issue #4-11**: Study default QCL and transmission scheme for PDSCH scheduled by DCI format 1\_0 with SI-RNTI or P-RNTI in CSS set Type 0/1/1A/2

#### Round-1

Proposal #4-11:

* + TBD

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| **Company** | **Comment** |
| Moderator |  |
| OPPO | Support to study. Suggest to apply the same solution as issue #4-10. |
| Xiaomi | It can be discussed after issue#4-10. |
| Lenovo/MotM | We believe this issue is related with the conclusion of Issue #4-10. We are fine with further study |
| ZTE | We are OK to further study, but it should be deprioritized.  One additional comment to FL, it is better to point out which two companies suggested the proposal, then people may be easy to find detailed description from the corresponding contributions. |
| Ericsson | We think the default should be Rel-15. Enhancement can be further studied. |
| QC | Support the study and clarify how the broadcast PDSCH and SSB would be transmitted with SFN schemes.  Reply to ZTE: I believe Qualcomm and OPPO are the two companies. FL to further confirm. |
| Samsung | Okay to further study. |
| CATT | Support to study, but this issue should be deprioritized. |
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## Other issues

This section contains other issues the companies want to highlight for discussion regarding support of SFN PDCCH transmission.

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| **Company** | **Comment** |
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## Beam Failure Detection and Recovery, Radio Link Monitoring

### Issue #5-1 (Number, counting and prioritization of RS for implicit BFD)

Several companies discussed the issues of the reference signals configuration for beam failure detection (BFD), counting of BFD RS and prioritization of RS for BFD monitoring when two TCI states are activated for CORESET. Companies’ views for these issues are summarized below.

**Issue #5-1:**

* One BFD RS pair for SFN PDCCH is counted as two BFD RSs
  + **Supported**: Apple, LGE, Convida Wireless, Qualcomm, Sony
* BLER for BFD RS is calculated according to the following rule:
  + Alt 1: For a CORESET with two activated TCI states, two RS indexes are included in  and UE calculates two hypothetical BLER for the CORESET
  + **Supported**: Spreadtrum, Convida Wireless,
  + Alt 2: For a CORESET with two activated TCI states, UE calculates single hypothetical BLER for each CORESET
  + **Supported**: ZTE, vivo, Xiaomi, NEC, Qualcomm, Sony, CATT
* For the implicit BFD RS, the maximum number of monitored BFD RSs X should be increased
  + X = 4, FFS other values
  + **Supported**: CATT, NEC?, NTT DOCOMO, LGE, Sony
  + **Not supported**: vivo, Mediatek, Qualcomm
* When the number of BFD RS determined from active TCI states of CORESETs for PDCCH monitoring is larger than X, UE selects X RS based on following rule
  + Alt 1: UE selects X RS provided for active TCI states for PDCCH receptions in CORESETs associated with the SS sets in the order from the shortest monitoring periodicity
    - If more than one CORESETs are associated with SS sets having same monitoring periodicity, the UE determines the order of the CORESET from the highest CORESET ID.
    - **Supported**: NTT DOCOMO
    - **Not supported**: Mediatek
  + Alt 2: UE selects X RS prioritizing CORSET with two TCI states
    - **Supported**: CATT?, NEC
    - **Not supported**: Mediatek
  + Alt 3:When configured with CORESET with one and two active TCI States, UE selects one RS from one CORESET and one RS from another CORESET
    - **Supported**: Nokia / NSB

Companies are invited to provide their views regarding the above proposals.

#### Round-1

Proposal #5-1:

* TBD

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| **Company** | **Comment** |
| Moderator | Please provide your preference to the proposals above. |
| Xiaomi | For the BLER for BFD RS calculation, we prefer the Alt 2: calculate single hypothetical BLER for each CORESET with two activated TCI states. Since Alt 1 can’t take SFN PDCCH transmission into account. |
| Lenovo/MotM | For BLER for BFD RS, we prefer calculation according to a single hypothetical BLER. Also, we think more discussion is needed on whether BFD RS is counted based on RS number or RS pair number for defining UE capability. One BFD RS pair for SFN PDCCH can be counted as one BFD RS since they are used together for calculating one hypothetical BLER. Otherwise, it may lead to increasing BFD RS number. Moreover, UE is not expected to be configured with more than two RS or RS pair in the set |
| ZTE | We suggest focusing on BLER issue first as it is related to subsequent RAN4 work. As Xiaomi said, Alt 2, i.e. single hypothetical BLER for each CORESET with two activated TCI states should be supported as it can well reflect the SFN PDCCH transmission. |
| NEC | For BLER calculation, we support Alt 2.  For BFD RS determination, support Alt 2, CORESET with two TCI states should be selected firstly. And regarding the maximum number of BFD RS, we are fine to increase the number to be larger than 2. |
| MediaTek | Support one BFD RS pair for SFN PDCCH is counted as two BFD RSs  For BLER for BFD RS, support Alt 2.  For the implicit BFD RS, the maximum number of monitored BFD RSs, we don’t support to increase the number of BFD RSs. |
| Qualcomm | * The maximum number of BFD RS is two (i.e., no enhancement to increase # BFD-RS). The two BFD-RS can be selected from one SFN CORESET. * Support single hypothetical BLER for SFN CORESET. It is up to UE implementation how to calculate the single hypothetical BLER. |
| Sony | Our views are added.  If one BFD-RS pair of a CORESET is counted as two BFD-RSs in q0, then we think the total number of BFD RSs in q0 should be increased to support UE monitoring more than 1 CORESETs. |
| LGE | We support single hypothetical BLER for each CORESET. (i.e., Alt2)  Regarding the number of BFD RSs, the current limit is 2. Using the same limit for SFN CORESET would mean that we introduce a stronger limitation than legacy system.  - Legacy: up to 2 BFD RSs across 3 CORESETs with 1 TCI RS each.  - With SFN: up to 2 BFD RSs across 3 CORESETs with up to 2 TCI RSs each.  Therefore, we think that it is essential to increase the BFD RS limit. To address UE complexity issue, we can introduce a UE capability report including the value of two. |
| vivo | For BLER for BFD RS, we support Alt2.  For the maximum number of BFD-RS, it seems better to agree whether to enhance it or not first. |
| CATT | For SFN-ed transmission schemes, it is necessary that UE can determine BFD RSs in CORESET level, i.e. if a spatial relation RS for a SFN-ed CORESET is determined to be a BFD RS, all the spatial relation RSs for the SFN-ed CORESET are determined to be BFD RSs. Then, UE can monitor all BFD RSs simultaneously for SFN-ed CORESET and calculate single hypothetical BLER for better matching the SFN-ed channel conditions.  Besides, if both S-TRP and SFN-ed CORESETs are configured in one monitoring occasion, SFN-ed CORESET should be selected firstly, i.e. Alt 2, for ensuring that beams of each TRP can be monitored as much as possible.  Finally, we think the maximum number of BFD RSs can be discussed in AI 8.1.2.3. For SFN-ed transmission schemes, it is necessary that UE can determine BFD RSs in CORESET level, i.e. if a spatial relation RS for a SFN-ed CORESET is determined to be a BFD RS, all the spatial relation RSs for the SFN-ed CORESET are determined to be BFD RSs. Then, UE can monitor all BFD RSs simultaneously for SFN-ed CORESET and calculate single hypothetical BLER for better matching the SFN-ed channel conditions.  Besides, if both S-TRP and SFN-ed CORESETs are configured in one monitoring occasion, SFN-ed CORESET should be selected firstly, i.e. Alt 2, for ensuring that beams of each TRP can be monitored as much as possible.  Finally, we think the maximum number of BFD RSs can be discussed in AI 8.1.2.3. |
| Convida | Regarding the second bullet (hypothetical BLER calculation), we already had a conclusion in RAN1#106-e that there is no RAN1 impact, so we suggest not to discuss the issue again.  The existing spec already describes that two RS indexes are included in :   |  | | --- | | … the UE determines the set  to include periodic CSI-RS resource configuration indexes with same values as the RS indexes in the RS sets indicated by *TCI-State* for respective CORESETs that the UE uses for monitoring PDCCH and, if there are two RS indexes in a TCI state, the set  includes RS indexes configured with *qcl-Type* set to 'typeD' for the corresponding TCI states. |   Regarding the selection rule (e.g. RLM-RS rule), it was already captured in an FFS in agenda 8.1.2.4, so prefer to keep the discussion in 8.1.2.4. |

### Issue #5-2 (Explicit RS configuration for BFD)

Several companies have discussed the issue of explicit RS configuration for BFD. Based on the companies’ contributions the following alternatives are proposed.

**Issue #5-2:**

* For explicit configuration of BFD RS
  + Support defining CSI-RS resource or SSB pairs
    - **Supported**: ZTE, vivo, CATT, Lenovo / MotMob, Apple, Xiaomi, NEC, DOCOMO, Sony
  + Reuse Rel-15/Rel-16 approach for BFD RS configuration
    - **Supported**: Spreadtrum, Convida Wireless, Qualcomm, Nokia/NSB, vivo,

Companies are invited to provide their views regarding the above alternatives.

#### Round-1

**Proposal #5-2:**

* TBD

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| **Company** | **Comment** |
| Xiaomi | We support defining CSI-RS resource or SSB pairs for explicitly configuration of BFD RS. If not, BFRQ may be triggered when the BLER of SFN PDCCH is higher than Qout. |
| Lenovo/MotM | Support defining CSI-RS resource or SSB pairs for explicit configuration of BFD RS, which can be used for hypothetical BLER calculation based on SFN transmission. Otherwise, the false alarm rate may be higher if hypothetical BLER is calculated based on only one CSI-RS or SSB. If BFD RS configuration as Rel-15/Rel-16 for is used, the implicit or explicit linkage is desirable between two BFD RS for SFN transmission |
| ZTE | Support defining CSI-RS resource or SSB pairs. We have the same view as Lenovo. |
| NEC | Support defining CSI-RS resource or SSB pairs. |
| MediaTek | Support defining CSI-RS resource or SSB pairs. |
| Qualcomm | Support to reuse Rel-15/16 rule based on single RS. |
| Sony | Support the idea of defining BFD-RS pair.  But we would like to remind that in Rel.15/16, only periodic CSI-RS is allowed as explicitly configured BFD-RS, not SSB. So should we follow the same rule? |
| LGE | Explicit BFD is for when UE-specifically beamformed CSI-RS is used, which is not the main use case for SFN transmission. We propose not to use explicit BFD for SFN transmission. Implicit BFD is sufficient. |
| vivo | Support to reuse Rel-15/Rel-16 approach for BFD RS configuration. And I have a small question about defining BFD-RS pair, does it mean we need to enhance the RRC for explicit configuration of BFD RS? |
| Nokia/NSB | Support to reuse Rel-15/16 approach. |
| CATT | Support defining CSI-RS resource or SSB pairs. |
| Convida | We already concluded in RAN1#106-e that there will be no hypothetical BLER calculation enhancement in RAN1, so there is no need to further discuss to introduce explicit RS pairing for the purpose of enhanced BLER calculation.  In other words, physical layer indicates a beam failure event to higher layers “when the radio link quality for all corresponding resource configurations in the set  that the UE uses to assess the radio link quality is worse than the threshold”, as in Rel-15/16. |

### Issue #5-3 (NBI RS configuration)

Several companies have discussed the issue of configuration of new beam identification (NBI) reference signals, when two TCI states are activated for CORESET. Based on the companies’ contributions the following preference on the agreed alternatives from RAN1#105e meeting are provided.

**Issue #5-3:**

* When two TCI states are activated for a CORESET, NBI RS are configured as follows
  + Alt 4-1: Reuse the existing Rel-15 NBI configuration based on single CSI-RS resource
    - **Supported**: Spreadtrum, vivo, Qualcomm, Nokia/NSB
  + Alt 4-2: Introduce two new beam identification CSI-RS resource sets or new beam identification CSI-RS resource pairs
    - **Supported**: ZTE, NEC, Xiaomi, Lenovo / MotMob, Apple, DOCOMO

#### Round-1

Companies are invited to provide their views regarding the above alternatives.

**Proposal #5-3:**

* TBD

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| **Company** | **Comment** |
| Xiaomi | For SpCell, we prefer to reuse the existing Rel-15 NBI configuration based on single CSI-RS resource for NBI RS configuration. Since only one new bean can be indicated by RACH based BFRQ. While for SCell, we prefer to introduce CSI-RS resource pairs and a pair of new beam index can be indicated in MAC CE. |
| Lenovo/MotM | Support Alt 4-2 for identifying two new beams so that the transmission reliability for later PDCCH/PDSCH with SFN-based transmission would be improved with two new identified beams |
| ZTE | We think UE should have flexibility to report one or two new beams. |
| NEC | Support Alt 4-2. And share similar view with ZTE. |
| MediaTek | Support Alt 4-2 |
| Qualcomm | Support Alt 4-1, UE should recover in single TRP mode. |
| DOCOMO | Support Alt 4-2 |
| Sony | Similar view as ZTE that depending on the DL channel condition, it should eb up to UE to report single new beam (for sTRP fallback mode) or two new beams (for multi-TRP SFN mode). |
| LGE | Support Alt4-1. We believe that we are not discussing TRP-specific BFR being discussed in MTRP BM agenda. This operation is based on single BFD RS set and single BFI count for a BWP/CC as legacy. In this regard, it is natural to support a single NBI RS set as legacy. |
| Vivo | Agree with QC, UE can recover from STRP transmission first. |
| Nokia/NSB | Support Alt 4-1. |
| CATT | Support Alt 4-1 |
| Convida | Support Alt 4-1. |

### Issue #5-4 (Applicability of the BFR enhancements)

Several companies discussed the issue of applicability of beam failure enhancements for different BFD procedures when two TCI states are activated for CORESET.

**Issue #5-4:**

* When two TCI states are activated for a CORESET, BFR enhancements are applicable to
  + Rel-15 BFR and Rel-16 cell specific BFR procedure
    - **Supported**: Lenovo/MotMobility, Qualcomm, NEC, Nokia/NSB,

Based on the companies’ contributions the following proposal is made.

#### Round-1

**Proposal #5-4:**

* When two TCI states are activated for a CORESET, BFR enhancements are applicable to
  + Rel-15 BFR and Rel-16 cell specific BFR procedure

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| **Company** | **Comment** |
| Xiaomi | Does it mean the Rel-17 TRP specific BFR for CORESET with two activated TCI states will be discussed in AI 8.1.2.3? |
| Lenovo/MotM | Support the proposal |
| ZTE | Support |
| NEC | We have agreement in RAN1#105e that Rel-17 TRP specific BFR to be discussed in AI 8.1.2.3, then there seems no need to have this proposal.  **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and two TCI states are activated for at least one CORESET, support the following configuration of RS for BFD   * Down-select one alternative for implicit configuration   + **Alt 1-2**: RS of CORESETs with both single and two TCI states are used   + **Alt 1-3**: RS of CORESETs with only two TCI states are used * Down-select one alternative for explicit configuration   + **Alt 2-1**: Support defining CSI-RS resource or SSB pairs as BFD RS     - FFS other details   + **Alt 2-2**: Reuse the existing Rel-15/Rel-16 approach for BFD RS configuration * Note: down-selection can be done separately for Rel-15/16 cell specific BFR and Rel-17 TRP-specific BFR, Rel-17 TRP-specific BFR to be discussed under AI 8.1.2.3 |
| MediaTek | Support |
| Qualcomm | Support |
| DOCOMO | Support. We understand the following BFR are considered by the FL proposal.  1) CBRA/CFRA based BFR on SpCell in Rel.15.  2) BFR MAC CE based BFR on SCell in Rel.16.  3) CBRA BFR on SpCell (with BFR MAC CE on Msg.3/A) in Rel.16. |
| LGE | Support |
| vivo | Support |
| Convida | We prefer to wait with this proposal until it’s clear which BFR enhancement for two TCI state CORESETs we agree on. So far, we haven’t agreed much.  There’s no need to yet preclude the case with multi-TPR BFR and 2-TCI CORESET. |
| Moderator | **Proposal #5-4a:**   * When two TCI states are activated for a CORESET, BFR enhancements are applicable to   + CBRA/CFRA based BFR on SpCell in Rel.15.   + BFR MAC CE based BFR on SCell in Rel.16.   + CBRA BFR on SpCell (with BFR MAC CE on Msg.3/A) in Rel.16. |

### Issue #5-5 (Details of RLM for SFN PDCCH)

Two companies raised several issues of RLM RS set configuration for enhanced SFN transmission scheme of PDCCH.

**Issue #6-1:**

* For RLM, when RLM RS set is not explicitly provided, for a CORESET indicated with two TCI states, RSs in both TCI states are used as RLM RS
  + **Supported by**: NTT DOCOMO
* For RLM, when RLM RS set is explicitly provided, for a CORESET indicated with two TCI states, study how to ensure the RLM RS includes RSs in both TCI states of a CORESET.
  + **Supported by**: NTT DOCOMO
* Study whether/how to enhance RLM RS selection rule considering CORESET activated with two TCI states
  + **Supported by**: Samsung

#### Round-1

**Proposal #6-1:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| Lenovo/MotM | Fine with further study |
| MediaTek | Open to discuss |
| QC | Open to discuss this issue later. |
| DOCOMO | Support to discuss. |
| Samsung | Support to discuss. |
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## Issue #6-1 (Other non-categorized proposals)

The proposals supported by one company are provided below for consideration in the next RAN1 meetings.

* *TRP-specific timing offset pre-adjustment can be considered to further enhance the performance of HST-SFN transmission.*
* *QCL assumptions between the TRS/CSI-RS and SSB reference RS for scheme 1*
* *Study zone-based configuration for TCI/QCL information to mitigate potential high signaling overhead.*
* *Support variable-rate TRS transmission for HST deployment scenario.*
* *For PDSCH transmitted with Rel-17 HST-SFN scheme 1,* 
  + *Restricting the DMRS ports of the PDSCH within one CDM group*
  + *New tables for antenna port indication are supported.*
* *To further facilitate HST-SFN operation, support to extend the QCL assumption of PDCCH/PDSCH DMRS from its serving cell(s) to non-serving cell(s).*
* *NW should explicitly configure or implicitly indicate to UE from which TRP the frequency-domain QCL assumption can be ignored.*
* *Study PTRS design in case of SFN transmission scheme*
* *Efficient triggering method for SRS transmission*

# Other issues

This section contains other issues the companies want to highlight.

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# References

[1] RP-193133, New WID: Further enhancements on MIMO for NR, Samsung 3GPP TSG RAN Meeting #86, Sitges, Spain, December 9-12, 2019.

[2] R1-210876, Enhancements on HST multi-TRP deployment in Rel-17, Huawei, HiSilicon

[3] R1-2108793, Enhancement to support HST-SFN deployment scenario, FUTUREWEI

[4] R1-2108812, Remaining Issues M-TRP Operation for HST-SFN Deployment, InterDigital, Inc.

[5] R1-2108874, Discussion on Multi-TRP HST enhancements, ZTE

[6] R1-2108899, Discussion on enhancements on HST-SFN deployment, Spreadtrum Communications

[7] R1-2108955, Further discussion on HST-SFN schemes , vivo

[8] R1-2109042, Enhancements on HST-SFN deployment, OPPO

[9] R1-2109126, Discussion on HST-SFN deployment, NEC

[10] R1-2109188, Further discussion on HST-SFN deployment, CATT

[11] R1-2109274, Enhancements on HST-SFN deployment, CMCC

[12] R1-2109382, Enhancements on HST-SFN operation for multi-TRP PDCCH transmission, Xiaomi

[13] R1-2109472, Enhancements on HST-SFN, Samsung

[14] R1-2109546, Enhancements on HST-SFN deployment, MediaTek Inc.

[15] R1-2109595, Enhancements to HST-SFN deployments, Intel Corporation

[16] R1-2109662, Discussion on HST-SFN deployment, NTT DOCOMO, INC.

[17] R1-2109775, Enhancements on HST-SFN deployment, Sony

[18] R1-2109806, Remaining issues on HST-SFN enhancements, Ericsson

[19] R1-2109874, Enhancements for HST-SFN deployment, Nokia, Nokia Shanghai Bell

[20] R1-2109934, Enhancements for HST-SFN deployment, Lenovo, Motorola Mobility

[21] R1-2110017, Views on Rel-17 HST enhancement, Apple

[22] R1-2110081, Enhancements on HST-SFN deployment, LG Electronics

[23] R1-2110107, On Enhancements for HST-SFN deployment, Convida Wireless

[24] R1-2110169, Enhancements on HST-SFN deployment, Qualcomm Incorporated

# Appendix (Summary of the agreements)

The agreements made in RAN1#102e, RAN1#103e and RAN1#104e, RAN1#105e meetings are provided below.

**RAN1#102-e meeting agreements**

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| **Agreement**  For the discussion purpose consider the following categorization of the enhanced DL transmission schemes   * **Scheme 1**:   + TRS is transmitted in TRP-specific / non-SFN manner   + DM-RS and PDCCH/PDSCH from TRPs are transmitted in SFN manner * **Scheme 2**:   + TRS and DM-RS are transmitted in TRP-specific / non-SFN manner   + PDSCH from TRPs is transmitted in SFN manner   **Agreement**  Study the following aspects of the enhanced transmission schemes:   * **For scheme 1**:   + Target DL physical channels, i.e., PDSCH only or PDSCH + PDCCH   + Whether more than 2 QCL/TCI states are required and corresponding signaling details   + Whether and how to indicate scheme 1 for differentiation with Rel-16 non-SFNed transmission schemes with multiple QCL/TCI states   + QCL relationship between TRS and DMRS ports   + Note: Other schemes/aspects are not precluded * **For scheme 2**:   + Association of each MIMO layer of PDSCH to DM-RS antenna ports   + Whether more than 2 QCL/TCI states are required and corresponding signaling details   + Whether and how to indicate scheme 2 for differentiation with Rel-16 non-SFNed transmission schemes with multiple QCL/TCI states   Note: Other schemes/aspects are not precluded |

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| **Agreement**  Study TRP-based frequency offset pre-compensation including the following aspects:   * Aspects related to indication of the carrier frequency determined based on the received TRS resource(s) in the 1st step   + **Option 1**: Implicit indication of the Doppler shift(s) using uplink signal(s) transmitted on the carrier frequency acquired in the 1st step     - Indication for QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step     - Type of the uplink reference signals / physical channel used in the 2nd step, necessity of new configuration and corresponding signaling details   + **Option 2**: Explicit reporting of the Doppler shift(s) acquired in the 1st step using CSI framework     - FFS: Indication for QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step     - CSI reporting aspects, configuration, quantization, signalling details, etc. * New QCL types/assumption for TRS with other RS (e.g., SS/PBCH), when TRS resource(s) is used as target RS in TCI state * New QCL types/assumptions for TRS with other RS (e.g., DM-RS), when TRS resource(s) is used as source RS in the TCI state * Target physical channels (e.g., PDSCH only or PDSCH/PDCCH) and reference signals that should be supported for pre-compensation * Signalling/procedural details on whether/how the pre-compensation is applied to target channels * Whether multiple sets of TRS and pre-compensation on TRS is needed in 3rd step.   Note: Other aspects/schemes are not precluded |

**RAN1#103-e meeting**

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| **Agreement**  Support at least the following configuration for HST scenario in Rel-17   * The same DMRS port(s) can associate with multiple TCI states   + FFS other details   Note: DMRS and PDCCH/PDSCH from different TRPs are transmitted in SFN manner  **Agreement**  At most two TCI states are supported for HST scenario in Rel-17   * FFS: Whether to support more than two TCI states for FR2 * FFS configuration/signalling details of the TCI states   Note: DMRS and PDCCH/PDSCH from different TRPs are transmitted in SFN manner  **Agreement**  When the same DMRS port(s) are associated with two TCI states containing TRS as source reference signal, at least one variant is supported for Rel-17 HST-SFN scenario based on further evaluations   * **Variant A**: One of the TCI state can be associated with {*average delay*, *delay spread*} and another TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA) * **Variant B**: One of the TCI state can be associated with {*average delay, delay spread*} and another TCI state with {*Doppler shift, Doppler spread*} (i.e., QCL-TypeB) * **Variant C**: One of the TCI state can be associated with {*delay spread*}  and another TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA) * **Variant E**: Both TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA) * FFS: Indication method to apply QCL, e.g., via new QCL-type, or reuse existing QCL-type while UE to ignore certain QCL properties * Note: Each TCI state in the above variants may be additionally associated with {Spatial Rx parameter} (i.e., QCL-TypeD) * Note: Companies are encouraged to provide evaluation results for the above variants based on agreed EVM from RAN1#102e meeting * Note: Above variants are applicable to scheme 1 and/or TRP based pre-compensation as a reference for evaluation. * This agreement is for the purpose of evaluation and does not imply the support or lack of support of scheme 1 and/or TRP based pre-compensation |

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| **Agreement**  For PDCCH reliability enhancements, support SFN scheme + Alt 1-1.   * FFS: TCI state activation for CORESET, impact on default beam, BFD resource for BFR   Where the Alt 1-1 is agreed as:  Alt 1-1: One PDCCH candidate (in a given SS set) is associated with both TCI states of the CORESET. |

**RAN1#104-e meeting**

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| **Agreement**  Scheme 1 is supported in Rel-17   * TRS is transmitted in TRP-specific / non-SFN manner * DM-RS and PDCCH/PDSCH from TRPs are transmitted in SFN manner * FFS other details     **Agreement**  For scheme 1 and SFN transmission of PDCCH support Variant E for QCL assumption in TCI state when TRS is used as source RS    **Agreement**  Two TCI states are supported for scheme 1 in FR2  **Agreement**   * Support MAC CE activation of two TCI states for PDCCH * FFS other details   **Conclusion**  The decision on support of specification based TRP pre-compensation scheme for HST-SFN scenario to be made in RAN1#104-e-bis meeting. To facilitate RAN1 decision, companies are encouraged to provide evaluation results according to the agreed evaluation assumptions. The evaluations not compliant with agreed assumptions will not be considered by RAN1 in the decision process.  **Agreement**  For HST-SFN scenario:   * Support semi-static (RRC based) switching of scheme 1 (PDSCH) with 2a, 2b, 3, 4 * FFS all other details including RRC signaling, possible RAN4 impact (if any), etc. |

**RAN1#104b-e meeting**

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| **Agreement**  Introduce enhanced MAC CE signaling for PDCCH activating two TCI states for SFN-based PDCCH transmission   * The corresponding MAC CE includes at least the following fields   + Serving cell ID   + CORESET ID   + Two TCI state IDs * FFS whether for CA scenario additionally support RRC configured set of the serving cells which can be addressed by a single MAC CE * FFS whether or not enhanced MAC CE signaling is applicable to a CORESET configured with CORESETPoolindex   Send LS to RAN2 to inform about agreement on support of enhanced MAC CE for CORESET in Rel-17. LS is endorsed in R1-2104064  **Agreement**  Specification-based TRP Doppler pre-compensation scheme is supported in Rel-17 for FR1 with one or both:   * UL RS based Doppler estimation by gNB   + FFS: Details including UL RS enhancement * DL RS based Doppler feedback by UE   + FFS: Details   + FFS: Whether UE capability needs to be introduced * Whether to support one or both will be decided later   **Agreement**   * Support dynamic (DCI-based) switching of scheme 1 (PDSCH) with single-TRP scheme by TCI state field in DCI format 1\_1/1\_2   + This feature is UE optional * FFS all other details including RRC signalling, possible RAN4 impact (if any), etc.   **Working Assumption**  All QCL source RS resource types as defined in TCI state for Rel-16 multi-TRP are supported for scheme 1  **Agreement**  Support semi-static (RRC-based) switching of scheme 1 (PDSCH) with Rel-16 scheme 1a   * FFS: Whether dynamic switching is additionally supported   **For future meeting:**  Companies to consider Proposal #3-8a in FL summary (R1-2104020) for future meetings.  Companies to consider Proposal #3-10 in FL summary (R1-2104020) for future meetings.  **Agreement**  Scheme 1 for PDSCH is identified by   * New RRC parameter and the number of TCI states indicated by DCI   + FFS RRC configuration details, e.g., per BWP or per CC   + FFS whether or not restriction to a single CDM group for DM-RS is also supported |

**RAN1#105-e meeting**

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| **Agreement**  Confirm the following working assumption from RAN1#104b-e:  All QCL source RS resource types as defined in TCI state for Rel-16 multi-TRP are supported for scheme 1.  **Agreement**  UE is not expected to be indicated by MAC CE with single TCI state per any of TCI codepoint , if UE is configured with scheme 1 PDSCH by RRC , but not capable to support dynamic switching between scheme 1 and single-TRP by TCI state field in DCI Format 1\_1/1\_2  **Agreement**  For specification based TRP-based frequency offset pre-compensation scheme   * Support dynamic (DCI -based) switching with single-TRP scheme by TCI state field in DCI format 1\_1/1\_2   + This feature is UE optional   + UE is not expected to be indicated by MAC CE with single TCI state per any of TCI codepoint , if UE is configured with TRP-based frequency PDSCH by RRC , but not capable to support dynamic switching between TRP-based frequency and single-TRP by TCI state field in DCI Format 1\_1/1\_2 * Support semi-static (RRC based) switching with Rel-16 schemes 1a, 2a, 2b, 3, 4 * Support semi-static (RRC based) switching with Rel-17 scheme 1 (PDSCH)   **Agreement**  Enhanced MAC CE signaling is not applicable to any of the configured CORESETs in a BWP if the CORESETs are configured with different *CORESETPoolindex* values in the BWP.  **Working Assumption**  For TRP-based pre-compensation, Variant A (based on RAN1#103-e meeting agreement) are supported as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states.   * FFS: Additional support of Variant B   **Agreement**   * For TRP-based pre-compensation QCL assumptions is provided to the UE by using the existing QCL type(s) with certain QCL parameters dropped from the indicted QCL type   + FFS rule or signalling to determine which TCI state with dropped QCL parameters * UE does not expect to be configured different SFN schemes (scheme 1 or TRP pre-compensation) for both PDCCH and PDSCH.   + FFS whether this restriction is per UE or per CC * UE does not expect to be configured different SFN schemes (scheme 1 or TRP pre-compensation) for different CORESETs.   + FFS whether this restriction is per UE or per CC   **Agreement**  Enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is identified by the number of TCI states activated per CORESET and RRC parameter   * FFS: Configuration detail of RRC parameter   + Including whether the same RRC parameter is used for PDCCH and PDSCH   **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP -based pre-compensation) is configured and a CORESET is activated with two TCI states and UE is configured with enableTwoDefaultTCI-States and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold timeDurationForQCL, down-select rule to determine default beam(s) for Rel-17 SFN PDSCH reception in RAN1#106-e:   * **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a * **Alt 2**: Introduce new rules to determine TCI states based on two TCI state(s) of the CORESET   **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and two TCI states are activated for at least one CORESET, support the following configuration of RS for BFD   * Down-select one alternative for implicit configuration   + **Alt 1-2**: RS of CORESETs with both single and two TCI states are used   + **Alt 1-3**: RS of CORESETs with only two TCI states are used * Down-select one alternative for explicit configuration   + **Alt 2-1**: Support defining CSI-RS resource or SSB pairs as BFD RS     - FFS other details   + **Alt 2-2**: Reuse the existing Rel-15/Rel-16 approach for BFD RS configuration * Note: down-selection can be done separately for Rel-15/16 cell specific BFR and Rel-17 TRP-specific BFR, Rel-17 TRP-specific BFR to be discussed under AI 8.1.2.3 |

**RAN1#106e meeting**

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| **Agreement**  Support the following combination of the transmission schemes   * Single-TRP PDCCH + Rel-17 Scheme 1 PDSCH * Single-TRP PDCCH + Rel-17 TRP-based pre-compensation PDSCH * FFS: Other combinations of the transmission scheme   Note: The PDSCH corresponds to the PDSCH scheduled by DCI formats 1\_1 and 1\_2.  **Agreement**  For Rel-17 TRP-based pre-compensation scheme, indication of carrier frequency for uplink transmission (Doppler frequency reporting) in TRP-based pre-compensation scheme is supported using   * **Option 1** Implicit from RAN1#102-e agreement   + FFS enhancements to SRS (e.g multiple SRS resource in a set) to improve the accuracy of frequency estimation   For Option1, some companies raised concerns that there is no consensus on the benefit and the applicability of this scheme in FDD.  For Option1, some companies raised concerns that there is no benefit in low SNR scenarios.  **Agreement**  For TRP -based pre-compensation   * Alt-1: QCL parameters are dropped from the second TCI state of the indicated TCI codepoint containing two TCI states   **Conclusion**  For Variant A and B (if supported)   * For frequency offset pre-compensation QCL -like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step is supported by implementation without specification impact   **Agreement**  Confirm working assumption from RAN1#105e meeting without modification:  For TRP -based pre-compensation, Variant A (based on RAN1#103-e meeting agreement) is supported as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states.   * FFS: Support of Variant B   **Agreement**  In CA scenario support RRC configured set of the serving cells which can be addressed by a single MAC CE for activation of two TCI states of CORESET with the same CORESET ID for all the BWPs in the indicated CCs set   * FFS: Whether to reuse Rel-16 RRC parameters or introduce new RRC parameters. * FFS: UE capability * FFS: Whether/How to update the CORESET that is not configured to SFN scheme in the indicated CCs set   **Agreement**  If enableTwoDefaultTCI-States is configured and at least one TCI codepoint indicates two TCI states and time offset between the reception of the DL DCI and the PDSCH is less than the threshold timeDurationForQCL, default beam(s) for Rel-17 enhanced SFN PDSCH (scheme 1 or if supported TRP-based pre-compensation) reception:   * **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a   This is a UE optional feature  **Agreement**  For PDSCH reception scheduled by DCI format 1\_0, [1\_1 and 1\_2], if the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL*   * Support configuration when there is no TCI field in the DCI scheduling PDSCH   + UE applies the state(s) of the scheduling CORESET when receiving the PDSCH     - if there are two active TCI states for the CORESET, UE applies the both QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH     - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH * FFS if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL*   This is a UE optional feature.  **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or if TRP-based pre-compensation is supported in FR2) is configured and CORESET is indicated with two TCI states, and scheduling offset for AP CSI-RS is less than the threshold and *enableTwoDefaultTCIStates* is not configured   * If there is no other DL signal on the same symbol, use one of two TCI states as default beam for aperiodic CSI-RS reception, i.e.   + using one TCI state of the CORESET with the lowest CORESET ID in the latest slot as default beam for aperiodic CSI-RS reception. If there are two activated TCI states for the CORESET with the lowest CORESET ID, one of two TCI states will be selected, i.e. always selects the first TCI state if the CORESET has two TCI states * If there is other DL signal on the same symbol, reuse Rel-15/16 mechanism   **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and two TCI states are activated for at least one CORESET, support the following configuration of RS for BFD   * For implicit configuration   + **Alt 1-2**: RS of CORESETs with both single and two TCI states are used   FFS: The maximum number of BFD RS and details on RS determination  **R1-2108548** Summary#3 of AI: 8.1.2.4 Enhancements on HST-SFN deployment Moderator (Intel Corporation)  **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or if TRP-based pre-compensation is supported in FR2) is configured, and if the CORESET with the lowest ID in the active DL BWP is indicated with two TCI states   * If PL-RS and spatial relation information are not configured for PUCCH and enableDefaultBeamPL-ForPUCCH is configuredin FR2   + For single-TRP PUCCH transmission, select the first TCI state of the CORESET as default beam and PL RS * If PUSCH scheduled by DCI format 0\_0 and *enableDefaultBeamPL-ForPUSCH0-0* is configured in FR2, and if PUCCH resource is not configured on active UL BWP in the cell or if spatial relation is not configured in any PUCCH resource on active UL BWP in the cell,   + For single-TRP PUSCH transmission scheduled by DCI format 0\_0, select the first TCI state of the CORESET as default beam and PL RS * If PL-RS and spatial relation information are not configured for SRS and *enableDefaultBeamPL-ForSRS* is configured in FR2   + For single-TRP SRS resource, select the first TCI state of the CORESET as default beam and PL RS * FFS other details, if any * These are UE optional features   **Agreement**  When a CORESET is activated with two TCI states which overlaps with another CORESET, support extension of Rel-15 prioritization rule for PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with different QCL-TypeD   * FFS: Prioritization rule considers CORESETs indicated with 1 and/or 2 TCI states * Supports identifying two QCL-TypeD properties for multiple overlapping CORESETs   + UE capability is introduced * FFS other details * FFS: Strive to have same / similar solution as discussed under AI 8.1.2.1   **Conclusion**  No RAN1 specification impact on how to calculate hypothetical BLER for BFD |