**3GPP TSG RAN WG1 #106b-e R1-210xxxx**

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

**Source: Moderator (Intel Corporation)**

**Title: Draft 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 | Yes: Futurewei,  No: OPPO |
| Scheme 1 | Yes (9): HW/HiSi, Futurewei, ZTE, Spreadtrum, CATT, CMCC, Nokia / NSB, Intel, LGE  No (6): InterDigital, OPPO, Mediatek, Lenovo / MotMob, Apple, Qualcomm | Yes: Futurewei, Nokia / NSB, Intel  No: OPPO | Supported | Not supported |
| Pre-compensation | Yes (5): HW/HiSi, Futurewei, CATT, CMCC, LGE,  No (5): InterDigital, OPPO, Mediatek, Lenovo / MotMob, Qualcomm | Yes: Futurewei,  No: OPPO | 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 |
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### 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**: Huawei / HiSilicon, CATT, CMCC, Ericsson, Nokia / NSB, Lenovo / MotMob
  + Common RRC parameter for PDCCH and PDSCH
    - **Supported**: vivo, Qualcomm,

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 |
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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**: vivo, Nokia / NSB,
  + Per CORESET:
    - **Supported**: Huawei / HiSilicon, CMCC, Lenovo / MotMob,
  + Per CC:
    - **Supported**: Qualcomm, Intel
  + Per UE:
    - ….
* RRC parameter for PDSCH (scheme 1 or TRP-based pre-compensation scheme) is configured
  + Per BWP:
    - **Supported**: Huawei / HiSilicon, CATT, Nokia / NSB
  + Per CORESET:
    - **Supported**:
  + Per CC:
    - **Supported**: Qualcomm, Intel
  + 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 |
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### 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
  + 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 |
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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 |
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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 |
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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 |
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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

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~~ |
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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

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 |
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### 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…
* **Alt-2**: Not support of SRS enhancements in Rel-17
  + **Supported**: Huawei / HiSilicon, ZTE, Mediatek

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 |
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### 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 |
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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. |
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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 |
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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 |
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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
* 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

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 |
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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 |
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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 |
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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,

#### 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 |
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### 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:** CATT?
    - 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?,
    - Alt 4: the number of TCI states for CORESET > SS type > serving cell index > SS set ID
      * **Supported by:** Samsung
    - 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, Ericsson?, Lenovo / MotMob?, LGE, Xiaomi,
    - 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 |
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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
* 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,

#### 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 |
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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 |
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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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## 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
* 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,
* 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
  + **Not supported**: vivo, Mediatek
* 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?
    - **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 |
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### 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,
  + Reuse Rel-15/Rel-16 approach for BFD RS configuration
    - **Supported**: Spreadtrum, Convida Wireless

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 |

### 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**: ZTE, Spreadtrum, vivo,
  + 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

#### 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 |
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### 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 |
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### 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 |
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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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[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 |