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**Document for:** **Discussion and Decision**

# 1. Introduction

This contribution discusses some remaining issues for beam management, including beam failure recovery (BFR), beam indication and so on. Based on these discussion, we provides corresponding text proposals as well.

# 2. Discussion

## 2.1. Section 6 Link recovery procedures of TS 38.213

Various parameters regarding the beam failure recovery are configured BWP-specific by RRC signaling. It means a configuration of BFR is for a BWP, rather than a serving cell. Thus we propose to

- **Change "for a serving cell" to "for a bandwidth part"**

When there are two RS indexes in a TCI state, only one RS index is with QCL-TypeD configuration for the corresponding TCI state. In the current description, it may lead to misunderstanding that both of these two RSs are configured with QCL-TypeD. Thus we propose to

- **Refine the text to clarify that for the case of two indexes in a state, only the RS index with QCL-TypeD configuration will be included in $q_0$**

In the current agreements on QCL assumption, the DMRS ports of PDCCH can be QCLed (w.r.t. QCL-TypeD) with CSI-RS resource for tracking, CSI-RS resource for beam management or CSI-RS resource for CSI acquisition (for sub-6GHz), but not with SS/PBCH block(s). As a result, the set $q_0$ will not contain SS/PBCH block(s).Therefore, regarding the implicit determination of $q_0$ in the first paragraph, the "SS/PBCH block indexes" has been removed in the latest version of 38.213. But such kind of modifications are not done in other paragraphs. Thus we propose to

- **Remove any description on SS/PBCH block(s) within the set $q_0$**

In the last meeting, there was discussions on spatial transmit filters of the PUCCH upon the reception of a valid response from gNB. However, there was no consensus on this issue. Generally speaking, there are two basic scenarios when we are considering UL beam management:

1. With beam correspondence. In this case, if DL link is under the condition of "beam failure", the corresponding UL link will also be with bad quality. Thus UE may choose to switch Tx beam for find a better link for BFR request transmission. If UE has received a valid response from NW, it means the latest Tx beam used for BFR request transmission is with good enough quality. Naturally, the UE can use the same Tx beam for the subsequent UL transmission.
2. Without beam correspondence. In this case, if DL link is under the condition of "beam failure", the corresponding UL link for PUCCH transmission may or may not be with bad quality. It means that the UE does not sure about the quality of the UL link for PUCCH. As long as UE receives a valid response from NW, it can know that the Tx beam used for BFR request transmission is with at least acceptable quality. Thus it is safer to use the same Tx beam for the subsequent UL transmission.

Thus the Tx beam used for latest BFR request transmission is a good choice for the following PUCCH for both the cases with beam correspondence and the ones without beam correspondence. Based on the above discussions, we have the following proposal

- After successfully receiving BFR gNB response, the PUCCH transmissions shall use the same spatial filter as the PRACH transmission until the UE receives an activation or reconfiguration of *PUCCH-Spatialrelationinfo* of at least one of configured PUCCH resources

/************************ Start of Text Proposal for 38.213**************************/

# 6 Link recovery procedures

A UE can be provided, for a ~~serving cell~~ bandwidth part, with a set $\overline{q}_0$ of periodic CSI-RS resource configuration indexes by higher layer parameter *failureDetectionResources* and with a set $\overline{q}_1$ of periodic CSI-RS resource configuration indexes and/or SS/PBCH block indexes by higher layer parameter *candidateBeamRSList* for radio link quality measurements on the serving cell. If the UE is not provided with higher layer parameter *failureDetectionResources*, the UE determines the set $\overline{q}_0$ to include periodic CSI-RS resource configuration indexes with same values as the RS indexes in the RS sets indicated by higher layer parameter *TCI-states* for respective control resource sets that the UE uses for monitoring PDCCH. The UE expects the set $\overline{q}_0$ to include up to two RS indexes and, if there are two RS indexes in a TCI state, the set $\overline{q}_0$ includes the RS index~~es~~ with QCL-TypeD configuration for the corresponding TCI state~~s~~. The UE expects single port RS in the set $\overline{q}_0$.

The thresholds $Q_{out,LR}$ and $Q_{in,LR}$ correspond to the default value of higher layer parameter *rlmInSyncOutOfSyncThreshold*, as described in [10, TS38.133] for $Q_{out}$, and to the value provided by higher layer parameter *rsrp-ThresholdSSB*, respectively.

The physical layer in the UE assesses the radio link quality according to the set $\overline{q}_0$ of resource configurations against the threshold $Q_{out,LR}$. For the set $\overline{q}_0$, the UE assesses the radio link quality only according to periodic CSI-RS resource configurations ~~or SS/PBCH blocks~~ that are quasi co-located, as described in [6, TS 38.214], with the DM-RS of PDCCH receptions monitored by the UE. The UE applies the $Q_{in,LR}$ threshold to the L1-RSRP measurement obtained from a SS/PBCH block. The UE applies the $Q_{in,LR}$ threshold to the L1-RSRP measurement obtained for a CSI-RS resource after scaling a respective CSI-RS reception power with a value provided by higher layer parameter *powerControlOffsetSS*.

The physical layer in the UE provides an indication to higher layers when the radio link quality for all corresponding resource configurations in the set $\overline{q}_0$ that the UE uses to assess the radio link quality is worse than the threshold $Q_{out,LR}$. The physical layer informs the higher layers when the radio link quality is worse than the threshold $Q_{out,LR}$ with a periodicity determined by the maximum between the shortest periodicity among the periodic CSI-RS configurations ~~and/or SS/PBCH blocks~~ in the set $\overline{q}_0$ that the UE uses to assess the radio link quality and 2 msec.

Upon request from higher layers, the UE provides to higher layers the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the set $\overline{q}_1$ and the corresponding L1-RSRP measurements that are larger than or equal to the $Q_{in,LR}$ threshold.

A UE can be provided with a control resource set through a link to a search space set provided by higher layer parameter *recoverySearchSpaceId,* as described in Subclause 10.1, for monitoring PDCCH in the control resource set. If the UE is provided higher layer parameter *recoverySearchSpaceId*, the UE does not expect to be provided another search space set for monitoring PDCCH in the control resource set associated with the search space set provided by *recoverySearchSpaceId*.

The UE may receive by higher layer parameter *PRACH-ResourceDedicatedBFR*, a configuration for PRACH transmission as described in Subclause 8.1. For PRACH transmission in slot $n$ and according to antenna port quasi co-location parameters associated with periodic CSI-RS resource configuration or with SS/PBCH block associated with index $q_{new}$ provided by higher layers [11, TS 38.321], the UE monitors PDCCH in a search space set provided by higher layer parameter *recoverySearchSpaceId* for detection of a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI starting from slot $n+4$ within a window configured by higher layer parameter *BeamFailureRecoveryConfig*. For the PDCCH monitoring and for the corresponding PDSCH reception, the UE assumes the same antenna port quasi-collocation parameters as the ones associated with index

$q_{\text{new}}$ until the UE receives by higher layers an activation for a TCI state or any of the parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList*. After the UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI in the search space set provided by *recoverySearchSpaceId*, the UE continues to monitor PDCCH candidates in the search space set provided by *recoverySearchSpaceId* until the UE receives a MAC CE activation command for a TCI state or higher layer parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList*. After the UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI in the search space set provided by *recoverySearchSpaceId*, the PUCCH transmissions shall use the same spatial filter as the PRACH transmission until the UE receives an activation or reconfiguration of *PUCCH-Spatialrelationinfo* of at least one of configured PUCCH resources.

/************************ End of Text Proposal for 38.213**************************/

## 2.2. Section 5.1.5 Antenna ports quasi co-location of TS 38.214

In Section 5.1.5, there are two different UE behaviors defined for the cases regarding *TCI-PresentInDCI* set to be 'Disabled' as follows:

- One is for the case *TCI-PresentInDCI* set to be 'Disabled'
- The other is for the case *TCI-PresentInDCI* set to be 'Disabled' and the offset is less than a threshold

These two UE behaviors are colliding with each other. Thus we propose to

- **Fix the UE behavior for the cases that TCI-PresentInDCI set as 'Disabled'.**

There was some discussions on the beam determination of multi-slot PDSCH. Several solutions were proposed but no consensus has been achieved. Generally speaking, multi-slot PDCCH with repetition is used for the UE at cell edge with the aim to ensure the coverage. For this case, the requirement of low latency can be relaxed. Thus we have the following suggestion to simplify the solution for beam determination of multi-slot PDSCH

- ***For a UE configured with TCI states containing QCL-TypeD, the time offset between the reception of the DL DCI and the corresponding multi-slot PDSCH should be equal to or greater than the threshold Threshold-Sched-Offset.***

/************************ Start of Text Proposal for 38.214**************************/

### • 5.1.5 Antenna ports quasi co-location

The UE can be configured with a list of up to *M TCI-State* configurations within the higher layer parameter *PDSCH-Config* to decode PDSCH according to a detected PDCCH with DCI intended for the UE and the given serving cell, where M depends on the UE capability. Each *TCI-State* contains parameters for configuring a quasi co-location relationship between one or two downlink reference signals and the DM-RS ports of the PDSCH. The quasi co-location relationship is configured by the higher layer parameter *qcl-Type1* for the first DL RS, and *qcl-Type2* for the second DL RS (if configured). For the case of two DL RSs, the QCL types shall not be the same, regardless of whether the references are to the same DL RS or different DL RSs. The quasi co-location types corresponding to each DL RS are given by the higher layer parameter *qcl-Type* in *QCL-Info* and may take one of the following values:

- 'QCL-TypeA': {Doppler shift, Doppler spread, average delay, delay spread}
- 'QCL-TypeB': {Doppler shift, Doppler spread}
- 'QCL-TypeC': {Doppler shift, average delay}
- 'QCL-TypeD': {Spatial Rx parameter}

The UE receives an activation command [10, TS 38.321] used to map up to 8 TCI states to the codepoints of the DCI field *'Transmission Configuration Indication'*. When the HARQ-ACK corresponding to the PDSCH carrying the activation command is transmitted in slot n, the indicated mapping between TCI states and codepoints of the DCI field *'Transmission Configuration Indication'* should be applied starting from slot $n + 3N_{slot}^{subframe,\mu}$+1. After a UE receives higher layer configuration of TCI states and before reception of the activation command, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the SS/PBCH block determined in the initial access procedure with respect to 'QCL-TypeA', and when applicable, also with respect to'QCL-TypeD'.

If a UE is configured with the higher layer parameter *tci-PresentInDCI* that is set as 'enabled' for the CORESET scheduling the PDSCH, the UE assumes that the TCI field is present in the DCI format 1_1 of the PDCCH transmitted on the CORESET. If *tci-PresentInDCI* is not configured for the CORESET scheduling the PDSCH and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal to or greater than a threshold *Threshold-Sched-Offset*, where the threshold is based on reported UE capability [12, TS 38.331], or the PDSCH is scheduled by a DCI format 1_0, for determining PDSCH antenna port quasi co-location, the UE assumes that the TCI state for the PDSCH is identical to the TCI state applied for the CORESET used for the PDCCH transmission.

If the *tci-PresentInDCI* is set as 'enabled', the TCI field in DCI in the scheduling component carrier points to the activated TCI states in the scheduled component carrier or DL BWP and when the PDSCH is scheduled by DCI format 1_1, the UE shall use the *TCI-State* according to the value of the '*Transmission Configuration Indication*' field in the detected PDCCH with DCI for determining PDSCH antenna port quasi co-location. The UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) in the TCI state with respect to the QCL type parameter(s) given by the indicated TCI state if the time offset between the reception of the DL DCI and the corresponding PDSCH is equal to or greater than a threshold *Threshold-Sched-Offset*, where the threshold is based on reported UE capability [12, TS 38.331]. When the UE is configured with a single slot PDSCH, the indicated TCI state should be based on the activated TCI states in the slot with the scheduled PDSCH

For both the cases when *tci-PresentInDCI* is set to 'enabled' and *tci-PresentInDCI* is not configured in RRC connected mode, if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *Threshold-Sched-Offset*, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) in the TCI state with respect to the QCL parameter(s) used for PDCCH quasi co-location indication of the lowest *CORESET-ID* in the latest slot in which one or more CORESETs within the active BWP of the serving cell are configured for the UE. If none of configured TCI states contains 'QCL-TypeD', the UE shall obtain the other QCL assumptions from the indicated TCI states for its scheduled PDSCH irrespective of the time offset between the reception of the DL DCI and the corresponding PDSCH.

When the UE is configured with *aggregationF*actorDL > 1 and the configured TCI states contains 'QCL-TypeD', the UE is not expected that the scheduling offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *Threshold-Sched-Offset.*

<Unchanged parts omitted>

/************************ End of Text Proposal for 38.214**************************/

## 2.3. Section 6.1 UE procedure for transmitting the physical uplink shared channel of TS 38.214

In RAN1#92bis meeting, we had the following agreement

- For PUSCH scheduled by DCI format 0_0, the UE shall use a default spatial relation corresponding to the spatial relation, if applicable, used by the PUCCH resource with the lowest ID configured in the active UL BWP

The intention of the above agreement is to apply for the case where UE is configured with PUCCH resource via UE-specific RRC signaling. The UE behavior before the dedicated configuration of PUCCH resource is still not clear, and we need to clearly specify UE behavior in such cases. Thus we propose to

- **Specify the UE behavior before the dedicated configuration of PUCCH resource**

/************************ Start of Text Proposal for 38.214**************************/

## • 6.1 UE procedure for transmitting the physical uplink shared channel

PUSCH transmission(s) can be dynamically scheduled by an UL grant in a DCI, or semi-statically configured to operate according to Subclause 6.1.2.3 and according to Subclause 5.8.2 of [10, TS 38.321] upon the reception of higher layer parameter of *configuredGrantConfig* including *rrc-ConfiguredUplinkGrant* without the detection of an UL grant in a DCI, or *configurdGrantConfig* not including *rrc-ConfiguredUplinkGrant* semi-persistently scheduled by an UL grant in a DCI after the reception of higher layer parameter *configurdGrantConfig* not including *rrc-ConfiguredUplinkGrant*.

A UE shall upon detection of a PDCCH with a configured DCI format 0_0 or 0_1 transmit the corresponding PUSCH as indicated by that DCI. For any two HARQ process IDs in a given cell, if the UE is scheduled to start a PUSCH transmission in symbol *j* by a PDCCH in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than symbol *j* by a PDCCH starting later than symbol *i*.

For PUSCH scheduled by DCI format 0_0 on a cell, if the UE is not provided with dedicated PUCCH resource configuration, the UE shall transmit the PUCCH using the same spatial domain transmission filter of Msg3 PUSCH in Subclause 8.3; otherwise the UE shall transmit PUSCH according to the spatial relation, if applicable, corresponding to the PUCCH resource with the lowest ~~ID~~ *pucch-ResourceId* within the active UL BWP of the cell, as described in sub-clause 9.2.1 of [6, TS 38.213].

For uplink, 16 HARQ processes per cell is supported by the UE.

/************************ End of Text Proposal for 38.214**************************/

### 2.4. Section 6.2.1 UE sounding procedure of TS 38.214

We have an agreement on beam management as follows (R1-1719059, Slide 3):

***Agreement:***

- *NR supports gNB configuration of transmitting SRS with same Tx beam across multiple symbols via either of followings*
  - *configuring one SRS resource spanning multiple symbols*
  - *configuring UE to apply the same Tx beam across the SRS resources in a SRS resource set.*
- *UE can apply different Tx beams to different SRS resources if it is not configured to apply the same Tx beam across SRS resources in a SRS resource set, where the beams can be determined either (1) via a gNB-transparent way , or (2) via gNB indication.*

Based on the above agreement on beam management, the same Tx beam should be applied within one SRS resource when the SRS resource spans multiple symbols.

Thus we propose to capture the following in Section 6.2.1:

- **The UE shall transmit SRS with the same spatial domain transmission filter across the OFDM symbols occupied by a SRS resource.**

/************************ Start of Text Proposal for 38.214**************************/

## • 6.2.1 UE sounding procedure

The UE can be configured with one or more Sounding Reference s ignal (SRS) resource sets as configured by the higher layer parameter *SRS-ResourceSet*. For each SRS resource set, a UE may be configured with $K \geq 1$SRS resources (higher layer parameter *SRS-Resource*), where the maximum value of K is indicated by [*SRS_capability* [13, 38.306]]. The SRS resource set applicability is configured by the higher layer parameter *usage* in *SRS-ResourceSet.* When the higher layer parameter *usage* is set to 'BeamManagement', only one SRS resource in each of multiple SRS sets can be transmitted at a given time instant. The SRS resources in different SRS resource sets can be transmitted simultaneously.

For aperiodic SRS at least one state of the DCI field is used to select at least one out of the configured SRS resource set(s).

The following SRS parameters are semi-statically configurable by higher layer parameter *SRS-Resource*.

- *srs-ResourceId* determines SRS resource configuration identify.
- Number of SRS ports as defined by the higher layer parameter *nrofSRS-Ports* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Time domain behaviour of SRS resource configuration as indicated by the higher layer parameter *resourceType*, which can be periodic, semi-persistent, aperiodic SRS transmission as defined in Subclause 6.4.1.4 of [4, TS 38.211].
- Slot level periodicity and slot level offset as defined by the higher layer parameters *periodicityAndOffset-p* or *periodicityAndOffset-sp* for an SRS resource of type periodic or semi-persistent. The UE shall not expect to be configured with SRS resources in the same SRS resource set *SRS-ResourceSet* with different slot level periodicities. For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a slot level offset is defined by the higher layer parameter *slotOffset*.
- Number of OFDM symbols in the SRS resource, starting OFDM symbol of the SRS resource within a slot including repetition factor R as defined by the higher layer parameter *resourceMapping* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- SRS bandwidth $B_{SRS}$ and $C_{SRS}$, as defined by the higher layer parameter *freqHopping* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Frequency hopping bandwidth, $b_{hop}$, as defined by the higher layer parameter *freqHopping* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Defining frequency domain position and configurable shift to align SRS allocation to 4 PRB grid, as defined by the higher layer parameters *freqDomainPosition* and *freqDomainShift, respectively,* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Cyclic shift, as defined by the higher layer parameter *cyclicShift-n2* or *cyclicShift-n4* for transmission comb value 2 and 4, respectively, and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Transmission comb value as defined by the higher layer parameter *transmissionComb* described in Subclause 6.4.1.4 of [4, TS 38.211].
- Transmission comb offset as defined by the higher layer parameter *combOffset-n2* or *combOffset-n4* for transmission comb value 2 or 4, respectively, and described in Subclause 6.4.1.4 of [4, TS 38.211].
- SRS sequence ID as defined by the higher layer parameter *sequenceId* in Subclause 6.4.1.4 of [4].
- The configuration of the spatial relation between a reference RS and the target SRS, where the higher layer parameter *spatialRelationInfo*, if configured, contains the ID of the reference RS. The reference RS can be an SS/PBCH block, CSI-RS or an SRS configured on the same or different component carrier and/or bandwidth part as the target SRS.

The UE shall transmit SRS with the same spatial domain transmission filter across the OFDM symbols occupied by a SRS resource.

The UE may be configured by the higher layer parameter *resourceMapping* in *SRS-Resource* with an SRS resource occupying $N_S \in \{1,2,4\}$ adjacent symbols within the last 6 symbols of the slot, where all antenna ports of the SRS resources are mapped to each symbol of the resource.

<Unchanged parts are omitted>

/************************* End of Text Proposal for 38.214**************************/

## 2.5. Default QCL assumption of aperiodic CSI-RS

In the last meeting, an agreement was achieved regarding the default QCL assumption and associated threshold for the reception of aperiodic CSI-RS as follows [6]:

> **Agreement**
> NW may schedule an ap-CSI-RS with a shorter delay than a threshold, and the UE applies a default QCL assumption
> - At least applies for CSI-RS for CSI acquisition
> - All CSI-RS symbols in one resource set should be below the threshold or all CSI-RS symbols in one resource set should be above the threshold
> - FFS: Default QCL assumption
> - FFS: Exact threshold with reference to UE capability

For the PDSCH transmission, there is also a default QCL assumption if the scheduling offset is less than its corresponding threshold. Thus there potentially may be up to two default QCL assumptions and up to two thresholds. The motivation to introduce default QCL assumption is to facilitate the DL data buffering before UE decodes the corresponding DCI and does the following demodulation/measurement. If these two default QCL assumptions and thresholds are different for PDSCH and aperiodic CSI-RS, the UE behavior will be ambiguous for some slot(s) and UE implementation will become more complicated. Thus we propose

- **The default QCL assumption of aperiodic CSI-RS is the same as that of PDSCH**
- **The threshold associated with default QCL assumption of aperiodic CSI-RS is the same as that associated with PDSCH**

# 3. Conclusion

In this contribution, we discuss some remaining issues of beam management and propose corresponding TPs as well.

# 4. References


[1] 3GPP TS 38.211: "NR; Physical channels and modulation"
[2] 3GPP TS 38.212: "NR; Multiplexing and channel coding"
[3] 3GPP TS 38.213: "NR; Physical layer procedures for control "
[4] 3GPP TS 38.214: "NR; Physical layer procedures for data "
[5] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification"
[6] Chairman's notes of RAN1#94